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GEO-2000 Alternative Policy Study for Europe and Central Asia

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GEO-2000 Alternative Policy Study for Europe and Central Asia:
Energy-related environmental impacts of policy scenarios, 1990-2010

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About RIVM
RIVM, the National Institute of Public Health and the Environment in Bilthoven, The Netherlands, is a supporting scientific organisation for the ministries in the Netherlands who deal with public health, the environment and nature. Since the late 1980s, a core task of RIVM has been integrated assessment in environment and public health, on the basis of extensive monitoring, modelling, scenario analysis and an active dialogue with the scientific community and those using the assessments in policy making. RIVM fulfils specific roles in its relations with various international organisations. To UNEP, RIVM has been a Collaborating Centre for Environment Assessment, Reporting and Forecasting since 1994.

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For the West Europe subregion, a key input for this study were the calculations carried out for the integrated assessment of policy alternatives for thirteen prominent EU environmental problems by scientists from RIVM, CSERGE/EFTEC, NTUA and IIASA cited as RIVM and others 2000 in the text. The RIVM scientists involved were Keimpe Wieringa, Jean-Paul Hettelingh, Bronno de Haan and Bart Strengers (RIVM).

Analysis for this report was begun relatively early in the GEO-2000 preparation process since it would be used to derive specifications for all GEO-2000 region-specific alternative policy studies. This took place at meetings of the GEO collaborating centres in Bahrain, 15–20 November 1997, and Brasilia, 2–6 February 1998. Most useful comments at various stages were received from Miriam Schomaker, Ronald Witt, Franciose Belmont, Sherry Heileman, Robin Clarke and Marion Cheatle (UNEP), Ram Shrestha (Asian Institute of Technology), Diana Vorsatz (Central European University), Kornelis Blok (Utrecht University), Jaap van Woerden and Ronald Albers (RIVM). The participants of the GEO-2000 regional consultations in Geneva (May 4–5, 1998) and a workshop held in Brussels by DG Environment (September 15–16, 1998) also provided very useful comments and suggestions. Ruth de Wijs of RIVM assisted in the English-language editing.

ABBREVIATIONS, DEFINITIONS AND CONVENTIONS

Abbreviations

AP	Accelerated Policies scenario
BL	Baseline scenario
CA	Central Asia
CDM	Clean Development Programme
CE	Central Europe
CHP	Combined heat and power
CLRTAP	Convention on Long-range Transboundary Air Pollution (UN-ECE)
CO2	Carbon dioxide
CSERGE	Centre for Social and Economic Research on the Global Environment
DALY	Disability Adjusted Life Years
EE	Eastern Europe
EEA	European Environment Agency
EFTEC	Economics for the Environment Consultancy
EMAS	Ecomanagement and Audit Scheme (European Union)
EST	Environmentally Sustainable Transport
FSU	Former Soviet Union
GDP	Gross domestic product
GEO	Global Environment Outlook
GEO-2000	Second Global Environment Outlook
EU	European Union
GJ	Gigajoules
GNP	Gross national product
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
JI	Joint Implementation
kWh	Kilowatt-hours
n.a.	Not available
MCT	Maximum application of Control Technology
NH_3	Ammonia
NOx	Nitrogen oxides
NTUA	National Technical University of Athens
OECD	Organisation for Economic Cooperation and Development
PHARE	EU financial and technical cooperation programme with countries in Central and Eastern Europe (abbreviation for Poland and Hungary Assistance to Reconstruction of their Economies)
ppm	Parts per million
ppp	Purchasing power parity
PM_{10}	Particulate matter less than 10 micrometer in aerodynamic diameter
p.y.	per year
RIVM	National Institute of Public Health and the Environment
SO_2	Sulphur dioxide

TACIS	Technical Assistance programme of the EU for countries of the Commonwealth of Independent States (FSU)
TFP	Total Factor Productivity
UAP	Urban air pollution
UNCED	United Nations Conference on Environment and Development
UN-ECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds
WE	Western Europe
WHO	World Health Organisation

Conventional signs in tables

–	nil
.	unknown
blank	empty on logical grounds

Definitions

Baseline scenario: The baseline scenario in this report depicts possible developments in the four subregions of Europe and Central Asia, assuming a world that can be characterised by steady economic growth and increasing international relationships. The 'baseline scenario' described in this report should not be interpreted as one without policy effort. First of all, for economic growth to recover in the eastern parts of Europe as assumed in the scenario, institutional and financial reforms are an absolute requirement. Secondly, the scenario assumes full implementation and effectiveness of currently formulated environmental policies. In some cases, we therefore indicated some of the pitfalls which could lead to less positive developments.

Accelerated policies scenario: The alternative, accelerated policies scenario is built from a combination of earlier scenario studies and indicates how trends in selected environmental issues may change if additional but moderate energy and environmental policies are assumed to be implemented in addition to those assumed in the baseline scenario.

Annex B countries: Those countries that have been assigned emission targets under the Kyoto protocol.

Source statements

Tables, graphs and maps based on data that are not taken from a publication have their sources mentioned without reference. No source is mentioned if this concerns data from RIVM.

ABSTRACT

The GEO-2000 study into alternative policy options for Europe and Central Asia focuses on energy use as an important driver for environmental problems across the region. It considers the question of what can be achieved by moderate measures, and whether this will be enough. The report includes an outline of the methodology for all region-specific studies on alternative policies for GEO-2000.

Its main findings are as follows:

1. Full implementation of existing policies could improve the general environmental situation in Europe and Central Asia. However, improvement will be *insufficient* to meet current policy targets or protect all ecosystems against acidification and climate change. Neither will guidelines for protection of human health be met everywhere.

2. *Transport* and *electricity* use stand out in particular. Notwithstanding cleaner vehicles, air pollution in cities and transport corridors will be increasingly dominated by mobile sources, making urban air pollution and summer smog persistent problems.

3. The toughest problem is the emission of greenhouse gases, although the technical potential is available to meet the region's Kyoto Protocol commitments. Along with trading emission rights across the region, *integrating policies* for different environmental problems could help to reduce abatement costs. In particular, combined strategies for reduction in the framework of the Kyoto Protocol (greenhouse gases) and other environmental problems (transboundary and urban air pollution) could optimise use of the opportunities for energy-efficiency and fuel switching – and thus create large ancillary benefits. Emission trading too should be considered in such context: part of the price paid by the importing countries is that the accompanying decreases in energy-related pollution also take place abroad.

4. The potential to reform environmentally *damaging subsidies* has not yet been fully used in any of the four subregions.

5. The four subregions are firmly connected for all five environmental problems studied; this emphasises the importance of environmental *cooperation* at the scale of the whole region.

CONTENTS

1. INTRODUCTION

1.1 The policy question for this assessment

Energy plays a central role in many environmental problems of Europe and Central Asia. Compared to most other areas in the world, energy use in most countries in this region is high. Not surprisingly, energy efficiency was identified as an issue of crucial importance for more sustainable development in the region in the first Global Environment Outlook (UNEP 1997). Therefore, this alternative policies study in the context of the second Global Environment Outlook will explore options for policies on energy and the environment between now and 2010. Effects on five environmental themes related to the use of energy will be estimated. These themes have been selected from the list of prominent pan-European environmental problems identified in the Dobris Assessment (EEA 1995a):

- Climate change.
- Acidification.
- Summer smog.
- Urban air pollution.
- Risks of reactor accidents associated with nuclear power generation.

The central question chosen for analysis here is:
"What can be achieved by full implementation of accepted environmental policies, or alternatively by additional moderate energy and environmental policies, and is the achievement enough?"

With energy as the connecting theme, the actual form of moderate measures differs between parts of the region, as elaborated in Chapter 5. In general terms, they include measures that are not only environmentally but also economically attractive, and measures with very low costs and considerable impacts.

Europe and Central Asia is an area of large diversity in many respects. The political situation of the past – free market economies in the West and centrally planned economies in the rest of pan-Europe – has left its mark. But climatic, environmental and economic factors also play a role. In GEO-2000, a division is made into four subregions: Western Europe, Central Europe, Eastern Europe and Central Asia (see Table 1.1 and Figure 1.1).

Table 1.1: The subregions of Europe and Central Asia

Western Europe	Andorra, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Holy See, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Spain, Sweden, Switzerland, United Kingdom
Central Europe	Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Macedonia, Slovakia, Slovenia, Turkey, Yugoslavia
Eastern Europe	Armenia, Azerbaijan, Belarus, Russian Federation, Georgia, Moldova, Ukraine
Central Asia	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan

Most countries in the Western European subregion rank among the wealthiest in the world. In this subregion, the material standard of living is high, and agricultural and industrial production volumes, along with environmental pressures, are large. Environmental policies in response to these pressures got underway relatively early. Such policies have been successful in decoupling economic growth and environmental pressure, at least for now and for some of the issues. For some problems (e.g. freshwater quality), the situation even significantly improved. For other problems such results have not been achieved. For example, the Western European subregion is still responsible for a large proportion of the world's greenhouse gas emissions. At the moment, there are several signs of exhaustion of simple technical measures to further reduce pressures. On the other hand, there are also claims that considerable progress can still be made; in particular by changing the basic incentives for resource use (e.g. prices determined by subsidies and taxes).

Central and Eastern Europe and Central Asia are being confronted with a special situation, i.e. a very poor state of the environment caused by decades of neglect and abuse. Following the political and economic transitions that began in the early 1990s, the profound restructuring of the economy and the redistribution of wealth and the ownership of resources offer a unique opportunity for the establishment of a more sustainable economic system. However, the hardships caused by the deep recession of the 1990s and the continued shortage of capital, especially in Eastern Europe and Central Asia, have tended to move environmental issues to the bottom of the political agenda. Whether environmental protection can be achieved using moderate measures and through integration with the economic transition is the question determining the environmental landscape of the 21st century in these subregions.

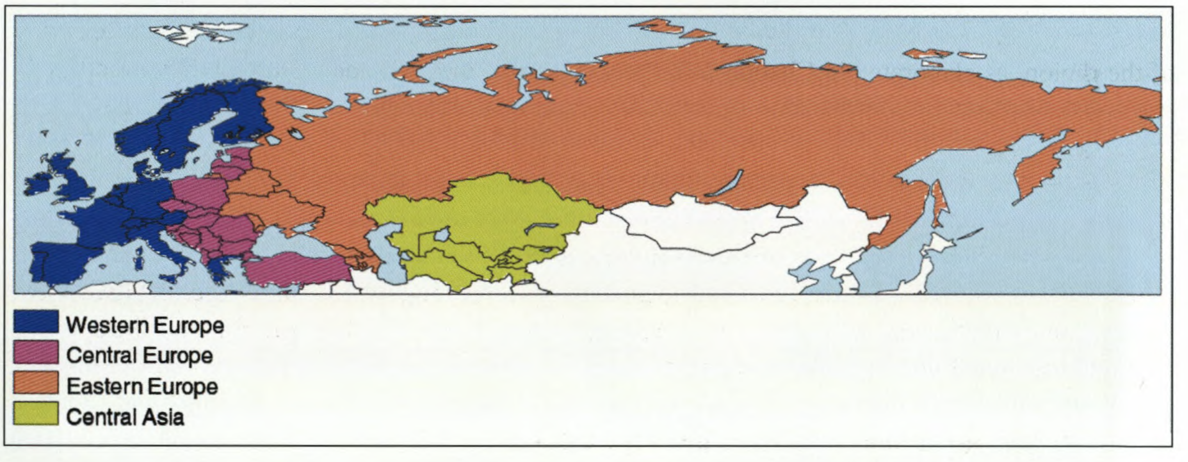


Figure 1.1: The subregions of Europe and Central Asia

1.2 Methodology

In this study, six standard steps were followed to structure the analysis. They form the common methodology for all the region-specific alternative policy studies for GEO-2000.

1. *Policy question:* The first step in the analysis defined the major policy question and the scope of the study (see Section 1.1).

2. *Baseline scenario:* A baseline scenario was subsequently developed. It describes possible social, economic and energy developments up to approximately 2010. This baseline scenario includes, in principle, all accepted policies within the region, but not additional ones. The baseline scenario is discussed in Chapter 2.

3. *Environmental impacts of full implementation of accepted environmental policies:* The implications of developments under the baseline scenario were estimated next, assuming the full implementation of accepted environmental policies with regard to the selected environmental issues. The results of this analysis are described in Chapter 3 and 4.

4. *Additional moderate measures:* The next step defines the potential alternative policies. These include, for instance, fuel switching, energy efficiency measures and use of renewable energy. In correspondence with the policy question as described in section 1.1, the focus is on moderate measures. This step is described in Chapter 5.

5. *Environmental impacts of additional moderate measures:* Impacts of measures such as those identified in Chapter 5 were investigated and compared to those of the baseline scenario. This step is described in Chapter 6.

6. *Conclusions:* Conclusions are drawn in the final step (see Chapter 7).

The analytical breakdown used to systematically identify the major pressures and causal relationships between scenario assumptions and impacts is shown in Figure 1.2.

It should be noted that the data used in this study for Central and Eastern Europe and Central Asia are beset with larger than average uncertainties. Nevertheless, the general findings and trends in each subregion are in line with those found in other studies. The scenarios are meant as analytical tools to assess environmental impacts under specific assumptions. They should not be interpreted as forecasts. In addition, the term 'baseline scenario' as used in this study is not meant to imply that this course of events is without policy effort. First of all, for economic growth to recover in the eastern parts of Europe as assumed in the scenario, institutional and financial reforms are an absolute requirement. Secondly, the scenario assumes full implementation and effectiveness of currently formulated environmental policies. In some cases, we therefore indicated some of the pitfalls which could lead to less optimistic developments.

The methods used are described in more detail in appendix 1.

Box 1.1: The energy system

The energy system consists of a chain of processes. It starts with the extraction or collection of primary energy sources, such as coal, crude oil, natural gas, biomass, uranium and sunlight. The energy content of the annual flow of these sources is often referred to as primary energy consumption. Primary energy is converted into energy carriers such as petrol and electricity, which are then converted into energy end-use provisions to provide the desired energy services. The annual flow of these energy carriers is called final energy consumption. Due to conversion losses, final consumption is less than primary consumption (e.g. the generation of electricity in many conventional power plants has an efficiency of less than 40 per cent).

Environmental pressures are caused by all parts of the energy system; some of the prominent pressures are selected for analysis in this study. Nuclear risks in Europe are for a large part determined by the use of nuclear power plants for the generation of electricity. Greenhouse gas emissions in the region are largely carbon dioxide emissions from fossil fuel consumption in the end-use sectors or from energy conversion. In addition, carbon dioxide and methane emissions during extraction and transport play a role. Acidification and urban air pollution result mainly from emissions during energy conversion and final energy consumption; agriculture and metal production also play a role here.

Opportunities to reduce environmental impacts can be found in all parts of the system. For example, carbon dioxide emissions can be lowered in the first part of the system by switching to energy sources with a lower carbon content (e.g. natural gas) or with a zero net carbon content (e.g. hydropower, nuclear power, biomass or solar-based electricity). In the second part of the system, lower conversion losses result in lower carbon emissions. One important option here is the combined generation of heat and power, which can raise the overall efficiency of converting fuels into electricity. Last but not least, demand for final energy can be reduced. Energy demand is determined by a complex of factors, including production and consumption patterns, income, and available technology. Energy conservation measures result in the use of less energy to deliver the same energy services. Studies have indicated a large potential for energy conservation; this is seen, for instance, in more efficient production methods in industry or the use of energy-efficient lighting in households.

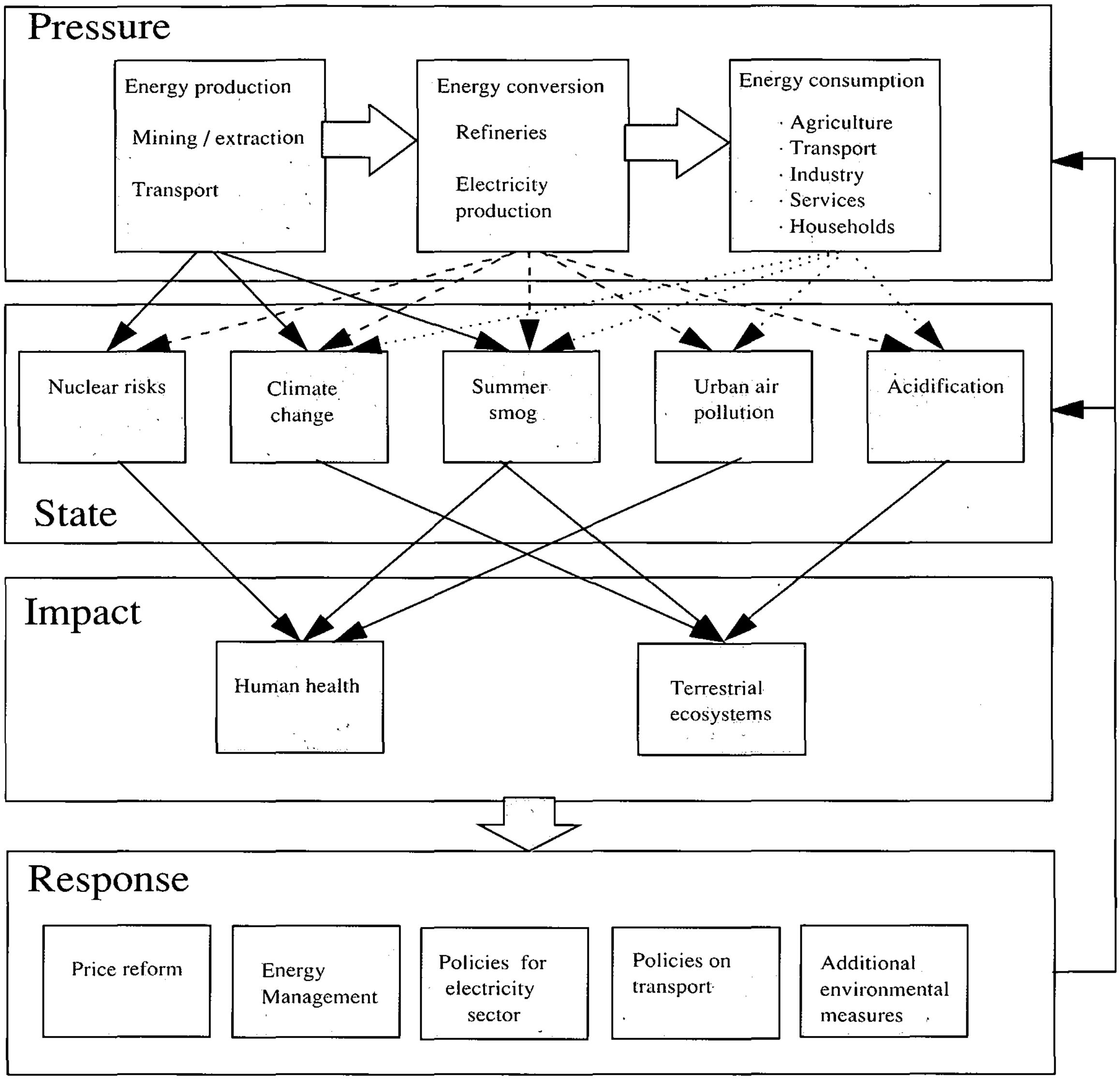


Figure 1.2: Analytical breakdown of the assessment

2. BASELINE SCENARIO (SCENARIO WITHOUT ADDITIONAL POLICIES)

This chapter describes the baseline scenario of this study in terms of economic, demographic and energy developments in the region, on the basis of current policies and projections. Chapter 3 assesses the environmental impacts of the baseline scenario, assuming that all accepted environmental policies are fully implemented.

The baseline scenario of this study is based on several detailed sectoral scenarios, the most important of which are the OECD Global Linkages study (OECD 1997a), preliminary studies under preparation for the European Commission (eventually published as RIVM and others 2000), and *Official Energy Pathways* (UN-ECE 1996; IIASA 1997). By choosing this basis, the baseline scenario is consistent with the leading baseline scenarios in Europe (e.g. EEA 1999; RIVM and others 2000). Of course, these are time-bound insights and there is no such thing as an 'official future'.

2.1 Demographic and economic assumptions

Introduction

The baseline scenario of this study has been derived from the OECD Global Linkages study (OECD 1997a), where two scenarios are outlined for the world economy up to the year 2020 on the basis of different policy assumptions: a high-performance and a business-as-usual scenario (labelled High-Growth and Low-Growth scenario, respectively).

One important consideration for using the OECD scenarios in this regional study is that they represent sets of consistent global economic projections. Furthermore, the sharp increase of international linkages in the High-Growth scenario can be considered a shortcut to assumptions reflecting the coming accession of many Central European countries to the EU.

Obviously, outlooks on the unknown future are always beset with uncertainty. In the case of Eastern Europe and Central Asia, projections are even more difficult, being strongly dependent on political, social and economic stability within the subregions. In view of these uncertainties, this section on economic and demographic developments will consider both scenarios from the OECD study. However, it should be noted that these scenarios are not forecasts, nor can they be considered as the upper or lower limits of growth possibilities.

For reasons of simplicity, subsequent chapters and sections will be narrowed down to only one baseline scenario, following a path between the High- and Low-Growth OECD scenarios. This does not mean an essential loss of nuance, as the baseline scenario is no more than a tool allowing analysis of the trends in the state of the environment under full implementation of current policies and alternative policies.

High-Growth versus Low-Growth

Both scenarios for the European and Central Asia region feature moderate population growth, ageing, economic recovery in Central and Eastern Europe and Central Asia, and a continued transition towards a service-oriented economy. However, the differences between the two scenarios and between the subregions are considerable, as illustrated by Table 2.1 and Figures 2.2 and 2.3.

Table 2.1: Characteristics of the High-Growth and Low-Growth scenarios

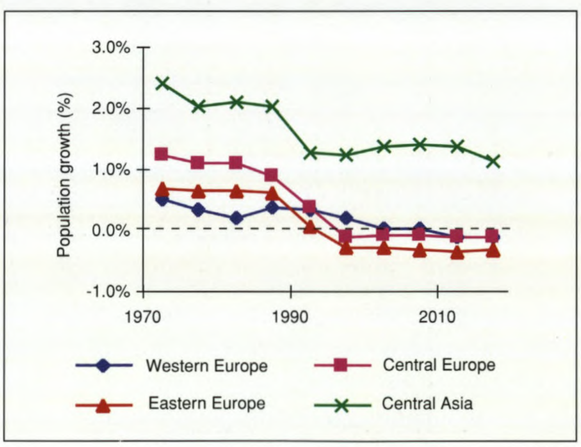
	High-Growth	Low-Growth
Trade barriers	Tariff equivalents fall to zero by 2020	Tariff equivalents reduced to 50% of their 1992 level
Convergence of non-OECD and OECD economies	OECD share in global income in 2020: 33%	OECD share global 44%
Labour-market-related reforms	Large increase with respect to labour-market flexibility	No major increase
Demographic development	Both scenarios are based on the 1997 UN Medium growth projections	

Source: OECD 1997a

The key feature of the High-Growth scenario is a marked increase of linkages between the economies of different regions of the world, continuing into the 21st century. Optimistic economic growth paths are assumed, especially for non-OECD regions, on the basis of assuming effective domestic policies and an open international climate. With respect to international trade and finance, the High-Growth scenario assumes a strong commitment to reducing existing barriers. A key characteristic is the rapid pace of technical progress with an easy flow of knowledge across borders, thanks to the assumed openness of the economies.

In the Low-Growth scenario, the growth of most economies is based on their performance over the last 25 years. Relatively slow progress on policy reforms, when added to the effects of an ageing population in many regions, could cause a progressive slowing of OECD growth rates while allowing a moderate economic growth in non-OECD regions.

The two scenarios assume the same population trends. This implies rapid population growth in Central Asia and slow growth in the other three subregions (see Figure 2.1). Figure 2.2 shows that



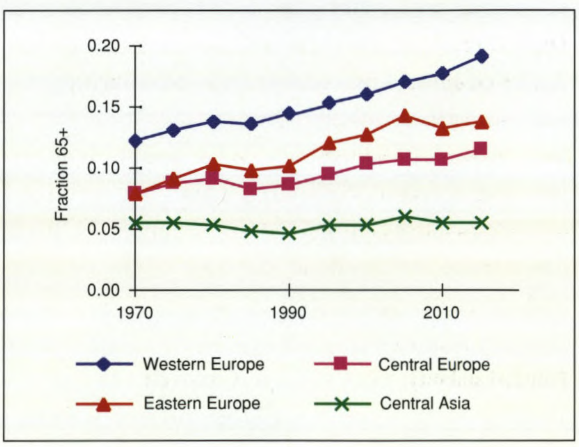


Figure 2.1: Demographic developments, following the baseline scenario
Population size will stabilise and the population in the three European subregions will age.
Source: OECD 1997a; UN 1997 medium projections

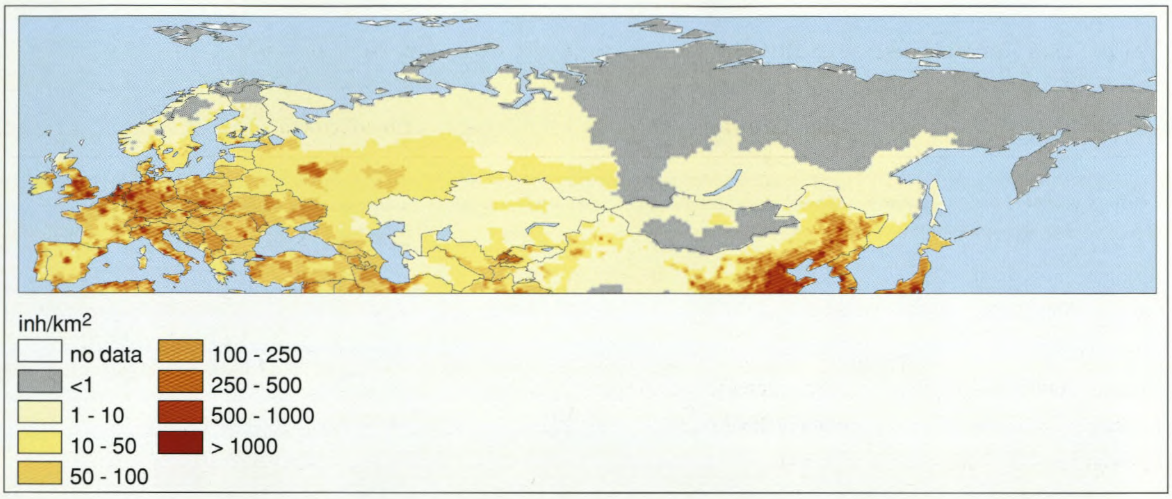


Figure 2.2: Population density in the Region in 2010, following the baseline scenario[1]
Source: RIVM on the basis of UN 1997; Tobler and others 1995

nevertheless in 2010 the central parts of Western Europe and Central Europe will continue to be the most populated parts of the Region.

The two scenarios and their consequences differ because, among other things barriers, opportunities and characteristics differ. Table 2.2 gives an overview of the most important factors in each of the subregions, indicating whether they represent a favourable or unfavourable influence on GDP growth.

Table 2.2: Differences in barriers, opportunities and characteristics between High-Growth and Low-Growth scenarios

	Western Europe		*Central Europe*		*Eastern Europe*		*Central Asia*	
	HG	*LG*	*HG*	*LG*	*HG*	*LG*	*HG*	*LG*
Barriers								
Ageing of population	–	–	–	–	–	–	0	0
Opportunities								
Accession to EU	+	0	++	+	+	0	0	0
Increased international trade	++	0	++	0	++	0	++	0
Technology and qualified personnel	++	+		0	++	0	+	0
Crucial factors								
Savings rate	0	0	++	+	++	+	++	+
Openness of economy	++	+	++	+	+	0	+	0
Political stability	++	++	++	+	+	0	+	0

– = unfavourable; + = favourable; 0 = no significant change; HG = High Growth; LG = Low Growth

[1] Demographic development is equal in the High- and Low-Growth scenarios.

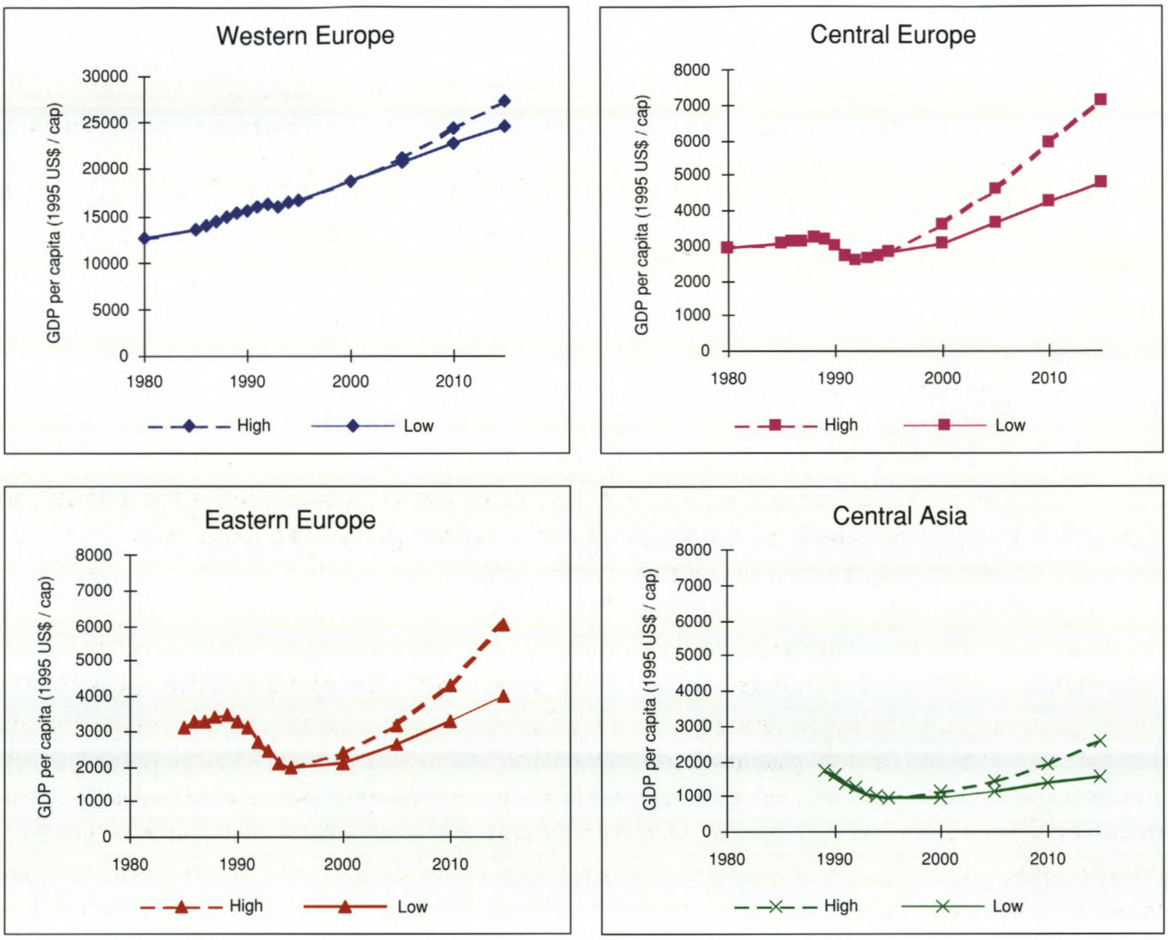


Figure 2.3: GDP per capita development derived from OECD High- and Low-Growth scenarios

The economies of Central and Eastern Europe, and Central Asia are assumed to recover but the growth rate is very uncertain. Economic growth in Western Europe is assumed to be more modest.

Source: growth rates: OECD 1997a; 1995 level and trends in the period 1980–1995: World Bank 1997b

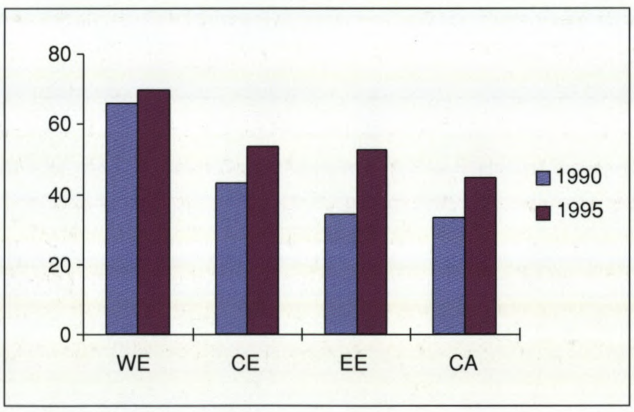


Figure 2.4: Share of service sector in GDP

The service sector gains importance in all subregions between 1990 and 1995.

Source: World Bank 1997b

The following sections describe the pattern that emerges for each of the four subregions on the basis of OECD study projections and information from other sources.

Western Europe

Western Europe no longer enjoys the strong growth in productivity it witnessed earlier in the 20th century. Obviously, increased international competition is one factor behind reduced production growth; an ageing population is another (see Figure 2.2). Nevertheless, as a result of favourable, long-term productivity prospects and the implementation of economic reform programmes, the average income per capita in the High-Growth scenario increases in the period 1990–2020 at about 2.5 per cent per year. In both scenarios, Western Europe, along with the USA and Japan, still lead in technology. The savings rate in the Western European subregion remains almost constant.

The share of the service sector in the economy continues to increase, while the shares of industry and agriculture shrink. Currently, as a result of classic environmental policies, many industrial pollution problems no longer increase proportionally to growth of production. However, progress with respect to the emission of greenhouse gases has not been as good, while at the same time, a shift in environmental pressure to consumers and the transport sector has occurred. In the baseline scenario it is expected that this trend will continue.

Central Europe

The abrupt shift from a planned to a market economy caused economic production to decline by about 25 per cent for the region as a whole after its peak in 1986, although the speed and the degree of transformation varied considerably among the Central European countries. Currently, many countries in Central Europe seem to be moving toward resolution of some of their political and institutional problems, and almost all countries in the region are now experiencing (sometimes strong) GDP growth. The global financial crisis of 1999, and in particular the Russian crisis, has slowed down economic growth – but in view of the strong public finances and relatively robust financial sectors in most Central European countries, this is considered to be a temporary event.

An important change in the whole of Europe will be the accession of successive cohorts of Central European countries to the European Union. In principle, the accession countries will have to harmonise their legislation to EU standards before accession can take place. The exact elaboration of this principle, however, will be negotiated. Even though the potential member countries have made great progress in developing market institutions, harmonising rules to EU standards and upgrading financial sector technologies, there is still much to be done (World Bank 1997c)[2].

In the High-Growth scenario, the overall real growth of GDP per capita in the 1995–2010 period is 5 per cent per year, resulting from an increase of foreign trade and continued growth in investment. This trend matches, among other things, the projection made in the World Bank's 1997 *Global Economic Prospects* (World Bank 1997b). The High-Growth scenario can be seen as a likely scenario under accession conditions (see Box 2.1). In the Low-Growth scenario overall real growth of GDP per capita is 2.7 per cent. An important factor moderating growth in this scenario is the limited increase in foreign trade. Moreover, handicaps such as an ageing population and important gaps in social security play an important role.

In Central Europe the industrial sectors traditionally played a large role in economic activity, while the sectoral share of the service sector was small. In recent years, the share of the service sector has increased sharply, mostly due to the strong decline in the industrial sector (see Figure 2.4). In the baseline scenario the services and transport sectors are assumed to grow quickly.

[2] On the environmental consequences of EU accession, see Box 3.3 (end of Chapter 3).

Box 2.1: High-Growth scenario as EU-accession variant

The High-Growth scenario is based on the assumption of combined high increases of international trade and of investments in efficient technology. These assumptions are likely for Central European countries that will join the EU. Negotiations on the accession of Poland, Hungary, the Czech Republic, Slovenia, Estonia and Cyprus have been started. The accession of these countries is assumed to be followed in the mid-term by Slovakia, Bulgaria, Rumania, Latvia and Lithuania. As Figure 2.5 indicates, High-Growth conditions include an increased savings rate and the increased importance of international trade for the economy of Central Europe, as well as a considerably higher growth in GDP.

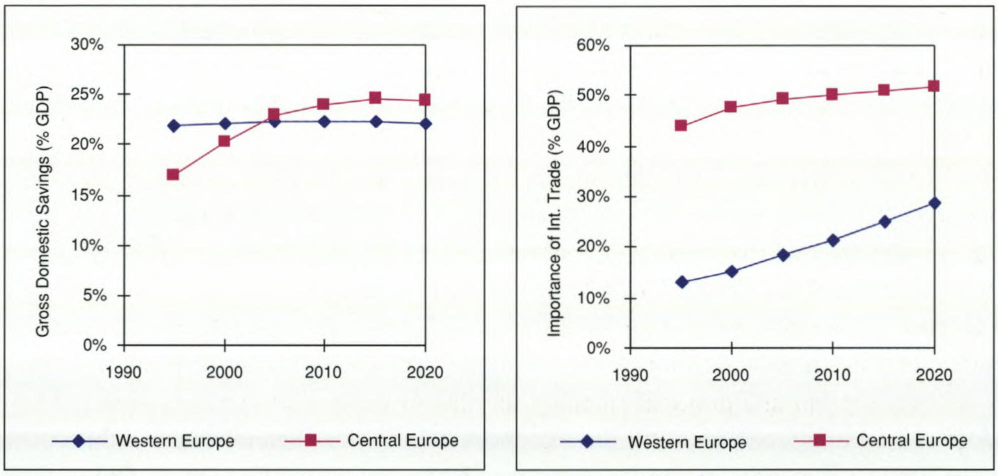


Figure 2.5: Savings and importance of international trade assumed for the OECD High-Growth scenario

Rising savings rates and importance of international trade in Central Europe are assumed under the OECD High-Growth scenario.

Source: CPB WorldScan modelling results (CPB pers. comm. 1997)

Eastern Europe

Just as for Central Europe, the Eastern European subregion has had to cope with a heavy economic recession during the past decade. In the Russian Federation, for instance, GNP fell by more than 40 per cent. So far, the Russian Federation and the other countries of the former Soviet Union have had an even more difficult time recovering from their economic transition than the Central European countries. In 1998, after some initial signs of economic recovery in 1997, the Russian Federation and Ukraine (the two largest countries in the subregion) were facing face difficulties as result of a financial crisis, in particular as a result of the increased borrowing costs in international capital markets. Obviously, the Russian crisis also worsened the external environment for many of the countries in the area. In 1999, the subregion again saw some signs of recovery.

In contrast with the current situation, both the High- and Low-Growth scenarios project considerable economic growth in the subregion which will require a stable macro-economic climate and continued structural reforms.

After 2000 in the High-Growth scenario, improving business confidence and increasing foreign direct investments will raise real income growth to 6 per cent, provided that the important challenges with respect to social cohesion and rule of law can be met. Such a scenario matches the 1997 World Bank's *Global Economic Prospects* (World Bank 1997b). As a result, by 2010 the subregion will be back at prosperity levels experienced before the beginning of the crisis in the mid-1980s. In the Low-Growth scenario, a less stimulating global economic climate causes real growth to fall back to 4.4 per cent a year. But a stable macro-economic climate in the subregion is also required for the OECD Low-Growth scenario. The 2000 World Bank's Global Economic Prospects depict a scenario that seems to match the OECD Low-Growth scenario provided that far-reaching reforms can be implemented (World Bank 2000).

In view of the existing economic situation in Russia and Ukraine, in the baseline scenario for the Eastern European subregion the OECD Low-Growth scenario is used for the 2000-2005 period, after which a path in between the two OECD scenarios is followed.

Central Asia

Some of the Central Asian countries, e.g. Kyrgyz Republic and Kazakhstan (the largest economy in the region), have made considerable progress with economic restructuring and saw a return of economic growth by the mid-1990s. The short-term expectations for the region are therefore relatively optimistic. A number of World Bank country and regional projections (World Bank 1997b) assume an average growth of GDP of 5 per cent and higher between now and 2010. However, uncertainty in this region is relatively large. Crucial issues encompass the consolidation of gains in fiscal reform and political stability, and the development of the productive and export potential of the agriculture, energy and mining sectors. Another crucial issue is the oil price – a decline can hurt the energy exporting countries in the region. Obviously, country-to-country differences will be large during this period.

Because the population is relatively young (see Figure 2.2) and because of the favourable natural resource endowment, the long-term economic position of the Central Asian countries could be considered slightly better than that of the rest of the former Soviet Union. Under the High-Growth scenario, GDP grows by 6.1 per cent per year in the 1995–2010 period. Under the Low-Growth scenario the average GDP growth is projected to be 4.4 per cent per year.

Total factor productivity

The differences between the European subregions can also be illustrated by the development in total factor productivity (TFP) as projected by the OECD in the High-Growth scenario. TFP is thought to increase under the influence of a number of factors, including further improvements in employment skills and investments in more efficient technology. The projected TFP growth rates can therefore be interpreted as a proxy measure for technological innovation, with improvement of energy efficiency being the most important aspect for this study.

Table 2.3 shows that TFP for new operations is assumed to increase for the capital goods sector by 1.9 per cent in Western Europe in the 1995-2020 period, as opposed to 3.2 per cent and 3.4 per cent in Central and Eastern Europe, respectively. Productivity increases in international transport are the most pronounced, with a stiff 4.2 per cent in Western Europe and no less than 8.6 per cent in Eastern Europe. A similar pattern is assumed for all sectors. Under the assumptions stated, the projected productivity growth increases from West to East over the 1995–2020 period.

Table 2.3: Total factor productivity improvement of new capital stock assumed for the OECD High-Growth scenario over the 1995-2020 period

	Western Europe	Central Europe	Eastern Europe and Central Asia
	%		
Consumption goods	1.8	3.0	3.0
Capital goods	1.9	3.2	3.4
Intermediate goods	3.1	4.4	5.1
Natural gas and oil	2.8	2.2	3.4
International transport	4.2	7.5	8.6

Large increases in total factor productivity assumed for the High-Growth scenario reflect sizeable technological innovation in Central and Eastern Europe, and Central Asia.
Source: CPB WorldScan modelling results (CPB, pers. comm. 1997

2.2 Energy assumptions

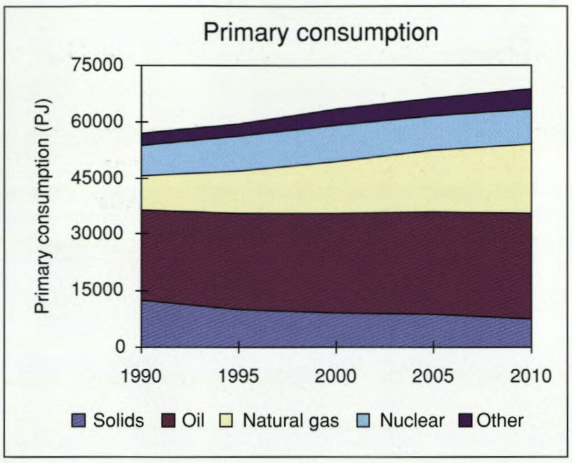
The developments in energy production and use are characterised by moderate (Western Europe) to rapid (Eastern Europe, Central Asia and especially Central Europe) decreases in overall energy intensity, a growing share of electricity in energy end-use, new power plants with significantly higher thermal efficiencies and a continuing market penetration by natural gas.

Western Europe

The baseline energy scenario for Western Europe is that of Capros and others (1997), which implies a continuation of present trends for Western Europe. Energy use will continue to increase, especially in the transport sector, but modestly. Natural gas is expected to be the fastest growing of all primary fuels, with an increasing share in all end-use sectors, particularly in power generation. The share of coal declines as a result of competition from natural gas. However, one cannot be sure whether this last assumption is realistic for the later stages of the scenario: increasingly competitive prices and especially national policies could stabilise the market share of coal.

Table 2.4 and Figure 2.6 summarise important trends in the West European energy sector in the baseline scenario. They show that primary energy use in the baseline scenario increases at about 0.9 per cent per year, which is comparable to other scenarios (e.g. 1.1 per cent and 0.5 per cent in the two scenarios of IEA's 1996 World Energy Outlook). As a result of the large investments assumed in the economic scenario, the improvement of energy intensity[3] is about 1.5 per cent annually over the whole period. This is high in comparison with other scenarios (e.g. IEA 1997) or compared with the rate in recent years. An important factor here is the continued introduction of highly efficient gas turbines.

At the moment, Western Europe shows the largest net energy imports in the world. In the High-Five scenario, Western Europe becomes even more dependent on imports of energy, especially natural gas (from Eastern Europe) and oil (West Asia and possibly Central Asia).



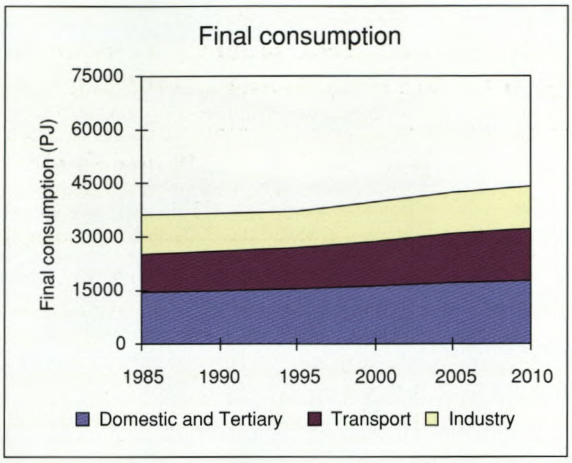


Figure 2.6: Energy use in Western Europe, no additional policies assumed
The energy scenario for Western Europe shows a continuation of present trends.
Source: Capros and Georgakopoulos 1997

Table 2.4: Energy indicators for Western Europe, no additional policies assumed

		1990	1995	2000	2005	2010
Share of gas	%	16.5	19.6	22.2	24.5	27.1
Energy intensity (primary)	GJ/US$	8.3	8.0	7.5	7.0	6.4
Change in energy intensity	% p.y.	-0.3	-1.2	-1.5	-1.6	-1.5
Share of electricity	%	11.9	12.4	12.8	13.1	13.4
Thermal efficiency of electricity production	%	36.7	38.1	38.7	39.3	40.9

Note: Energy intensity in GJ per 1995 ppp$. Source: Capros and Georgakopoulos 1997

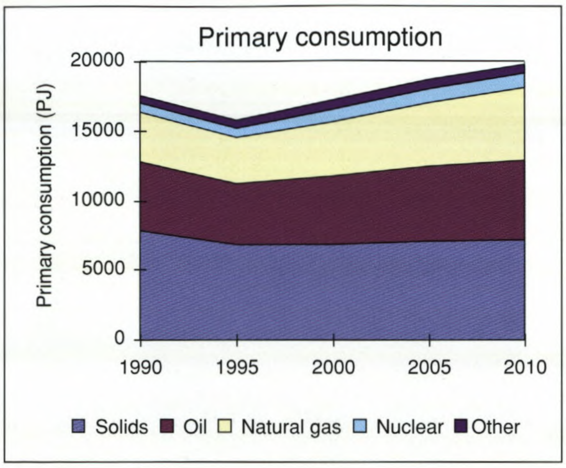
Central Europe

The baseline energy scenario as used for Central Europe in this study has been derived from the *Official Energy Pathways*. These projections, submitted by governments to the UN-ECE, are published in the UNECE Energy Data Base (UN-ECE 1995).

The economic collapse in Central Europe led to a decline in energy use between 1989 and 1995 (Figure 2.7). Since 1993, the Central European countries have begun to recover from the economic setback. In the subregion as a whole, intensity of energy use is much larger than the Western European average but improving, even though developments differ per country per year. For example, the energy intensity of the Czech and Polish economies has improved considerably since the late 1980s, while in Hungary it has remained almost constant. However, in some Central European countries energy intensity has even increased.

Even in the baseline scenario, that is, without additional policies, energy intensity will continue to improve. This results from increasing energy prices, increasing efficiency, penetration of more

[3] Energy intensity is defined here as primary energy use divided by Gross Domestic Product. Differences in energy intensity across countries are sometimes difficult to measure accurately because GDP figures are not always completely comparable. International differences in energy intensity are not only influenced by energy efficiency but also by factors such as economic structure.



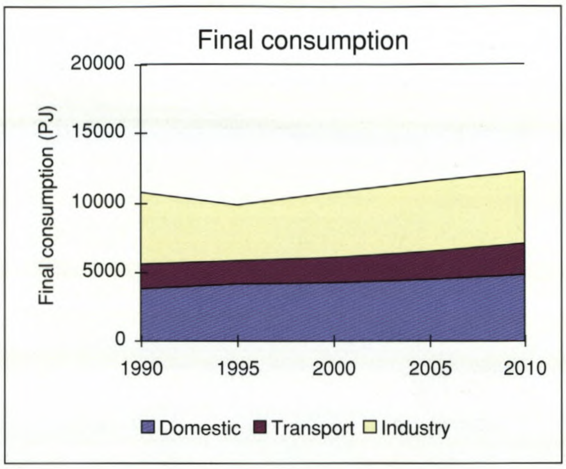


Figure 2.7: Energy use in Central Europe, no additional policies assumed
Energy use in Central Europe in 2010 is more than 10 per cent above 1990 level.
Source: IIASA 1997

Table 2.5: Energy indicators for Central Europe, no additional policies assumed

		1990	1995	2000	2005	2010
Share of gas	%	20.7	21.2	22.6	24.6	26.2
Energy intensity (primary)	GJ/US$	16.2	15.1	13.7	12.1	10.5
Change in energy intensity	% p.y.	.	-2.1	-2.0	-2.5	-2.7
Share of electricity	%	9.1	10.5	10.4	10.9	11.5
Thermal efficiency of electricity production	%	30.1	31.5	33.8	34.3	34.5

Note: Energy intensity in GJ per 1995 ppp$. Source: Based on IIASA 1997; DGVII 1996

efficient technology and the growing contribution of less energy-intensive sectors of the economy. The projected improvements in the 1995-2010 period are between 2 per cent and 3 per cent per year (see Table 2.5). This is within the 2 per cent to 4 per cent per year range found in other scenarios (DGXVII 1996; DoE 1997; ECN 1997). In the baseline scenario, primary energy use in Central Europe reaches a level of more than 10 per cent beyond its 1990 level by the year 2010.

Energy demand in 1990 was dominated by industry. In the baseline scenario, energy use by households, the service sector and especially transport are projected to increase in importance. The increase in energy use in the transport sector might be even more rapid than assumed in the *Official Energy Pathways*, as a result of modal shift. It is expected that in Central Europe more and more passenger transport will be based on private cars and less on public transport. This will be discussed in section 2.3.

In the past, coal has been the principal energy source in Central Europe. Demand for natural gas is assumed to grow sharply, replacing coal as the main energy source, while the market share of oil remains more or less stable. Coal declines from almost 45 per cent in total consumption to a market share of 36 per cent. By implication, gas imports, mainly from the Russian Federation, are assumed to grow sharply.

Electricity use is projected to reach a level of 515 billion kWh in 2010, a growth rate slightly above that of energy use. At the moment, electricity generation in Central Europe is mostly based on coal. For the period up to 2010, an assumed shift away from coal in the power sector is the main driving force for the projected increase in the market share of natural gas. In some Central European countries – especially the Czech Republic, Slovakia and Lithuania – nuclear expansion rather than an increased use of gas might compensate for the decrease in coal consumption. In this scenario, the total capacity of nuclear power plants in the Central European subregion increases by 45 per cent over the 1995–2010 period.

Eastern Europe

The energy scenario for Eastern Europe is derived from the *Official Energy Pathways*, like the Central European energy scenario. In fact, since the Eastern Europe subregion is larger than the area covered in the *Official Energy Pathways*, the projections have been scaled to match the 1990 and 1995 situation, known from other sources (BP 1997)[4].

The Former Soviet Union already had one of the highest energy intensities in the world before its economic collapse and the 'gap' for this indicator with reference to Western Europe is very large. This inefficiency has been mainly a result of policies where domestic energy prices were highly subsidised (van Beers and de Moor 1998). A second reason is that heavy industry accounts for a relatively large portion of total economic activity. During the transition years, the energy intensity index rose even higher, as the recorded GDP declined faster than energy use.

Energy intensity is assumed to improve as a result of growth in less energy-intensive production sectors (structural shift) and the 'autonomous' increase in energy efficiency. The assumed energy intensity improvement is in accordance with other scenarios (e.g. DoE 1997). As the subregion's economies rebuild they will have the opportunity to reduce energy inefficiency. Nevertheless, energy intensity remains well above the level of Western Europe.

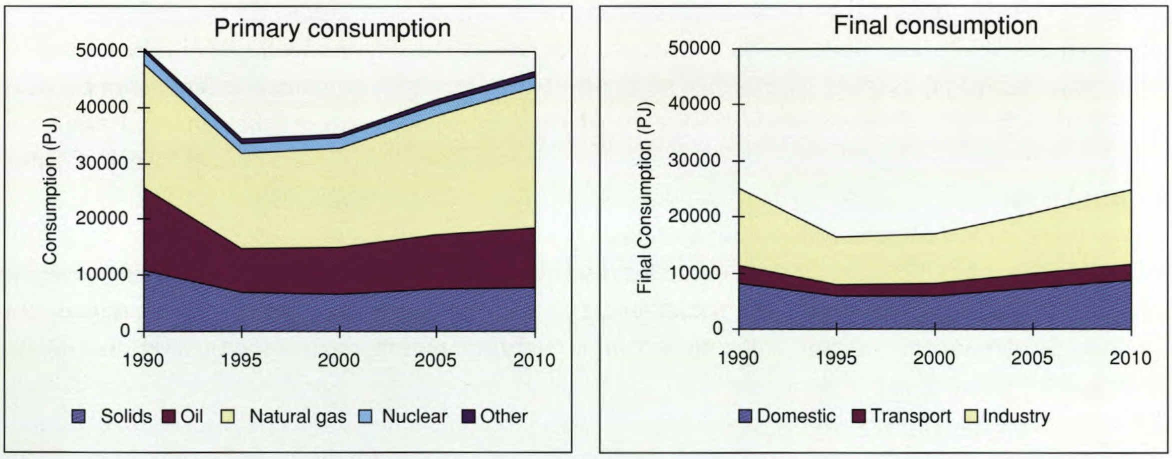


Figure 2.8: Energy use in Eastern Europe, no additional policies assumed

The energy mix in Eastern Europe is dominated by natural gas.

Source: Based on IIASA 1997 and BP 1997

[4] The *Official Energy Pathways* assume stabilisation of energy demand in the Eastern European subregion after 2005. Since this is unlikely under the social and economic assumptions in the reference scenario, we have extrapolated the 2000-2005 developments included in the pathways.

However, it is easy to imagine how favourable development assumed here could be eroded. First of all, future growth could also be based on less energy-efficient technology or even on current energy-wasting technology. And, despite the positive assumptions in the OECD scenario, the shortage of domestic and foreign investments could still make it difficult to reform energy economies in the industrial sector.

In the baseline scenario, Eastern European primary energy use reaches its 1990 level again after 2010. The assumed increase in personal incomes, combined with an economic shift towards services, causes the demand in the service and household sectors to grow faster than in industry. Private transport grows at a moderate rate, as implied by the Official Energy Pathways. However, a sharper growth in transport might realistically be assumed, partly because of the intensive growth in the use of private cars (see section 2.3).

Table 2.6: Energy indicators for Eastern Europe, no additional policies assumed

		1990	1995	2000	2005	2010
Share of gas	%	43.7	49.9	50.1	51.9	54.2
Energy intensity (primary)	GJ/US$	35.4	40.0	39.1	37.1	32.3
Change in energy intensity	% p.y.	.	2.4	-0.5	-1.0	-2.7
Share of electricity	%	8.7	9.0	9.0	9.1	9.2
Thermal efficiency of electricity production	%	32.1	33.5	35.8	36.3	36.5

Note: Energy intensity in GJ per 1995 ppp$. Source: Based on IIASA 1997 and BP 1997

The fuel mix in Eastern Europe is determined by the attractive economics of its gas deposits. Between 1995 and 2010, the share of coal in total primary consumption falls from 21 per cent to 17 per cent; the share of oil remains stable at 23 per cent (between 1990 and 1995 this dropped from 30 per cent to 23 per cent) and that of natural gas rises to a level of almost 55 per cent of primary energy use (a level also found in other scenarios like DGXVII 1996 and DoE 1997). The electricity generation sector plays a key role in this, since all new thermal power generators are assumed to be gas-fired.

Central Asia

Large parts[5] of the Central Asian subregion are very rich in fossil fuel resources. Coal is by far the most important but the subregion also has vast resources of crude oil and natural gas. This subregion is assumed to play a more important role in energy exports in the future. However, this assumption is strongly dependent on political and economic stability within the subregion and also in the surrounding countries.

The energy intensity in 1990 and 1995 in Central Asia was very high, although it should be mentioned that the subregion's GDP (the denominator) is underestimated by using exchange rates for converting local currency to US dollars. An energy intensity improvement similar to Eastern Europe is assumed for this subregion. Combined with strong economic growth, this results in a considerable increase in primary energy use.

[5] Especially Kazakstan, Turkmenistan and Uzbekistan

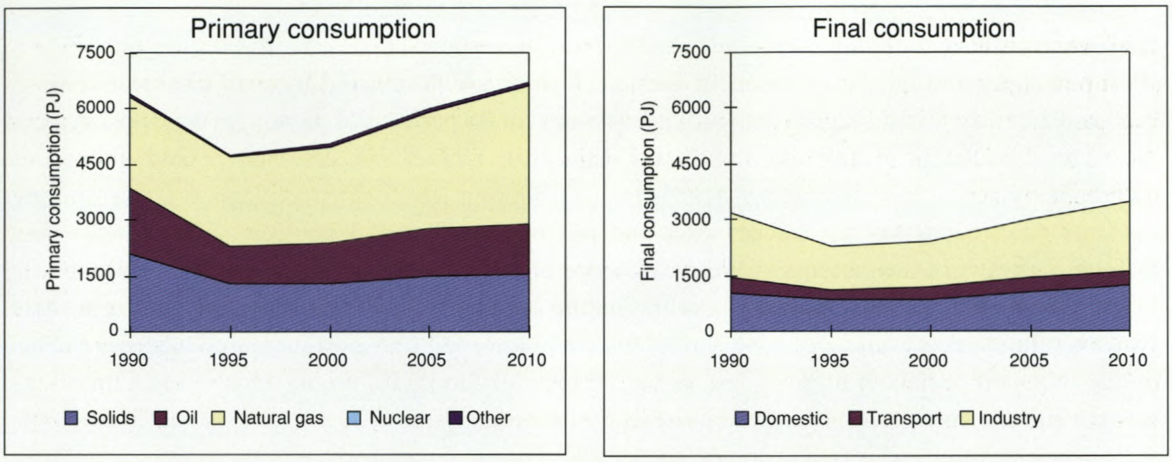


Figure 2.9: Energy use in Central Asia, no additional policies assumed
Source: based on IIASA 1997 and BP 1997

Table 2.7: Energy indicators for Central Asia, no additional policies assumed

		1990	1995	2000	2005	2010
Share of gas	%	38.7	50.9	51.2	52.9	55.3
Energy intensity (primary)	GJ/US$	31.2	36.1	34.5	32.5	28.6
Change in energy intensity	% p.y.	.	2.9	-0.9	-1.2	-2.5
Share of electricity	%	.	.	.	.	.
Thermal efficiency of electricity production	%	.	.	.	.	.

Note: Energy intensity in GJ per 1995 ppp$. Source: based on IIASA 1997 and BP 1997

The energy mix in Central Asia before 1990 featured more coal and slightly less natural gas than in Eastern Europe. However, in the 1990-1995 period coal lost its market share to natural gas. It has been assumed that the market share of natural gas will continue to expand at the expense of coal, just as in Eastern Europe. However, this is not completely certain. It is also possible that development will be oriented towards using the cheap and abundant coal resources. Since the quality of the coal is very poor, this could increasingly cause environmental problems. In contrast to Eastern Europe, the use of nuclear energy is very small. In our study, only commercial energy is taken into account. Traditional energy (such as wood) might still play an important role.

2.3 Transport assumptions

At present, energy use in transport in Central and Eastern Europe and Central Asia is much smaller than in Western Europe. However, more open borders and increased incomes for some people in the Central and Eastern European subregions have spurred considerable growth in private car ownership and use. At the same time, in Western Europe environmental pressures caused by transport are also becoming increasingly important. Therefore, in this section special attention is paid to potential developments in the transport sector.

Historic trends

Both passenger and freight transport in Western Europe are dominated by road transport (Figures 2.10 and 2.11). In this subregion, private cars account for 85 per cent of passenger transport in terms of person-kilometres. Total mobility in the European Union, measured in person kilometres, increased by about 3.6 per cent per year between 1985 and 1995. Air travel grew fastest, 6.2 per cent per year, car travel by 3.8 per cent and rail by less than 0.3 per cent. There are striking differences between the patterns in Western Europe and Central and Eastern Europe. Total mobility in the latter two subregions is smaller, while public transport (bus, train) has a much larger share. However, fundamental changes have started to take place: road transport increased whereas rail and public transport remained more or less stable, or even declined. In freight transport in Central and Eastern Europe, transport by road is increasingly becoming popular.

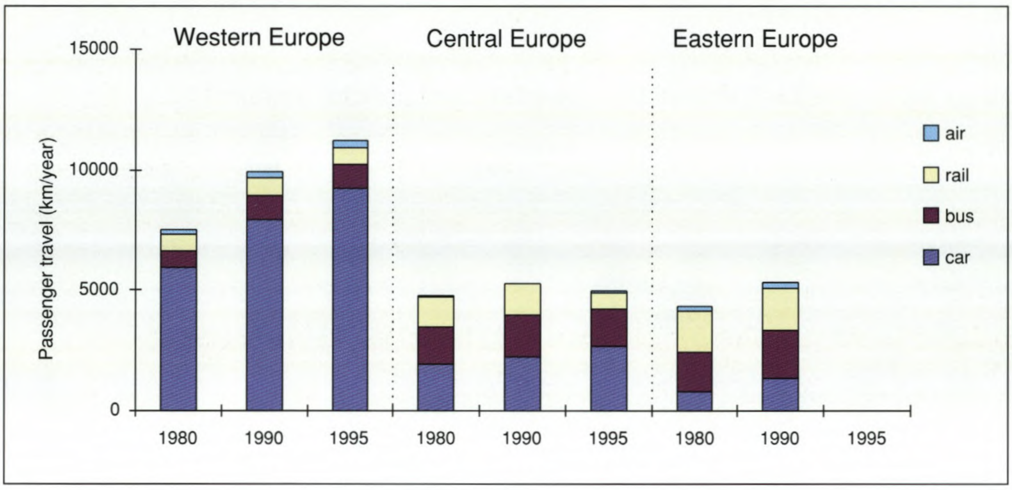


Figure 2.10: Passenger transport

Compiled on the basis of EEA 1998; TRAFICO 1998; Schäfer 1998; IFO 1998; EEA 1998; RIVM staff estimates

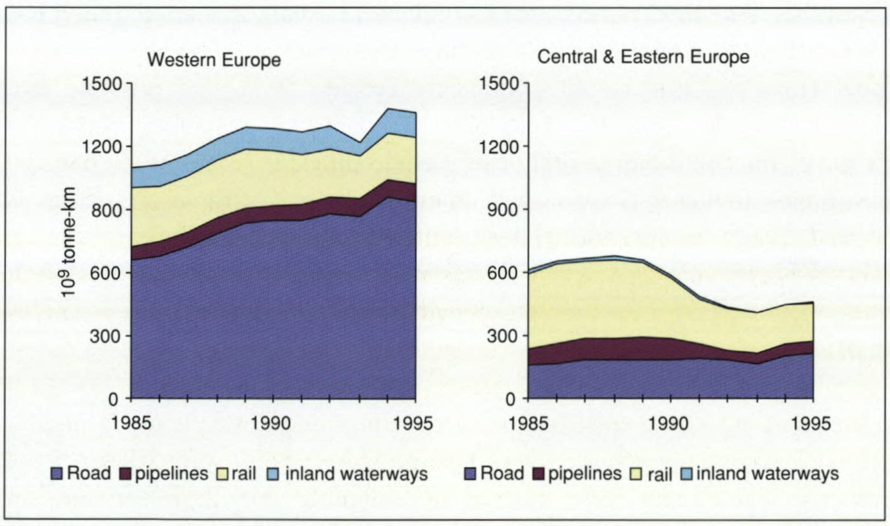


Figure 2.11: Trends in freight transport

Road transport dominates in Western Europe. It has increased faster than any other form of transport.

Source: EEA 1998

The energy demands of transport are determined by mobility growth and changes in modal split, occupancy (fewer people per car) and car size. In Western Europe these factors have over the last two decades strongly outpaced increases in car efficiency. While total mobility increased by about 3.5 per cent a year between 1985 and 1995, fuel efficiency improved over the last two decades at only about 1 per cent a year (Schipper and others 1993; CE 1997). Moreover, since the late 1980s the fuel efficiency improvement of new cars has even been much slower. With ever-increasing car use, this meant that net energy use for transport and, consequently, carbon dioxide emissions have increased (Figure 2.12).

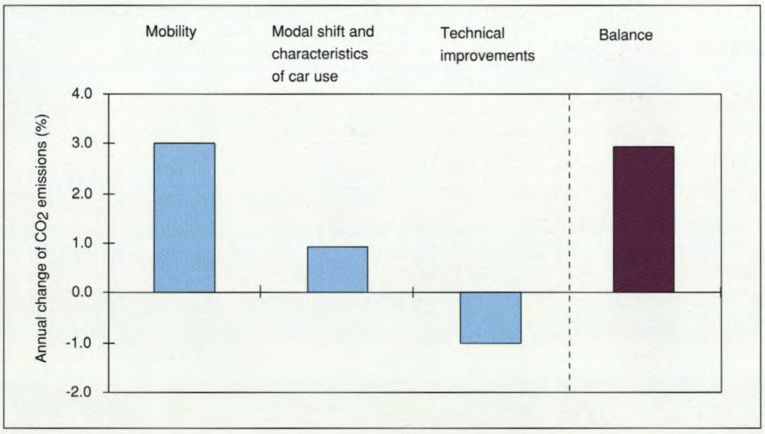


Figure 2.12: Balance of trends influencing carbon dioxide emissions from passenger transport in Western Europe over the past two decades
Growth in private car use has sharply outrun technical improvements in car efficiency.
Source: CE 1997

The situation is slightly different for air pollutants like nitrogen oxides and volatile organic compounds. The introduction of the three-way catalyst in Western Europe has brought the volume of these emissions down. In the near future, however, emissions could increase again as a result of growth in mobility if no new measures are taken. At the moment, the contribution of air transport (passenger and freight) to total Western European carbon dioxide emissions is still limited. However, the volume of air transport is growing faster than any other transport mode.

Outlooks

It is expected that with no changes in policy, the volume of passenger and freight transport in the four subregions will grow strongly. Two specific scenario studies were available for Western Europe (RIVM and others 2000) and Central Europe (Trafico 1998)[6] that are consistent with the baseline scenario of this study. The Western European scenario was made on the basis of the baseline scenario described in this report. The assumed population growth in the 'business-as-usual' scenario of the Trafico study is equal to the baseline scenario described here; the assumed growth rates for economic growth are comparable (3.5 per cent per year versus 4 per cent per year).

In Western Europe, passenger transport volume is expected to grow by slightly more than 30 per cent. Bus and rail transport are likely to grow at a much slower pace, despite policies to encourage

[6] The study covered almost all countries of Central Europe (Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Former Yugoslavia, Republic of Macedonia, Poland, Romania, Slovakia and Slovenia) and a few Eastern European countries (Belarus, Moldovia and the Ukraine).

these modes. Freight transport in the region is expected to grow by around 50 per cent. The Trafico study for Central Europe does not make explicit assumptions about accession to the EU, but is based on a survey of national authorities and reflects accession-oriented policies. It is expected that EU accession and the growth of pan-European trade will stimulate transport volume in the Central European subregion. A key assumption in the Trafico projection is that the 2030 transport patterns in these countries are more or less similar to those in EU countries in 1990. The volume increase in the 1994–2010 period is about 60 per cent for passengers and almost 80 per cent for transport.

A strong empirical relationship exists between changes in average income per capita and changes in car ownership. On the basis of this relationship and current trends it is possible to estimate car ownership in 2010, as indicated in Table 2.8.

Table 2.8: Changes in car ownership

	1995	2010
	cars per 1000 inhabitants	
Western Europe	436	475
Central Europe	136	220
Eastern Europe	90	140
Central Asia	57	90

Source: IEA 1996; RIVM staff estimates

The consequences for energy use also depend on improvements in car efficiency, average car use and trends for other transport modes. In some respects, changes in the Central and Eastern European subregions will have positive impacts because an outdated stock of vehicles is replaced by cleaner and more modern ones. On the other hand, much of the recent increase of car fleet in the Central and Eastern European subregions has occurred through the introduction of second-hand cars from Western Europe. On the basis of income development, demographic developments[7] and comparison with the more detailed projections for Western and Central Europe, estimates were made for transport energy use for Eastern Europe and Central Asia. In these subregions the same trends are expected as for Central Europe, although somewhat later.[8]

Table 2.9: Projected increases of transport energy use 1995–2010, no additional policies assumed

	Baseline		Trafico	RIVM estimate
	RIVM	OEP		
	%			
Western Europe	27			
Central Europe		25	75	
Eastern Europe		31		60
Central Asia				120

Source: RIVM : RIVM and others 2000; OEP: IIASA 1997, Trafico 1998 and RIVM staff estimates
OEP = Official Energy Pathways

[7] In particular, the number of persons older than 20.
[8] The projected increase in private car use in Central Asia is somewhat more rapid than in the other subregions as result of the very low current car ownership and because below an income level of 2000 US$ per capita per year car ownership increases even more steepy with rising incomes.

Table 2.9 shows the increases in transport energy use in the *Official Energy Pathways*, the Trafico study and RIVM estimates. It can be concluded that despite the assumed continuing technical progress in energy efficiency, energy use for transport and emissions of major air pollutants from transport will increase significantly under this scenario. Moreover, the increase in transport assumed in the *Official Energy Pathways* is relatively modest – and should therefore be interpreted as a lower limit. Therefore, next chapter will pay attention to the consequences of stronger transport growth.

2.4 Main findings

This chapter has outlined a socio-economic and related energy scenario for the European and Central Asia region up to 2010. The scenario is based on the two scenarios developed in the OECD Global Linkages study. It is characterised by rapid economic expansion of the economies in all four subregions, stimulated by further market liberalisation and increased international trade across the Region - which finds itself in the middle of a globalising world. In such a scenario we assume a high level of technology diffusion and further adoption of material-intensive lifestyles throughout the region. At the same time, however, we assume that support will be sufficient to implement currently formulated environmental policies. More in particular, the following applies.

- The scenario projects steady economic growth in Western Europe and economic recovery in the other three subregions. Obviously, uncertainties are much larger in the latter subregions and economic recovery hinges on the question of whether institutional and financial problems can be solved.
- Economic growth and growth in transport can be particularly large in Central Europe – spurred on by accession to the European Union. Although accession has not been explicitly assumed in our baseline scenario, many of the central assumptions of the scenario are consistent with accession (see also Box 2.1).
- In all regions the growing share of the service sector could represent a slightly downward pressure on the growth of energy consumption. At the same time, however, the transport sector is expected to grow rapidly, resulting in a strong upward pressure on sectoral demand and emissions. Although our baseline scenario conservatively estimates a growth of 20-30 per cent in transport energy use, other estimates extend to increases of 100 per cent from 1994 to 2010.
- The ratio between energy use and GDP is expected to fall relatively rapidly in all four subregions but nevertheless energy demand could grow by 1.0 per cent per year in Western Europe up to 2.3 per cent per year in Central Asia.
- With the adoption of western lifestyles, transport and electricity use could become important driving forces of environmental problems in Central Europe. Comparable trends can be expected in Central Asia and Eastern Europe but somewhat later.

3. ENVIRONMENTAL IMPACTS OF THE BASELINE SCENARIO

Energy conversion and use impact on several health and environmental issues in the region. Impacts are caused in all stages of the energy system. Not only climate change but also emissions of metals, acidifying compounds and particulate matter to air are largely caused by use of fossil fuels. The latter result in long-range urban as well as regional and often even transboundary air pollution. Frequent oil spills – mainly due to a lack of maintenance of extraction equipment and pipelines – are causing serious degradation of land and water resources, especially in Eastern Europe and Central Asia. The Caspian Sea is severely polluted along its coast with oil and phenols (see e.g. Mnatsakanian, 1992). Non-fossil energy sources such as nuclear energy and hydropower can also have significant environmental impacts.

As mentioned in the first chapter this document focuses on five types of impacts selected from a list of prominent European environmental problems: climate change, acidification, summer smog, urban air pollution and nuclear radiation by accidents. The consequences of the baseline scenario for these problems are discussed in section 3.2 to 3.6. In section 3.7 we summarise the findings. A box in this last section discusses in general terms the potential environmental consequences of accession of Central European countries to the European Union.

3.1 Annotations to the baseline scenario

The previous chapter outlined a socio-economic scenario for the next 15 to 20 years. Key components in this scenario are moderate population growth and ageing, economic recovery in Central and Eastern Europe and Central Asia, and a continued transition towards a service-oriented economy. The resulting picture on energy is characterised by a moderate (Western Europe) to fast (Eastern Europe, Central Asia and especially Central Europe) decrease in overall energy intensity, a growing share of electricity in energy end use, significant increases in thermal efficiency of power plants and a fast market penetration of natural gas. Finally, the scenario assumes full implementation of all existing environmental policies for 2010.

This scenario is called the 'baseline scenario', but this should not be seen to imply that this course of events is without pitfalls or policy effort. For economic growth to recover in the eastern parts of Europe, institutional and financial reforms are an absolute requirement. An important element will be the mobilisation of capital and of modern technology to build a modern industrial base and infrastructure. This will also be a precondition for the assumed fast decrease in energy intensity. As past experience in Western Europe has shown, the first steps in environmental management are often the easiest. A good legal system with established environmental standards can play a key role in this. However, further improvements in the efficiency of using and supplying energy are increasingly confronted with institutional and behavioural inertia. For example, citizens usually act on the basis of short time-horizons, status and comparison; small businesses often go for the quick profit in fulfilling the need to survive.

The upshot from the annotations here is that without sufficient policy efforts, future developments can certainly be less positive than the baseline scenario assumes. The most critical and uncertain assumptions are the following:

- *It is assumed that all policies in place and 'in the pipeline' – i.e. those accepted but not yet implemented – will indeed be implemented and meet expectations.* This is, obviously, an optimistic assumption. In the past, different forms of 'implementation failure' have resulted in developments that have been less favourable than originally planned. For full implementation of policies, a prerequisite is that environmental protection has to be high on the political agenda of decision-makers during the 1998–2010 period. This will not be obvious, in view of other priorities such as EU transformation and reform of EU agricultural policy in Western Europe or the socio-economic challenges currently facing Eastern Europe.

- *The baseline scenario assumes moderate (Western Europe) to considerable (other subregions) improvement of energy intensity.* Although the assumptions are certainly technically feasible and in good correspondence to assumptions in other assessments, energy intensity could also improve much more slowly than assumed. In particular, with the prospect of stable or even declining fuel prices and without government action in the form of national and international programmes for energy efficiency research and development, the improvements may be an elusive goal for the coming decades. In particular in Central and Eastern Europe and Central Asia, the assumed efficiency improvement depends on the rate of renewal of the capital stock.

- *Considerable amounts of capital will be needed in the baseline scenario to expand the oil and gas supply system and modernise the electric power system.* This in turn requires a balanced interplay between governments and private firms in order to make domestic and foreign capital available and send the right signals to energy consumers. During the transition period, especially in Eastern Europe and Central Asia, social tensions resulting from rising energy prices, decline of employment in the coal industry etc. may pose major challenges to governments. Nevertheless, the prospects are quite good.

- *Transport is assumed to grow moderately in the baseline scenario.* As discussed in the previous chapter, environmental pressures from transport – particularly in Central Europe – could grow much faster than has been assumed in the baseline scenario.

- *Coal is assumed to lose market share in all four subregions.* The assumed substitution of coal by natural gas will be driven by the premium value of the latter as an efficient, convenient and clean fuel. In Central Europe, a major obstacle could be the consequences in terms of energy import dependence and the balance of payments, as natural gas has to be imported. Another impediment may be the upward pressure on gas prices as a result of high demand from Western Europe. In Central Asia there are signs that the subregion might try to export crude oil and natural gas, while using its cheap and abundant coal resources for local consumption. If this were to be the case, the poor quality of this coal could be responsible for a considerable burden on the environment of this subregion (Soni 1996).

In view of these assumptions, this chapter will - in addition to describing the impacts of the baseline scenario - indicate developments which are less positive than our baseline scenario but also plausible. This underlines that actual developments will need to be monitored critically.

Table 3.1 gives an overview of the assumed policies in the baseline scenario.

Table 3.1: Annotations to the baseline scenario

	Western Europe	Central Europe	Eastern Europe	Central Asia
Characteristics economy and energy	• Steady economic growth • Relativily strong improvement of energy intensity	• Strong economic growth • Strong improvement energy intensity • Increase of share of natural gast	• Strong economic recovery • Moderate improvement of energy intensity	• Strong economic recovery • Moderate improvement of energy intensity • The subregion will use its vast oil and natural gas supply instead of domestic coal
Characteristics environmental policies	• Full implementation of environmental policies in pipeline, including the Current Reduction Plans existing national policies for acidifying compounds and summer smog precursors • For nuclear power plants it has been assumed that there is only expansion by plants that are currently already under construction. In addition, all plants older than 30 years are taken out of production. Finally, no extra safety measures with regard to nuclear plants have been included.			
Required conditions	• Considerable governmental action to promote energy efficiency • Action to achieve environment emission targets for acidification and summer smog	• Sufficient capital availability, environmental awareness • Government decisions on fuel choice in power sector	• Mobilisation of domestic and foreign capital • Redressing tax evasion and widespread non-payment of utility charges	• Measures to further fiscal reform, political stability and social coherence

The baseline scenario assumes autonomous inprovements as well as the fruits of policies in place and in the pipeline.

3.2 Climate change

Human activities, in particular during the twentieth century, have caused increases in the concentrations of greenhouse gases in the atmosphere (most importantly carbon dioxide, methane, nitrous oxide and several halogenated compounds). Currently, there is growing evidence that the increased concentrations are causing a so-called enhanced greenhouse effect (climate change) – although the exact impacts are still uncertain. The latest scientific understanding of climate change is described in reports of IPCC (IPCC 1996).

Carbon dioxide is at the moment the largest contributor to the enhanced greenhouse effect (about 65 per cent). By far the largest anthropogenic source of carbon dioxide is the burning of fossil fuels. Also for methane, the second largest contributor to the enhanced greenhouse effect, energy production is an important cause of emissions. Although only 15 per cent of the world's population lives in the European region it is responsible for no less than 34 per cent of the global emissions of carbon dioxide and 22 per cent of methane emissions (CDIAC 1995).

Emissions trends

In this report the focus is on anthropogenic emissions of the three most important greenhouse gases (carbon dioxide, methane and nitrous oxide). It does not deal with emissions or sinks from land-use change and forestry. Emissions of these three gases in the region in 1990 in terms of carbon dioxide equivalents are indicated in Figure 3.1. In Europe and Central Asia as a whole, carbon dioxide

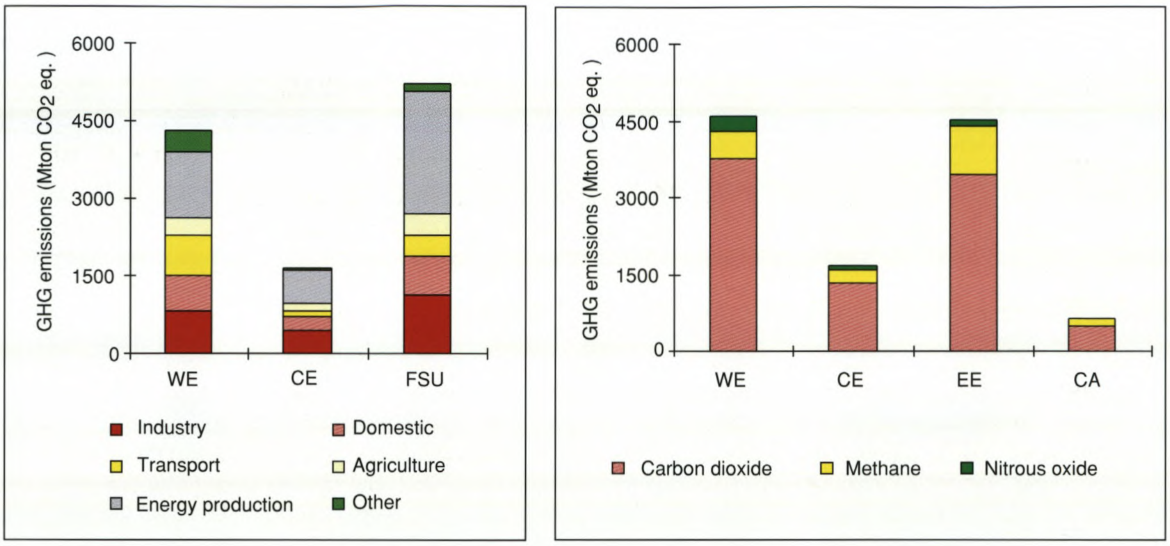


Figure 3.1: Greenhouse gas emissions in 1990

Carbon dioxide emissions dominate greenhouse gas emissions in the region. The most important sectors causing greenhouse gas emissions are industry and energy production sector (mining, refineries and electricity production).

Source: Carbon dioxide emissions calculated on the basis of Chapter 2; additional information from Hendriks and others (1998) and Olivier and others (1996)

emissions are responsible for approximately 80 per cent of total greenhouse gas emissions while methane emissions contribute to approximately 12–16 per cent and nitrous oxide emissions to approximately 4–8 per cent depending on the subregion.

Carbon dioxide emissions under conditions of the baseline scenario can be easily estimated on the basis of fossil fuel use. For methane, the most important anthropogenic sources of emissions are landfills, agriculture, industrial processes and energy-related emissions such as coal mining, the petroleum industry and the production and transport of natural gas. The larger methane contribution from Eastern Europe and Central Asia is mainly caused by very high leakage during the transport and distribution of oil and natural gas, and by coal mining. For nitrous oxide, the most important emissions sources are agriculture, industrial processes and fuel combustion. Trends in emissions of methane and nitrous oxide in Western Europe have been taken from the EU Priorities study (RIVM and others 2000). For the other regions of the world no major changes in their emissions for these gases have been assumed. The resulting trend in greenhouse gas emissions is indicated in Figure 3.2.

Emissions from Western Europe decreased between 1990 and 1995, mainly due to relatively small economic growth, economic restructuring in Germany and fuel switching from coal to natural gas in the UK. For Western Europe, the baseline scenario results in emissions of the three most important greenhouse gasses in 2010 of 6 per cent above the 1990 level. For Central Europe, the baseline scenario results in an emissions level of 3–4 per cent above the 1990 level. For Eastern Europe, the 2010 emissions are projected to be 10 per cent below the 1990 level; the 1995 level was almost 35 per cent below the 1990 level. Finally, in Central Asia, developments without additional policies result in a 2010 emission level 3 per cent larger than the 1990 level.

In response to the UNCED conference in 1992 in Rio de Janeiro, many European countries have developed climate change action plans involving policy measures and often targets to bring back greenhouse gas emissions in 2000 to 1990 levels or less. The 1997 negotiations in Kyoto resulted in targets for a large number of European states for the period 2008–2012[9]. The emissions reductions required to achieve these goals can be estimated as: 8 per cent for Western Europe, 5.5 per cent for Central Europe, stabilisation for Eastern Europe and no targets for Central Asia. Within Western Europe, national targets will differ considerably as a consequence of the EU burden-sharing policy. It can be concluded that the emissions paths of the Western European and Central European sub-regions will not comply with the Kyoto commitments without additional policies. Eastern European emissions are projected to fall below the Kyoto commitments.

Emissions from transport are projected to grow fastest in all four sub-regions. In Western Europe, the share from transport will increase from 18 per cent in 1990 to 24 per cent in 2010. In all subregions, the share of emissions from power generation is also projected to increase.

Impacts

For analysis of climate-related impacts, emissions from other global regions have also to be taken into account. And because climate change is a slow process with substantial delays, the impacts (i.e. not the policies but the changes in the environment) will be evaluated here using projections that continue up to 2050. For this, a global scenario considered to be consistent with the assumptions and projected emissions trends for Europe and Central Asia has been used. It should be noted that the regional distribution of climate change impacts is beset with larger uncertainties than the difference between the scenarios.

Global mean temperature has increased by 0.5°C over the last century and many examples of changing ecosystems have already been attributed to climate changes. Without alternative policies (the baseline scenario), global temperature is expected to show an increase of 1.2 °C in 2050. This

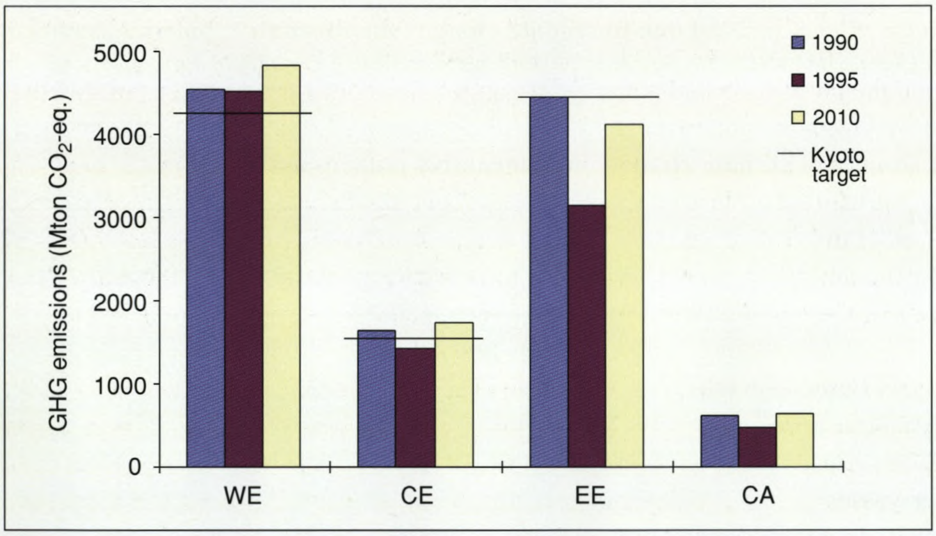


Figure 3.2: Greenhouse gas emissions (excluding forestry and land use changes) under the baseline scenario

The horizontal line indicates subregion's Kyoto target. Under baseline conditions, Western Europe and Central Europe will not meet their Kyoto targets.

[9] The Kyoto targets refer to the average emissions over the 2008-2012 period. For reasons of simplicity, the Kyoto targets are compared here with the expected emissions in 2010.

implies that the change in global temperature in the coming decades will be above 0.1 °C per decade. At this level and rate of change, climate change is expected to have widespread consequences such as sea-level rise and possible flooding of low-lying areas, melting of glaciers and sea ice, changes in temperature and rainfall patterns and changes in the incidence of climatic extremes. As a result of climate changes, about 30 per cent of the area of natural vegetation in Western Europe, Central Europe and Central Asia might be at risk because of climate change (see Figure 3.3 and Table 3.2). For Eastern Europe this could be slightly less. Risk here is defined as change of local climatic circumstances, so that the requirements of the locally present vegetation no longer correspond with these circumstances.

Changes in temperature and precipitation due to climate change may have both a negative and positive impact on crop yield in the region. Table 3.2 gives the tentative results for two main crops – temperate cereals and maize – in terms of areas with increasing or decreasing yield. In both Western Europe and Central Europe a considerable yield reduction is expected for temperate cereals. In contrast, for the combined regions of Central Asia and Eastern Europe, the area where yields increase is larger than the

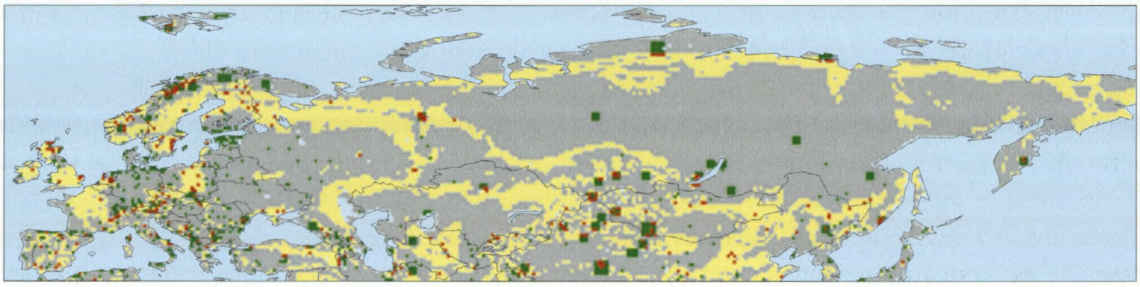


Figure 3.3: Ecosystems at risk in 2050 due to climate change, no alternative policies assumed
Large natural areas in Europe and Central Asia could be impacted by climate change, including several nature reserves.

Table 3.2: Regional impact of climate change, no alternative policies assumed

	2010			2050		
	WE	CE	FSU[10]	WE	CE	FSU[10]
	% relative to 1990 area					
Areas with decreasing yields of temperate cereals	0	0	0	6	2	2
Areas with increasing yields of temperate cereals	0	0	1	0	0	4
Areas with decreasing maize yields	12	0	6	47	1	1
Areas with increasing maize yields	1	0	3	4	0	4
Natural vegetation at risk[11]	10	15	5	32	35	25
Global temperature change (°C)	------- 0.3 -------			------ 1.2 ------		
Sea level rise (cm)	------- 4 -------			------ 17 ------		

[10] Former Soviet Union (FSU) includes both Eastern Europe and Central Asia
[11] At risk: with change in potential vegetation

area where they decrease. For maize, the area in Western Europe where yields decrease is relatively large. Again, increases are expected to dominate over decreases in the combined yield from Eastern Europe and Central Asia in 2050. Table 3.2 also shows the impacts on natural ecosystems.

3.3 Acidification

Acidification has been an important environmental problem within the European region for decades. Forests, soils and freshwater systems in large areas of the region are being damaged by acid deposition, originating largely from man-made emissions of three gaseous pollutants: sulphur dioxide, nitrogen oxides and ammonia. In order to combat transboundary air pollution, many countries in the Western, Central and Eastern European subregions have committed themselves to the Convention on Long-range Transboundary Air Pollution (CRLTAP) and its protocols.

Because the Europe and Central Asia region extends further east than is usual in acidification analysis, model coverage that is both detailed and uniform for the whole region is not available. For this reason, a detailed analysis was done for the three Western subregions, while lower resolution calculation results were used for the region as a whole to show the larger context[12].

Emission trends

In recent years, emissions of sulphur oxides in Western and Central Europe and the part of Eastern Europe west of the Urals have already decreased sharply, in line with the CLRTAP protocols (see Figure 3.4). The same applies to ammonia emissions, under influence of changes in agricultural policy in Western Europe and a reduction of agricultural activity in Central and Eastern Europe. Decreases in nitrogen oxides have been much lower. In Western Europe, serious doubts exist on whether the proposed reduction of 30 per cent in 2000 relative to 1990 can be met – mainly because of increasing emissions from transport (EEA 1998).

In the baseline scenario, it is assumed that current national and international emission reduction policies will be fully implemented (European Union policies, national policies and the current reduction plans in the context of CLRTAP). Under this assumption, emissions of most acidifying compounds are projected to decrease significantly over the 1990–2010 period in Western Europe, Central Europe and the part of Eastern Europe west of the Urals (see Figure 3.4). In Central and Eastern Europe, sulphur dioxide emissions are decreasing by 60 per cent and 40 per cent, respectively, while in Western Europe these emissions are decreasing by 70 per cent. Ammonia emissions decrease by only 10 per cent in Western and Eastern Europe, and even increase slightly in Central Europe. Furthermore, in the part of Eastern Europe west of the Urals nitrogen oxides are projected to increase, compared to the low 1994 level.

The emission path as assumed in the baseline scenario will certainly require considerable effort, especially if transport increases faster than assumed. Box 3.1 discusses a less favourable projection of acidifying emissions in these three subregions.
In order to decrease nitrogen oxide emissions as projected under this scenario, a considerable set of

[12] Two models have been used to assess the trends in acidification under baseline conditions: (1) the IIASA integrated assessment model RAINS (see Alcamo and others, 1990; Amann and others 1997) was used to look in detail at the Western and Central European subregions and the western part of the Eastern European subregion, and (2) outputs of the STOCHEM model (Derwent 1998) were used to estimate the effects in Europe and Central Asia.

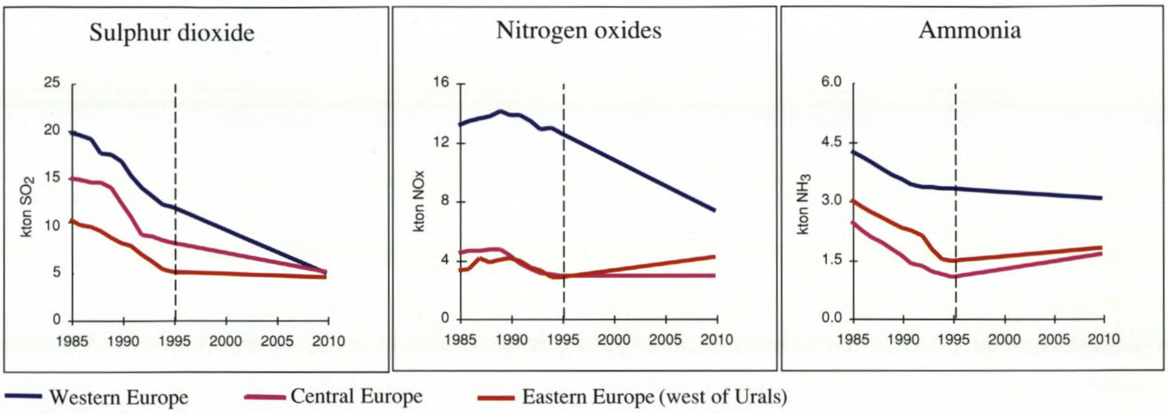


Figure 3.4: Emissions of acidifying compounds in three of the European subregions, no alternative policies assumed

Acidifying emissions are, in general, decreasing under baseline conditions.

Note: Left of the vertical dashed line historical data is used; right the results of scenario analysis.

Source: Amann and others 1997; EEA 1998

measures is necessary in view of the expected growth in the transport sector. The sectoral distribution of acidifying emissions in Western and Central Europe shows that in Central Europe in 1990 energy, industry and households were relatively important causes of emissions while agriculture, forestry and transport were less important than in Western Europe (Figure 3.5). In the 1990–2010 period, in both regions the percentages of emissions from agriculture (ammonia) and transport (nitrogen oxides) are projected to increase.

In Central Asia and Siberia, large sulphur emissions are caused in particular by large metallurgical plants and (low-quality) coal-fired power plants. Large sulphur emissions can be found in Central Siberia around Magnitogorsk, Chelybinsk, the Kansk-Achinsk brown coal basin and the area around the Norilsk metallurgical plant. Norilsk emitted more than 2 million tonnes of sulphur dioxide per year in the late 1980s and is probably the largest source of sulphur dioxide in the world (Mnatsakanian 1992). A similar quantity is probably still being emitted. The emissions in the north and east of Kazakhstan are caused mainly by the use of low-quality coal in power plants. The largest single polluter is the Ekibastus power plant, which in 1992 caused the most air pollution of all power plants in the former Soviet Union (Mnatsakanian 1992).
The scenario assumes no additional control on emissions in Central Asia and Siberia, so that

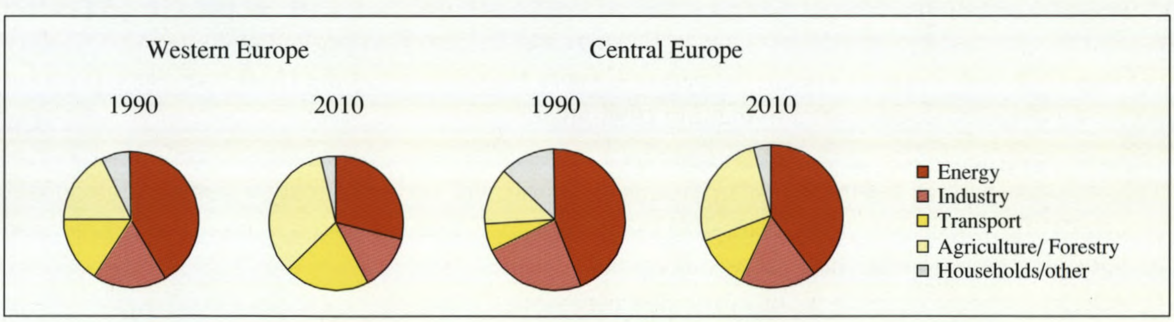


Figure 3.5: Sectoral distribution of emissions of acidifying compounds in Western and Central Europe

In the 1990–2010 period, in both subregions the proportion of emissions from agriculture (ammonia) and transport (nitrogen oxide) are projected to increase.

emissions of sulphur dioxide, nitrogen dioxide and ammonia are all expected to increase slightly in these subregions.

Impacts

In the recent past, the north-western and central parts of the European region were exposed to very high levels of acidifying deposition. In the period 1990–1995, some progress can be observed. In the baseline scenario, further improvement is projected as a result of current policies to decrease acidifying emissions and from changes in energy use and agricultural practices. Nevertheless, many ecosystems will continue to receive acid deposition beyond their critical loads. In Siberia and Central Asia, acidification risks are projected to increase slightly in these subregions.

In Western Europe, despite the emission reductions, around 5 per cent of total ecosystems remain unprotected in 2010 under the baseline scenario (i.e. ecosystems receiving acid deposition beyond their critical loads). For some countries such as the Netherlands, Germany and the United Kingdom, 30 per cent or more of the ecosystems remain exposed to deposition levels exceeding their critical loads. The projected improvements fall short of the objective of the EU acidification strategy to reduce the number of unprotected ecosystems to less than 2.5 to 3 per cent. On average, the situation in the Central European subregion improves more strongly than in Western Europe, going from more than 30 per cent unprotected ecosystems in 1990 to 6 per cent in 2010. Again, the situation may improve less in individual countries such as Poland and the Czech Republic. In Eastern Europe, in 2010 generally only 1-2 per cent of the ecosystem is still exposed to deposition of acidity exceeding their critical loads, compared with 8 per cent in 1990.

By 2010, emissions in the eastern part of Eastern Europe and Central Asia could cause the largest acidification problem in the region. Terrestrial ecosystems in almost the whole of Siberia are relatively sensitive to acidifying deposition, in particular in the Western part. This is mostly due to the semi-permafrost, limiting the ability of the soil layer to recover from stress. In contrast, soils in Central Asia are not very sensitive to acidification.

Emissions from power plants and metallurgical plants in Norilsk (Central Siberia) currently already affect taiga and tundra ecosystems for many kilometres around the plants. If uncontrolled, emissions

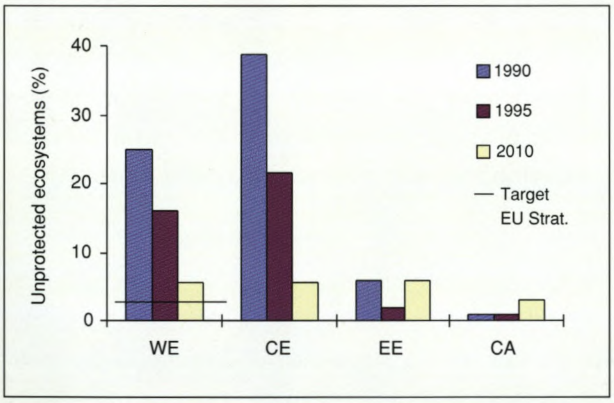


Figure 3.6 Ecosystems exposed to deposition of acidity exceeding their critical loads, no alternative policies assumed

Acid deposition on ecosystems decreases further in Western, Central and Eastern Europe, but still a large share of the ecosystems remains insufficiently protected.

Source: Amann and others 1997; Bouwman and van Vuuren 1999

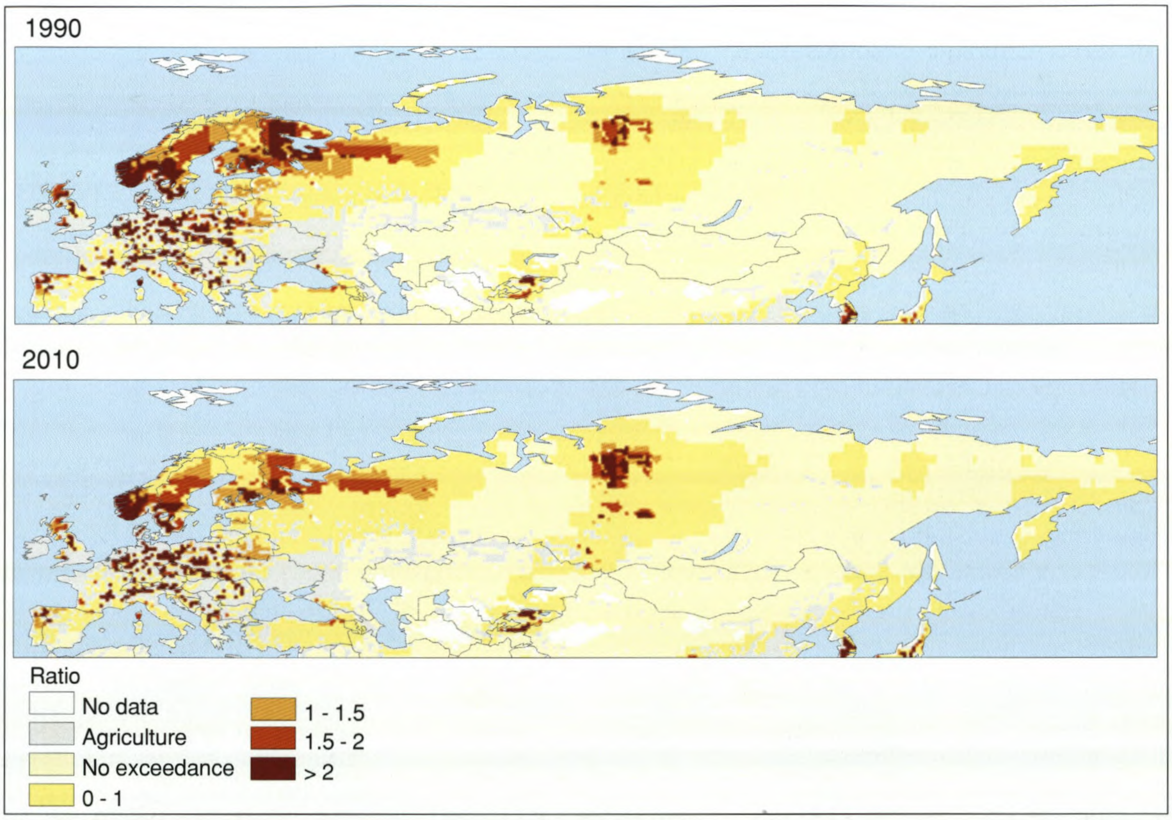


Figure 3.7: Ecosystems exposed to deposition of acidity exceeding their critical loads, no alternative policies assumed

In 2010, still a large share of ecosystems in northern and central Europe will be exposed to acidification – while the situation in central Siberia is expected to become worse.

Note: Figure shows the ratio between deposition and critical load.

Source: Bouwman and Van Vuuren 1999

are expected to increase along with increasing energy consumption. In that case, sulphur deposition in this part of the Europe and Central Asia region could get drastically worse. As a result, acidification risks are projected to increase under the baseline scenario as indicated in Figure 3.7 (see Bouwman and van Vuuren 1999).

Thus, under the baseline scenario the impacts of acidification are considerably reduced in the area west of the Urals, although they will certainly not have disappeared completely. In Central Asia and Eastern Europe acidification will become worse, assuming no new policies to control emissions.

3.4 Summer smog

Periods with photochemical smog (summer smog) occur over a large part of Europe every year. Summer smog causes respiratory problems and can cause damage to vegetation and materials. A key smog oxidant is ozone. The main causes of this type of smog are emissions of nitrogen oxides and volatile organic compounds. The components of summer smog have atmospheric residence times of several days or more and can therefore easily be transported over distances of more than 1000 km. The UN-ECE Convention on Long Range Transboundary Air Pollution (CLRTAP) adopted

Box 3.1: Less successful decrease of emissions

In the baseline scenario, we have assumed full implementation of national and international policies regarding acidifying emissions. However, implementation of these policies is certainly not straightforward, as discussed in section 3.1. Alternatively, it could be assumed that countries only implement the internationally agreed upon targets of the Current Reduction Plans. This means larger emissions than in the baseline scenario and consequently a much larger share of ecosystems remaining unprotected against acidification (Figure 3.8). In addition to less strict implementation of current policies, increased traffic and the resulting increase of nitrogen oxide emissions could result in less favourable development than assumed under the baseline scenario.

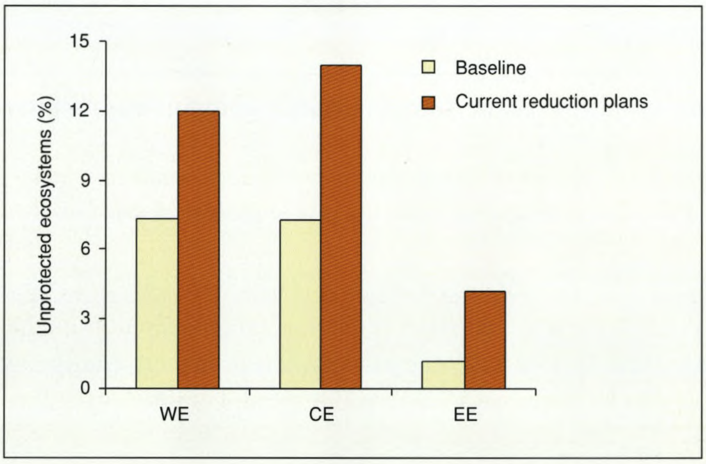


Figure 3.8: Ecosystems exposed to deposition of acidity exceeding their critical loads, baseline scenario versus current reduction plans
Less optimistic assumptions regarding the implementation of policies 'in pipeline' lead to significantly less improvement than assumed under the baseline.

Calculations using the RAINS model indicate that under Current Reduction Plans the improvement in share of ecosystems protected against acidification could be significantly less than under the baseline scenario. The calculations in fact indicate that only very limited improvement is made in comparison to the situation in 1995. In Western Europe and Central Europe still more than 10 per cent of the ecosystems will be exposed to levels higher than their critical load.

agreements on nitrogen oxides and non-methane volatile compounds in 1988 and 1991, respectively.

A relatively detailed analysis of tropospheric ozone concentrations of the baseline scenario (i.e. without alternative policies) is available for the part of the European region west of the Ural mountain range (Amann and others 1997). Some comments for the other subregions are made on the basis of a study by Stevenson and others (1998).

Emissions trends

In the baseline scenario, smog-causing emissions (in particular, non-methane volatile compounds and nitrogen dioxide) are assumed to decrease significantly in Western Europe, Central Europe and the western part of Eastern Europe over the whole 1990–2010 period, in agreement with reduction targets under the CLRTAP. Emission projections for non-methane volatile compounds are indicated in Figure 3.9, while emissions of nitrogen oxides have already been shown in the section on acidification.

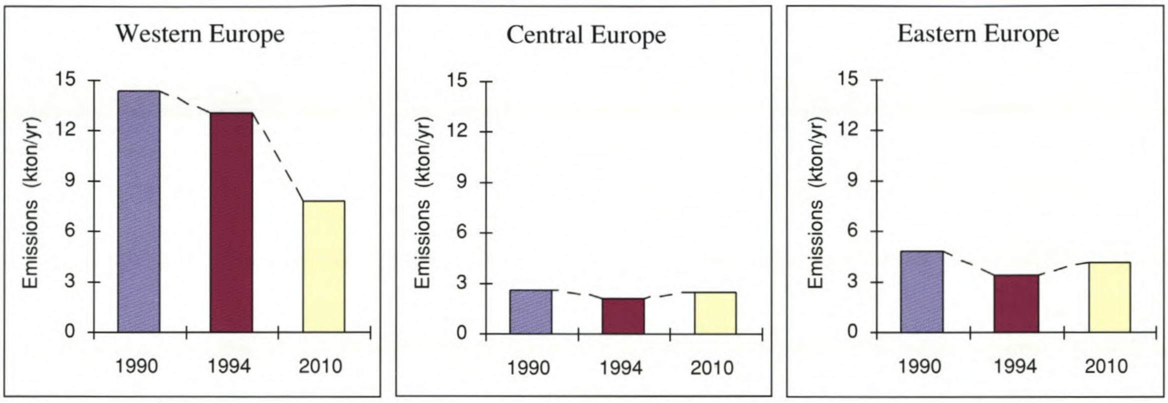


Figure 3.9: Emissions of non-methane volatile organic compounds, no alternative policies assumed

Under the baseline scenario, emissions of non-methane volatile compounds (a summer smog precursor) in 2010 are significantly decreased in Western Europe but less so in Central and Eastern Europe.

Source: Amann and others 1997

So far, progress towards achieving emission-reduction targets for non-methane volatile organic compounds has been mixed. In 1990–1994, emissions fell in Eastern Europe by about 30 per cent. At the end of the 1990's both Central and Western Europe still emitted 80-–90 per cent of their 1988 emissions.

For the baseline scenario (without alternative policies) it is assumed that emissions in Western Europe are further decreased. Emissions in Central Europe and Eastern Europe, however, are expected to increase again as a result of economic recovery. In 2010, emissions levels in these two subregions will be 2 per cent and 15 per cent less than 1990 emissions, respectively.

Impacts

As an indicator for summer smog impacts, the time-weighted ozone concentration exceedence of the 0.06 ppm eight-hour average level is used, corresponding to revised WHO air quality guidelines for Europe. The long-term goal would be to eliminate all exceedences of this level after 2010. In the current study, this has been applied to the background concentration of ozone; i.e. outside cities[13]. The choice of this indicator and this scope has the advantage that uniform information is available for all four subregions, allowing easy comparison. However, it has to be noted that the exceedences quoted cannot be used directly for evaluating risks to human health or vegetation, although trends will generally be in the same direction[14]. Obviously exceedence of the 0.06 ppm level implies that the 0.04 ppm standard (used to prevent risks for natural vegetation and crops) will still be regularly exceeded.

Under the assumption that emissions outside Europe remain constant, implementation of policies currently in place or in the pipeline (i.e. the baseline scenario) should substantially reduce the exposure of the population to summer smog. However, health risks are not eliminated. The average

[13] Ozone concentrations within cities may differ from the background concentration as a result of the complex chemistry of summer smog.

[14] For evaluating population health risks, exceedence in the individual cities of the 0.06 ppm eight-hour average should be used, taking the atmospheric chemistry characteristics of the individual cities into account. This usually shows lower exceedences than in the background. For evaluating risks of damage to natural vegetation and crops, exceedence of the 0.04 ppm level is the usual indicator. The concentrations of summer smog components, particularly their peak values, vary considerably from year to year. Also the spatial distribution differs considerably between years.

exposure of a person in Western Europe decreases by 55 per cent between 1990 and 2010. High exposures in 2010 remain in Belgium, the Netherlands, Luxembourg, Germany and France (1.7-3.3 ppm.hours). A similar reduction should occur in Central Europe. In this subregion the highest remaining exposures in 2010 are found in the Czech and Slovak Republics and Hungary (1.0-1.1 ppm.hours). In Eastern Europe the overall exposure in 1990 was significantly lower and under baseline conditions improves by 35 per cent.

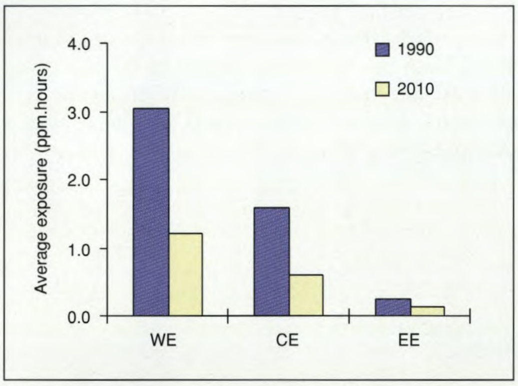


Figure 3.10: Ozone exposure exceeding the 0.06 ppb eight hour average, no alternative policies assumed

Exposure to summer smog exceeding air quality is likely to decrease under the baseline scenario. But health risks will not be eliminated by 2010.

RIVM and others 2000

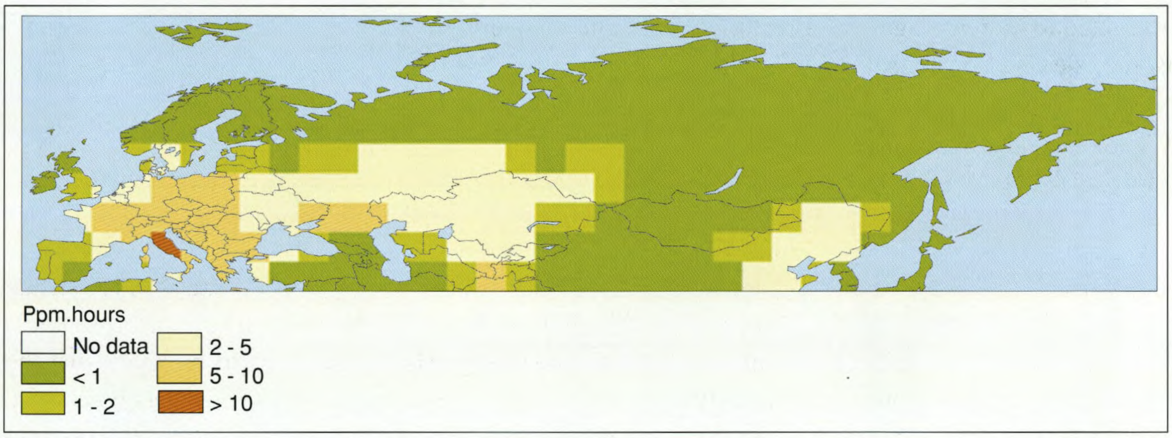


Figure 3.11: Population exposed to summer smog concentrations in 1992 exceeding the 0.06 ppb eight hour coverage according to the STOCHEM model

Although ozone concentrations in Western and Central Europe are much larger, models indicate that in Central Asia and some areas of Eastern Europe threshold values to protect human health can also be exceeded.

Note: Figure 3.11 is based on an atmospheric chemistry model and not on actual measurement. The actual summer smog situation and trends in the Region are uncertain, in particular east of the Urals.

Source: Derwent, 1998; Stevenson and others, 1998

Surface ozone concentrations in Siberia are small compared to the western part of the region (Figure 3.11). Ozone surface concentrations in Central Asia are between these two levels. It should however be noted that the results of this calculation are beset with uncertainties and need to be checked further against actual measurement data. Under the assumptions of the baseline scenario, ozone concentrations in Central Asia and Eastern Europe are thought not to decrease.

Box 3.2: Alternative scenarios for summer smog

In the baseline scenario, we have assumed full implementation of national and international policies regarding nitrogen oxides and volatile organic compounds. Several factors could lead to higher summer smog levels than assessed under the baseline scenario. First of all, it could be assumed that countries only implement the internationally agreed targets of the Current Reduction Plans, while emissions of volatile organic compounds are stabilised slightly above the 1990 level. In addition, we could assume a significant increase in emissions outside the European and Central Asia region – in particular in other parts of Asia. Figure 3.12 shows the result of such alternative assumptions. It should be noted that the findings for Eastern Europe and Central Asia are particularly uncertain, due to lack of measurements. Nevertheless, the model results indicate that in the parts of the region west of the Urals internal smog production decreases only just enough to balance the increase in smog input from the rest of the world. In other parts of the Region – in particular Central Asia – smog concentration would increase significantly under these alternative assumptions. A rapid increase in traffic is one factor that plausibly could result in less favourable developments than assumed under the baseline scenario.

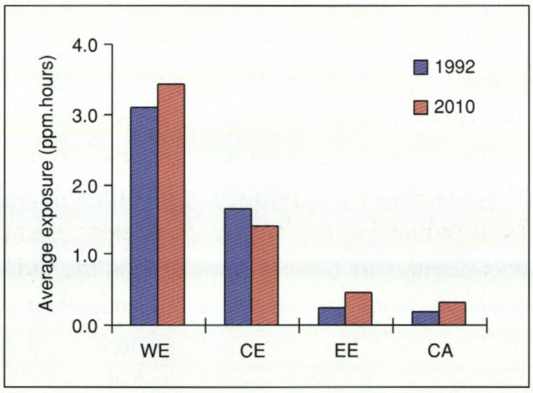


Figure 3.12: Ozone exposure, less favourable baseline assumptions

If emissions decrease less drastically – and emissions increase significantly outside the Region – ozone exposure is likely to remain high.

Based on Stevenson and others 1998

3.5 Urban air quality

More than two-thirds of the population of the European Region lives in urban areas. Unfortunately, air pollution is still a prominent problem in many cities in the region, despite some success in reducing certain pollutants. Recently, the European Environment Agency indicated that in Western Europe the dominant sources of air pollution are now motor vehicles and the combustion of gaseous fuels, while previously these were industrial processes and high-sulphur fuels. Along with this shift, also the type of air pollution has changed. In contrast, Central and Eastern Europe and Central Asia, industrial activities and electricity production are still the most dominant sources of air pollution – but also here the contribution of transport is growing rapidly. In this section, we will discuss the situation with regard to urban air pollution in the Region – in particular using calculations for the largest European cities (> 750,000 inhabitants) west of the Urals following the baseline scenario. For the subregions east of the Urals no overall assessment could be made due to lack of consistent data, and here anecdotal material has been used.

Until the beginning of the 1980s, the dominant source of atmospheric pollution in European cities was the combustion of high-sulphur fuels. Thanks to the increased share of low-sulphur fuels and the successful implementation of measures to reduce sulphur dioxide emissions, average sulphur dioxide concentrations have been reduced considerably in Western Europe. In the other European subregions, this shift is more recent and sometimes induced by falling industrial output. In 1990, gas treatment facilities had been only installed in a minority of industrial plants in cities in Eastern Europe – and consequently health guidelines were exceeded in several cities. At the moment, the long-term air quality guideline is still exceeded in a number of cities in Central and Eastern Europe and Central Asia but the problem is becoming more localised. According to available data, sulphur dioxide levels are on average not very high in cities in Central Asia, but can in some cities reach higher levels. Moreover, there was little evidence of a decline in time (Hertzman 1995). It can therefore be assumed that the situation has not changed much since then.

Exposure to particulate matter may be the largest problem in all subregions as far as direct effects for human health in cities are concerned. Although industrial emissions have decreased in Central and Eastern Europe, domestic space heating is still an important source of emissions. As a result, in almost all cities considered in this study the population is exposed to particulate matter concentrations of public health significance. Particulate matter also seems to be the main source of air pollution in Central Asia in particular from burning low-quality coal and automotive sources (Hertzman 1995; Mnatsakanian 1992).

Lead concentrations in Western Europe have dropped sharply since 1985 and are now well within the air quality guidelines in most cities, mostly thanks to the introduction of lead-free fuels. Lead concentrations in the Central and Eastern European and Central Asian subregions vary. In some cities very high levels – exceeding WHO air quality guidelines – can be associated with increased traffic (leaded fuels) and metallurgic activities. Thanks to the introduction of lead-free fuels, concentrations in other cities show a downward trend.

In many urban areas, especially in Western Europe, nitrogen oxide emissions from stationary sources such as power plants have decreased. Although nitrogen oxide emissions from traffic – at least in Western Europe – have been pushed back by the market penetration of catalytic converters and legislation for diesel engines, there are already signs that this is being nullified by increased traffic. Nitrogen oxide concentrations are high in cities of Central Europe, Eastern Europe and Central Asia, in particular near industrial areas.

Nitrogen oxide emissions contribute to the formation of tropospheric ozone, as discussed in the previous section. Currently, peak values of nitrogen oxides during episodes in many Western European cities exceed the short-term WHO air quality guideline levels (EEA 1995) and the concentrations show no clear downward trend. High hourly values above 360 µg/m3 were observed in some Mediterranean cities during recent years.

Other important urban air pollutants are benzene, poly-aromatic hydrocarbons such as benzo(a)pyrene, and heavy metals. Table 3.3 shows average concentrations.

Table 3.3: Average ambient concentration of air pollutants in cities, assuming no alternative policies

	NO_2		Benzene		PM_{10}		SO_2		B(a)P	
	1990	2010	1990	2010	1990	2010	1990	2010	1990	2010
	$\mu g/m^3$									
Western Europe	56	40	8	3	43	31	213	74	3	2
Central Europe	67	66	29	8	75	58	518	350	6	6
Eastern Europe	53	37	8	3	54	39	480	220	5	3
Central Asia	.	.	.	.	63	.	180	.	.	.

Note: Based on measurements and model results. B(a)P: benzo(a)pyrene. Heavy metals not included.

Table 3.4: Average exceedence of WHO or EU air quality thresholds, assuming no alternative policies

	NO_2		Benzene		PM_{10}		SO_2		B(a)P	
	1990	2010	1990	2010	1990	2010	1990	2010	1990	2010
	% of urban population									
Western Europe	81	40	51	4	73	52	79	8	71	56
Central Europe	97	91	79	46	98	94	73	60	97	96
Eastern Europe	87	24	85	0	96	81	73	48	100	96
Threshold	*40 $\mu g/m^3$*		*5 $\mu g/m^3$*		*30 $\mu g/m^3$*		*24 $\mu g/m^3$*		*1 ng/m^3*	

Note: Based on measurements and model results.
Source: Eerens and others 2000

Aggregated statistics for the exceedence of WHO or EU threshold values for cities in the Western, Central and Eastern European subregions are presented in Table 3.4. Figure 3.13 shows the total share of the urban population exposed to levels above the WHO air quality guideline for at least one pollutant. Under the baseline scenario, the situation improves considerably in the 1990-2010 period. However, in 2010 in Western Europe still a third of the population remains exposed to levels above the WHO air quality guideline, and in Central and Eastern Europe even more than half the population.

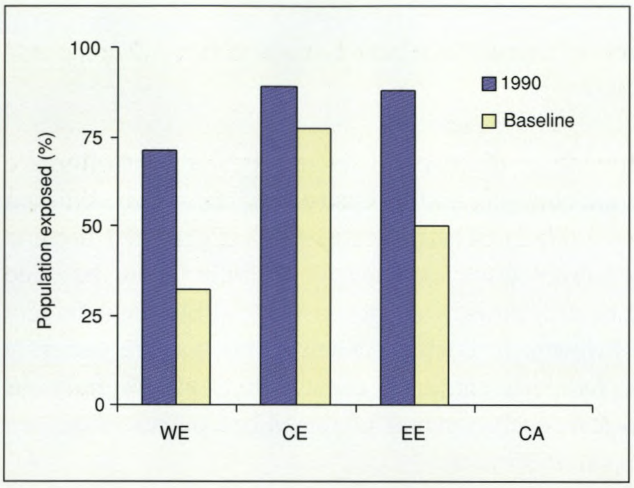


Figure 3.13: Urban population exposed to pollutants exceeding WHO or EU air quality guidelines
In 2010, still a third to half the urban population is exposed to pollutants exceeding health guidelines.
Note: Central Asia has not been included due to lack of data.
Source: Eerens and others 2000

3.6 Nuclear risks

Nuclear power generation does not contribute to the environmental impacts discussed in the preceding sections. However, the accident at the nuclear power plant in Chernobyl in 1986 has shown that large-scale accidents with nuclear power plants can lead to contamination across almost an entire continent. This section focuses on the excess cancer death risks associated with the generation of electricity in existing nuclear power plants, in particular risks from accidents involving release of radiation.

It should be noted that in some parts of the region potential environmental impacts of nuclear power generation outside the scope of this study could be more relevant. These other risks include those associated with storage of nuclear waste and the risks of accidental releases in types of installations other than the power plants themselves (especially for fuel enrichment and recycling of fuel). Obviously, nuclear accidents can occur at a wider range of installations than the power plants considered here, such as military and medical facilities and research institutions[15].

In order to estimate the risks of possible accidental releases from nuclear power plants in Europe, a risk assessment was made for all European power plants larger than 50 MW that were operating in 1992 and 1996 (213 power plants) (Stoop and others 1998; Slaper and Blaauboer 1995; Slaper and others 1994)[16]. In terms of risks, the early nuclear power plants of Russian design (like the LWGR and WWER-440 V203) have been classified as the most hazardous in terms of probability of accidents with significant releases of radioactivity. Subsequently, exposure and excess cancer death

[15] For example, the risks of nuclear-powered submarines dumped or sunk north of the coast of the Russian Federation (see e.g. IAEA 1997) or the various nuclear testing sites have not been included in this energy oriented analysis. However, these risks can not be ignored in a comprehensive assessment of nuclear risks in Europe - which our analysis is not.

[16] The nuclear power plants have been categorised according to major (safety) characteristics and operational features into a small number of risk types.

risks as a result of the excess doses received over a lifetime have been calculated for a large number of receptor locations (see appendix 1 for details).

In the 2000--2010 period, several factors influencing the risks of nuclear power generation are expected to change. Several new power plants are currently under construction and will be finished by 2010, while some existing power plants will have reached the end of their expected lifetime before 2010. Figure 3.14 shows the projected changes in nuclear capacity according to the baseline scenario (see also appendix 1). The decline in nuclear power capacity in Western Europe is largely caused by the assumed nuclear phase-out in Sweden. In contrast, when plants that are currently under construction or ordered are taken into account, nuclear power capacity in Central Europe and Eastern Europe is expected to increase. Simultaneously, several of the oldest power plants are assumed to be closed after a commercial life span of 35 years.

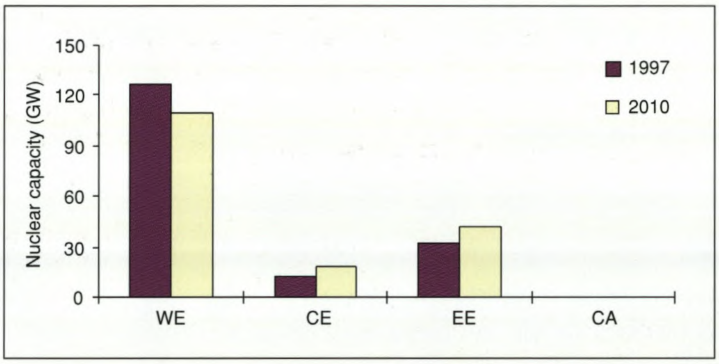


Figure 3.14: Capacity of nuclear power plants, no alternative policies assumed
Capacity of nuclear power in the baseline scenario declines in Western Europe, and increases in Central and Eastern Europe.
Source: Slaper and Stoop 1998

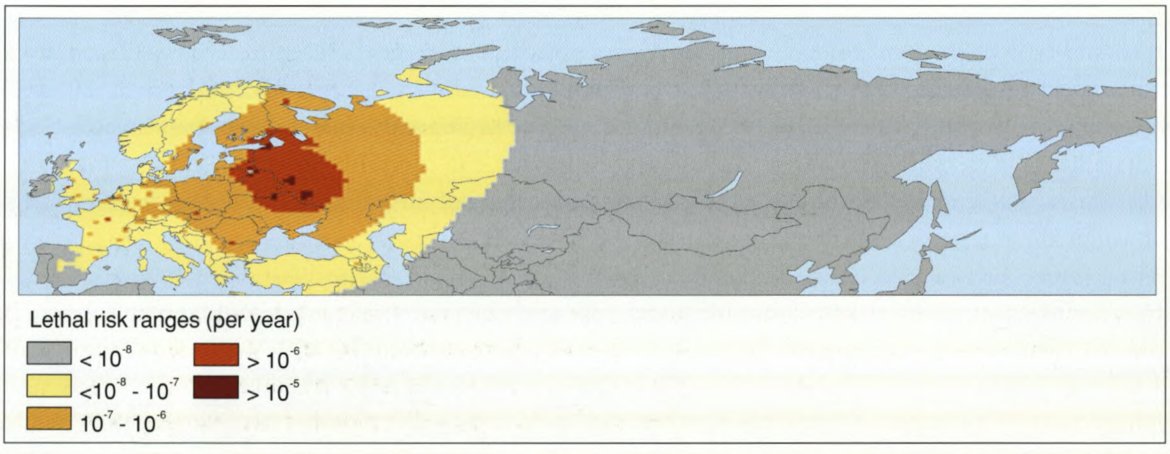


Figure 3.15: Excess risks of cancer deaths due to accidents in nuclear power plants in 1996
Risks are highest in Central Europe and the western part of Eastern Europe.
Source: Slaper and Stoop 1998

In addition, the risks of nuclear power generation will also be influenced by changes in management and safety. International and Western European organisations such as IAEA and the European Union have started risk management programmes to help improve the management and construction of power plants in Central Europe and the Former Soviet Union. On the other hand, organisation and management in the nuclear power sector in Eastern Europe and Central Asia have been hit hard by the economic recession and political changes. The actual impacts of these opposing trends are difficult to quantify and highly uncertain. Taking the balance, no major changes have been assumed in management and safety of existing plants in the baseline scenario.

The estimated excess death risk shows a large variation over Europe (see Figure 3.15). In Western Europe the excess death risks in 2010 are projected to be relatively low, on average 6.5 x 10^{-8}. Variation is high, ranging from less than 1 x 10^{-8} per year in Iceland and the south-western parts of Spain and Portugal to 10–20 x 10^{-8} in Germany, Austria, Sweden, the Netherlands and Belgium. The highest average risk in the subregion is found for the Finnish population. For the subregion as a whole, at least 40–50 per cent of the overall 2010 risk level is determined by reactors in Central and Eastern Europe.

Risks in Central Europe are projected to stay considerably higher than in Western Europe. The average risk for the Central European population under the baseline scenario in 2010 will be 21 x 10^{-8}, slightly below the average risk level for this subregion in 1992. Comparatively high risks are found in the Baltic States, where excess risks reach a level of over 100 x 10^{-8} per year.

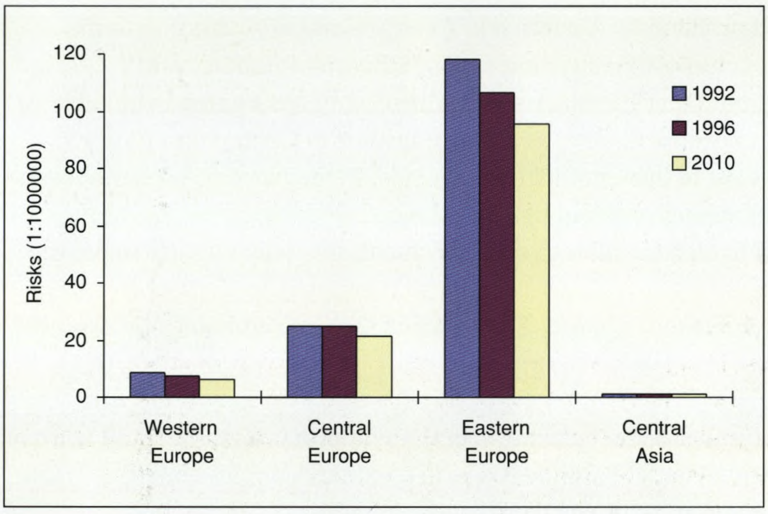


Figure 3.16: Average excess risk for cancer deaths due to accidents in nuclear power plants, no alternative policies assumed
Risks are highest in Central and Eastern Europe.
Source: Slaper and Stoop 1998

Comparatively high risk levels are also projected for large areas of Eastern Europe, including the western part of the Russian Federation, Ukraine and Belarus. In these countries a risk of 1000 x 10^{-8} is exceeded in the smaller regions around the nuclear reactors. Since the western part of the subregion is also the most densely populated part, the average excess risk for Eastern Europe is relatively high, about 106 x 10^{-8} in 1996, and, under the baseline scenario, about 96 x 10^{-8} in 2010. The highest risks are found for the population of Belarus. Risk levels decrease between 1992 and 2010 because several of the oldest nuclear power plants in the subregion are assumed to be closed down.

The risk level in Central Asia is currently very low on average and is expected to remain low, thanks to the low number of nuclear power stations in the region. The average excess risk found for the region in 2010 is 1×10^{-8}.

3.7 Main findings

Figure 3.17 summarises for each of the four subregions how environmental impacts develop under the baseline scenario. The plots show the values for each indicator relative to the highest level in any of the subregions. The following observations can be made.

- For climate change, greenhouse gas emissions increase between 1990 and 2010 in Western Europe, are almost stable in Central Europe and decrease in Eastern Europe and Central Asia. The Kyoto targets for Western Europe and Central Europe will not be met under the baseline scenario. If the developments in the baseline scenario are extended to 2050, many ecosystems within the region will suffer from climate change.
- For acidification, fewer ecosystems in Western and Central Europe and the western part of Eastern Europe will be exposed to deposition exceeding their critical loads. However, the objective of the EU acidification policy will not be met. In Siberia a larger proportion of the ecosystems will be exposed.
- Summer smog is, in particular, a problem in Western and Central Europe. According to the baseline scenario, the situation could significantly improve if all current policies are implemented; however, this will not meet EU targets. The situation in the Region could also become worse as a result of the expected rapid increase of transport in Central and Eastern Europe and as a result of an increase in background ozone levels. In the baseline scenario, ozone is expected to become an environmental problem in Central Asia.
- Urban air pollution is a problem in all four subregions; this situation is only slightly improved under baseline conditions.
- Nuclear risks are highest by far in Eastern Europe. The baseline scenario embodies no essential improvement.

Thus, although the environmental situation in general seems to improve slightly if all current environmental policies are implemented under baseline scenario conditions, improvement is in most cases not sufficient to meet the existing environmental targets. It should be noted that in the baseline scenario we have not included the environmental effects of accession of Central European countries to the EU. In Box 3.3, a qualitative assessment is made of the potential impacts.

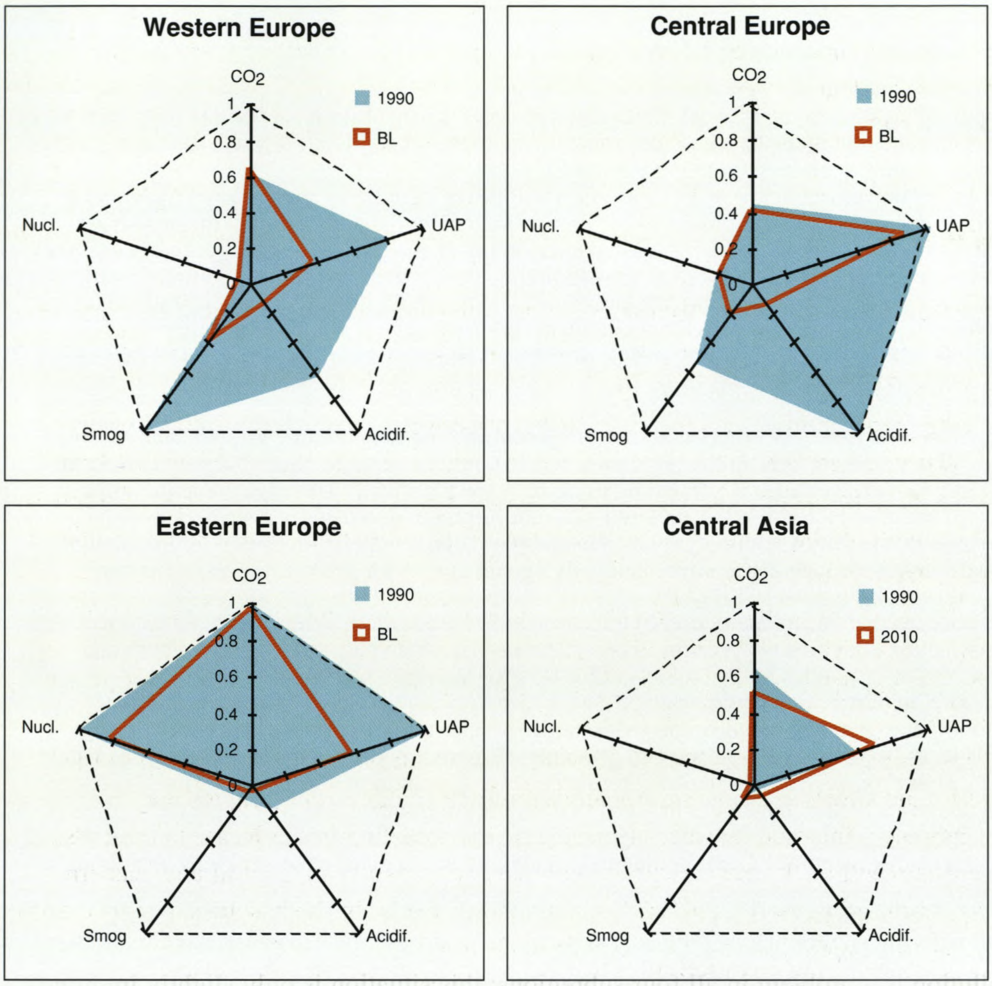


Figure 3.17: Overview of environmental impacts without alternative policies

Note:

- The plots show the values for each indicator relative to the highest levels in any of the subregions and time periods (=1.0).
- Climate Change (CO_2): Carbon dioxide emissions per capita
- Urban Air Pollution (UAP): Share of population exposed to nitrogen oxide levels exceeding WHO air quality guidelines
- Acidification (Acidif.): Share of ecosystems exposed to acidifying deposition exceeding critical loads
- Summer smog (Smog): Average time-weighted exceedence of the 0.06 ppm eight-hour average level by ozone background concentration.
- Nuclear (Nucl.): Average risk per person due to potential nuclear accidents in power plants

Box 3.3: Environmental impacts of EU Accession

The consequences of accession of Central European countries to the European Union have not been specifically taken into account in the baseline scenario. However, the OECD High-Growth scenario could be interpreted as the economic scenario coming closest to EU accession.

- Obviously, an important consequence of EU accession will be an increase in international trade and a growth in average distances between phases in the production chain; together this will mean a sharp increase in transport across Europe. This increase comes on top of the growth in transport resulting from normal economic development. Such a strong growth in transport is likely to put an additional burden on the environment with respect to carbon dioxide emissions, and those of nitrogen oxide and volatile organic compounds. New infrastructure, which will inevitably accompany increased transport, might lead to additional impacts. Environmental impacts will be distributed unevenly over Europe and will be most serious where concentrated traffic flows cross fragile or already heavily burdened environments, such as the Austrian Alps, fragile coastal zones and city centres.
- Accession might have indirect environmental effects by contributing to economic growth. The assumed growth rate of 3.3 per cent per year in the baseline scenario could increase to about 5.0 per cent per year if the OECD High Growth scenario is something to go by – see Chapter 2. The environmental impacts of economic growth are always ambiguous: pollution per unit of production usually decreases but total pollution increases as a result of volume growth. This, in particular, could be important to the required effort in Central Europe for meeting the internationally agreed targets for greenhouse gas emissions (Kyoto) and acidifying emissions (CLRTAP).
- There is some concern that during the period of transition to EU legislation, accession might lead to a shift in polluting production activities towards the accession countries. A first assessment of such effects, however, shows this to be studies looked mainly at the level of industrial sectors, they cannot rule out some industrial migration in terms of technologies.
- Positive environmental impacts may be expected in terms of upgrading environmental standards and practices to EU levels in accession countries. In principle, all items should be implemented immediately upon accession. However, transitional periods are likely to be agreed upon. Furthermore, there is concern that accession countries in their eagerness to reach the 'acquis communautaire' will leave themselves no room for sound priority-setting and for weighing the EU regulation against other options. In total, the required investments for meeting EU environmental regulation are assessed at several tens of billions of US dollars.
- Convergence of energy efficiency in accession countries towards EU levels could result in a large contribution to reducing environmental pressures in parts of Central Europe. However, this is considered to be more of a gradual effect of accession rather than the result of enforcement of common EU policy (Cofala and others 1999).

At present, it is difficult to quantitatively indicate the environmental consequences of accession that would include the effect of EU regulation, changes in Western Europe and EU policies, as well as the application of EU regional funds. For greenhouse gases, the overall result could likely represent an increase of emissions (assuming no new climate policies). In contrast, traditional environmental issues like acidification and air pollution by sulphur dioxide and particulate matter might benefit. For environmental problems related to transport, including summer smog, an increase of environmental pressures can be expected.

4. CONSEQUENCES OF THE BASELINE SCENARIO FOR PUBLIC HEALTH AND BIODIVERSITY

The projected changes in the state of the environment for the five environmental problems described in the previous chapter are likely to impact on both public health and biodiversity. In this chapter we will briefly discuss both. This discussion will demonstrate that while public health and biodiversity are influenced by energy-related environmental factors, their development over time is inextricably linked with many changes in the region. The chapter will discuss the potential consequences of the environmental changes in this context and, in doing so, will allow exploration of both the need and scope for alternative policies.

4.1 Public health

The background: large-scale transitions

Since the middle of the nineteenth century public health status has improved enormously, particularly in the established market economies. For instance, in Western Europe life expectancy doubled in this period from around 35 to almost 80 years. The survival curves in Figure 4.1, which are typical for Western European countries, show this gain in life expectancy to be initially due largely to a reduction in infant mortality (associated with a reduction of incidence of communicable diseases).

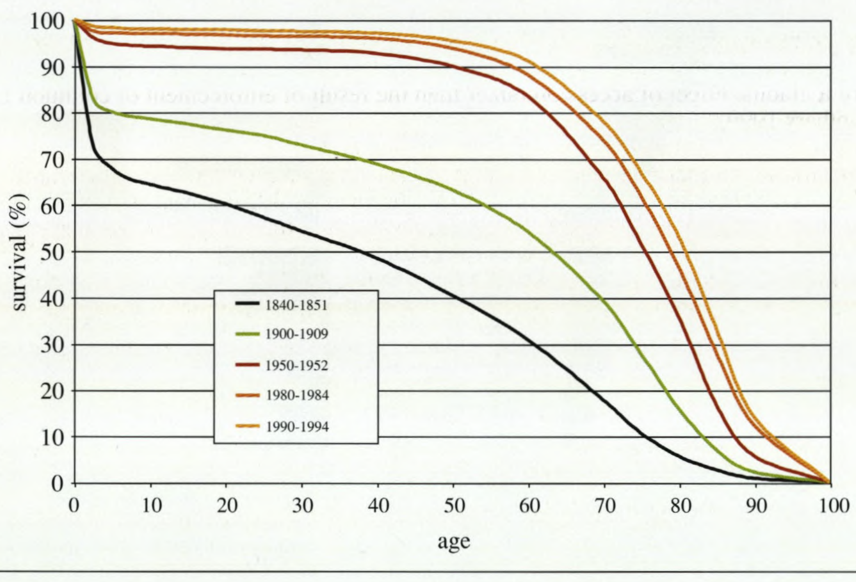


Figure 4.1. Typical Western-European survival curves

The gain in life expectancy in Western Europe over the last century is largely due to a reduction of infant mortality between 1840 and 1950.

Note: based on data for The Netherlands

Source: Ruwaard and Kramers 1998)

The development of life expectancy in high-income regions such as Western Europe is reflected in the differences in disease burden between high- and low-income regions in the world as shown in Figure 4.2 (WHO 1997; WHO 1999, Smith and others 1999). The differences between the left and right part of this figure can be explained by the general observation that as populations move from pre-industrial, agricultural to (post-)modern societies they go through a *health transition*, consisting of an *epidemiological* and a *fertility* transition. First, disease burden shifts from environmentally related infectious diseases at younger ages to chronic diseases at older ages, extending life expectancy. This shift is followed by a *fertility* transition drastically reducing the number of births brought about by the 'modernisation of society' (e.g. women's education, material security and reduction of social-economic inequity) (Wilkinson and Marmot 1998).

Figure 4.2 shows that in the low and middle-income regions infectious diseases such as acute respiratory diseases and diarrhoea (primarily affecting the very young) still substantially dominate disease burden. In contrast, chronic degenerative diseases prevail in high-income regions. Of course these different disease patterns are reflected in life expectancy: 77, 66 and 51 years for high-, middle- and low-income regions, respectively (UNDP 1999). To a large extent the health transition can be explained by a better management of environmental factors, such as the availability of safe drinking water and food, well-controlled public hygiene and more adequate housing. Furthermore, an important contribution to good health is made by an improved system of health regulations with respect to, for instance, food quality, drinking water and occupational and environmental conditions. At the national level, social-economic development, higher levels of education, reliable governmental practice, and ultimately medical technology have created favourable conditions for major improvements in public health in Western Europe (Ruwaard and Kramers 1998).

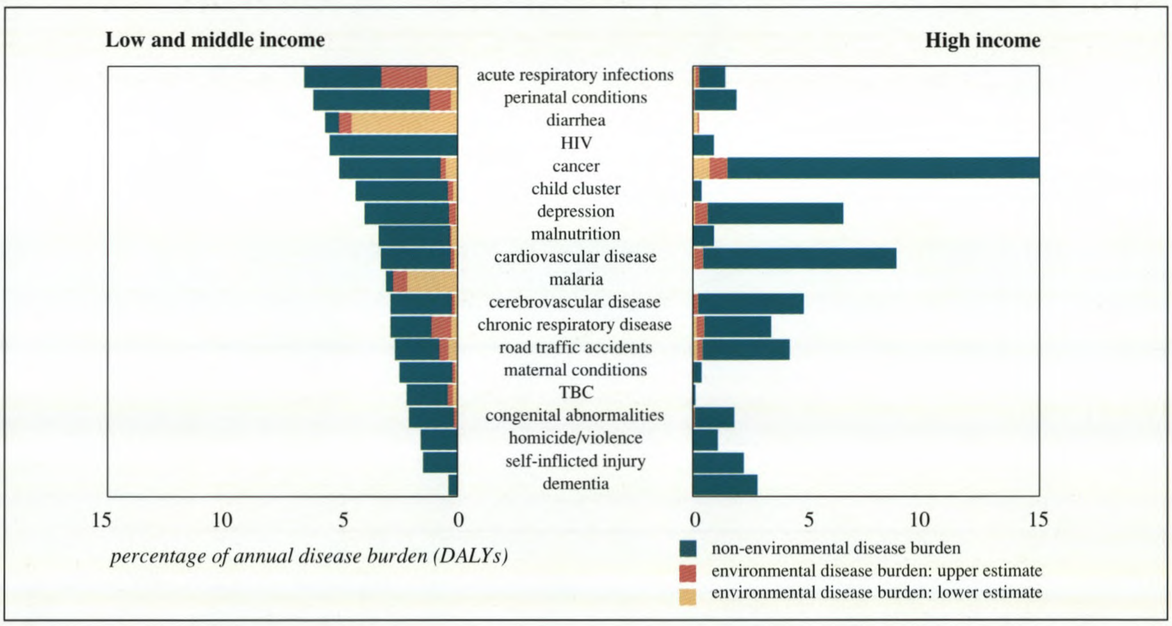


Figure 4.2: Pattern of disease burden in middle and low-income versus high-income regions of the world, 1998

In the low and middle-income regions, infectious diseases dominate disease burden, while chronic degenerative diseases prevail in high-income regions.

Note: Disease burden was measured in loss of disability adjusted life years (DALYs), an aggregate that combines years of life lost altogether and years lived with disease or disability, standardised by means of severity weights. Important environmental factors are housing (e.g. indoor air pollution), sanitation, (microbiological) quality of drinking water and food, urban air pollution, hazardous chemicals, radiation, spatial planning, existence of disease-vector habitats and land degradation.

Source: WHO 1997; WHO 1999 and Smith and others 1999; compiled by RIVM

While in the general health transition the *traditional* environmental risk factors are gradually reduced, they may become 'substituted' by *modern* environmental risk factors, such as the chemical, physical or biological pollution of urban air, water and soils. However, if risks are managed well, the health impact of these 'modern' risks is probably far less serious, both in nature and magnitude. Eventually large-scale environmental disturbances, such as land degradation, water stress and climate change may lead to resurgence of traditional health risks, e.g. vector-borne infectious disease and natural disasters (WHO 1997).

Differences in the European region in the context of the health transition
Figure 4.3 shows trends in life expectancy in the European subregions between 1970 and 1995. In Central and Eastern Europe the health transition started later and advanced slower than in Western Europe. Only after the Second World War did life expectancy in the former catch up somewhat but a gap of several life years remained. East -West differences in survival rates increased again after 1960. This is probably largely due to unfavourable developments in lifestyle factors, such as smoking, alcohol use and dietary patterns. Differences in health services, and occupational and environmental conditions account for another, relatively small fraction of the gap of probably less than 10 per cent (Hertzman and others, 1996).

After the radical political and economic changes in Central and Eastern Europe, and Central Asia, the public health gap widened even further around 1990 (Figure 4.3). Life expectancy remained constant or even decreased, especially in Eastern Europe, where life expectancy dropped from almost 70 years in 1985 to 66 in 1998. According to available data such a dramatic drop in life expectancy did not occur in Central Asia, but it should be noted that these data are beset with uncertainties. Several analyses point at disruption of the social environment as the main cause. This is manifest through lack of social cohesion, lack of subsistence, material or job insecurity, social exclusion and huge social-economic inequities (Hertzman and others 1996, Wilkinson 1997, Pearce 1996).

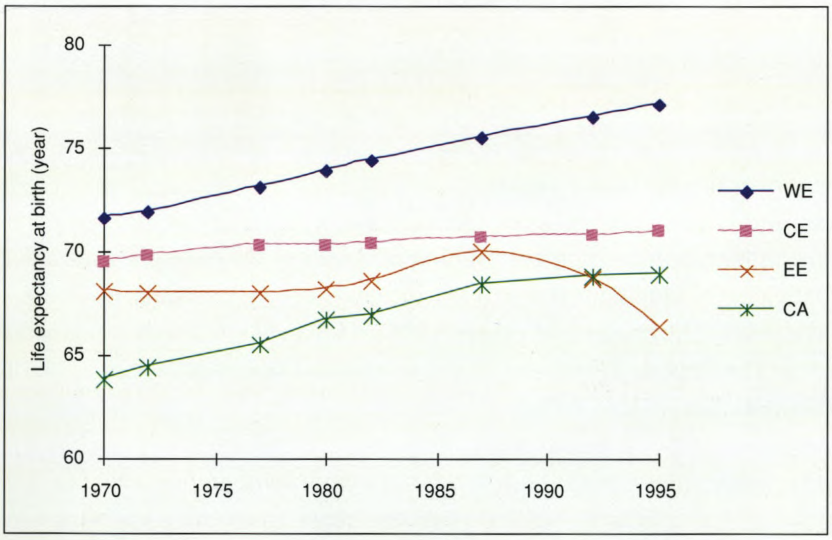


Figure 4.3: Life-expectancy in Europe and Central Asia
Life expectancy declined dramatically in Eastern Europe after 1987. Data on Eastern Europe and Central Asia are uncertain.
Source: World Bank 1997a; data compiled by RIVM

Figure 4.4 shows that underlying the differences in life expectancy is a marked difference in the pattern of disease burden between Central and Eastern Europe, and Central Asia, on the one hand (no desaggregated data were available) and Western Europe on the other. The environment- related disease burden, such as acute respiratory infections, diarrhoea and childhood diseases, is still higher in the former regions. In Western Europe the most common diseases are those typical of high-income countries (cardiovascular diseases and cancer). One might conclude that health transition is not yet fully completed in most parts of Eastern Europe and Central Asia. At the same time, however, the problem of lifestyle related cardiovascular disease is already fully manifest.

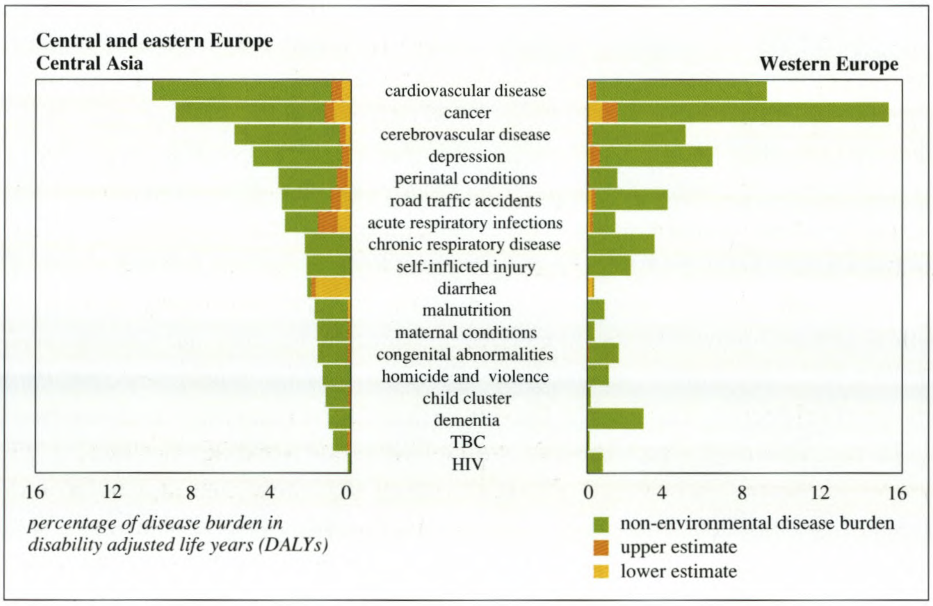


Figure 4.4. Pattern of disease burden in middle- and low-income versus high-income regions of Europe and Central Asia, 1998

In Central and Eastern Europe and Central Asia, the disease burden related to traditional environmental factors is still important.

Note: see Figure 4.2.

Source: WHO 1997; WHO 1999 and Smith and others 1999; compiled by RIVM

Priority issues in environment and health in the region

In this section we will focus on the relationship between changes in energy-related environmental problems and health. Obviously, other factors – such as pollution of drinking water (e.g. by nitrates) and soils, and environmental hotspots – may contribute to the disease burden, certainly in Central and Eastern Europe and Central Asia (Hertzman and others 1996). However these environmental problems are outside the scope of this report. Moreover, at the aggregated level they seem to be of less importance compared to air pollution (EEA, 1999).

General trends in focus towards public health policies in relation to environmental factors

The focus of public health policies has gradually shifted over the years from life expectancy to health expectancy, in particular in Western Europe (World Bank 1993; Olshanski and others 1991). Obviously, this trend is fed by the fact that in most Western European countries successful preventive medical and public health policies have stretched life expectancy enormously (de Hollander 1998). In this context, analysis does not only focus on clear mortality risks, but rather on aspects influencing the quality of life in a broader sense. There are indications that several situations may lead to adverse effects on health (Passchier-Vermeer 1993; Staatsen and others 1993; TNO-PG and RIVM 1998; Taylor 1998; Mackenbach and others 1997), in particular:

- aggravation of pre-existing disease symptoms, e.g. asthma, chronic bronchitis, cardiovascular or psychological disorders
- severe annoyance, sleep disturbance, as well as a reduced ability to concentrate, communicate or perform normal daily tasks
- feelings of insecurity or alienation, unfavourable health perception and stress in relation to a poor-quality local environment and perceived danger of large fatal accidents.

In Western Europe, the total contribution of environmental factors to the disease burden appears to be modest but certainly not negligible; it is not likely to exceed 5 per cent of the total disease burden (Figure 4.4 right-hand side and de Hollander and others 1999). Air pollution, outdoor as well as indoor, and residential noise appear to be the largest environmental health problems in this subregion if measured by their contribution to the burden of disease. In contrast, the pattern of disease burden in Central and Eastern Europe and Central Asia reveals a lasting and substantial contribution from environmental factors. This includes poor housing, inadequate household and community sanitation, and poor-quality drinking water and food, in addition to high levels of outdoor and indoor air pollution (Figure 4.4, left-hand side).

Energy-related environmental factors and health, the current situation

The disease burden in Western Europe for 1990 and for the baseline scenario in 2010 (described in Chapter 3) has been estimated in the context of the EU Environmental Priorities study (RIVM and others 2000) (see Figure 4.5). Such an assessment is not available for the other subregions. In following sections, we will use the estimates for Western Europe and other information for the other subregions to discuss the health impacts in the Region. The estimates shown in Figure 4.5 are based on exposure levels for fine particles, tropospheric ozone and ultra-violet radiation[17],[18].

Figure 4.5 shows that in Western Europe particulate matter and tropospheric ozone are important energy-related environmental factors with regard to their impact on public health. The effects of long-term exposure to suspended particulate matter in Western Europe contribute to perhaps 41,000 to 152,000 extra deaths per year due to respiratory diseases. However, the exact extent of the effects of long-term exposure is highly uncertain (EEA 1999). In terms of disability-adjusted life expectancy the impact of long-term particulate matter pollution may. amount to several hundreds of disability-adjusted life-years per million inhabitants annually. Given the large uncertainties these should be regarded as order-of -magnitude estimates. Short-term effects on public health are much better documented. Particulate matter seems to contribute more to short-term mortality and morbidity levels (22,000 to 47,000 extra deaths per year; 80 DALYs per million inhabitants) than exposure to sulphur dioxide and summer smog, which together are responsible for an estimated 3000 to 6000 deaths per year in Western Europe (EEA, 1999).

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[17] Exposure to particulate matter and tropospheric ozone (summer smog) is translated into loss of disability adjusted life expectancy on basis of the contribution to chronic respiratory disease and mortality, aggravation of existing disease necessitating medical consumption, such as use of medication, hospital visits or admission and precipitated death among the very weak. For the possible increase in exposure to ultra-violet radiation, additional morbidity associated with melanoma and other skin cancers were assessed.

[18] Although increase of ultra-violet radiation due to ozone depletion is not covered as a separate issue in this report (as the problem is not related to energy use) the health consequences have been shown as a reference (see Figure 4.5). This particular health impact is expected to increase but remains modest in comparison to air pollution-related problems.

In Chapter 3, it was indicated that the urban residents in Central and Eastern Europe and Central Asia are exposed to significantly higher levels of urban air pollution than residents in Western Europe. For instance, in Eastern Europe close to 90 per cent of the urban population is exposed to levels of particulate matter exceeding WHO guidelines. Sulphur dioxide concentrations are considerably larger in Central and Eastern European cities. As a result, air pollution by particulate matter will pose a much higher disease burden in these subregions. In contrast, exposure to tropospheric ozone in Central Europe and Eastern Europe and Central Asia is lower.

Energy-related environmental factors and health, trends under the baseline scenario
Under the changes projected in the baseline scenario, the disease burden for particulate matter in Western Europe is expected to decrease by about 40 per cent. For summer smog (tropospheric ozone) the reduction in disease burden is only 10 per cent. In general, slightly larger improvements can be expected in Central and Eastern Europe as a result of improved environmental management and the decrease in industrial activities. Given the favourable social-economic trends assumed under the baseline scenario, disease burden in Central and Eastern Europe, and Central Asia, will gradually converge with patterns in Western Europe. In that stage of the health transition public health will be increasingly determined by lifestyle and the social environment (e.g. income, education, job security, as well as unemployment, social inequity). Such determinants of social-economic health difference is among the most persistent public health problems in established market economies, involving differences in healthy life expectancy of more than 10 years.

Although more uncertain, climate change might also have a considerable impact on public health in the future (e.g. McMicheal and others 1996; Martens 1997). The direct effects of climate change may result from changes in exposure to thermal extremes and thus be expressed by an increase of both heat-related and cold-related mortality. In addition, changes in extreme weather events (storms, floods or droughts, with a potential knock-on effect through social disruption in severe cases) are likely to lead to an increase of morbidity levels. Finally, there is the risk of shifting geographical range and the longer seasons of some vector-borne diseases. Although these health impacts of climate change are still unclear at the moment, considerable impacts are likely under the conditions of our baseline scenario, with results represented as a 1.2°C increase in global average temperature in 2050.

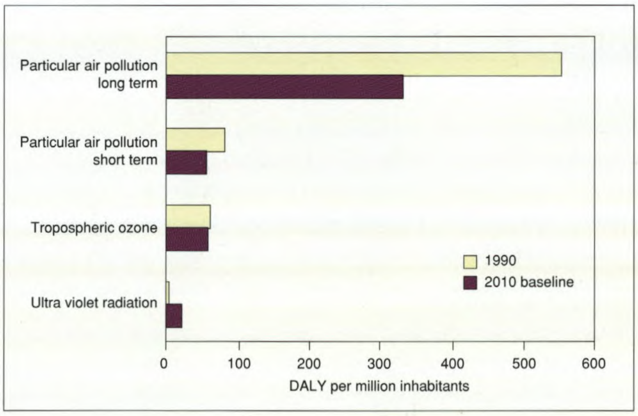

Figure 4.5. Disease burden in Western Europe associated with selected environmental exposures (baseline scenario)
The disease burden in Western Europe as a result of the selected environmental problems is projected to decrease under the baseline scenario.
Note: For definition of DALYs see Figure 4.2. Source: RIVM and others 2000

4.2 Pressures on biodiversity

The most recent assessment of the Environment in Europe indicates the current threat to Europe's biodiversity as severe, with a growing number of species in decline (EEA 1998). Globally, the most important threats to biodiversity include land-use changes and habitat loss, climate change, acidification and eutrophication, biotic exchange and elevated carbon dioxide concentrations. The relative contributions differ between the regions of the world (Leemans 1999). Other important factors in the European region are fragmentation of ecosystems, pollution and depletion of freshwater resources and urban and industrial contamination (EEA 1999).

In this section we will analyse what the changes in energy-related environmental pressures in the 1990-2010 period may imply for biodiversity within the Region and how the total pressure on biodiversity differs between the subregions. For this analysis, we will relate changes in environmental pressures to ecologically relevant minimum and maximum pressure levels, assuming

Box 4.1: Methodology of the Natural Capital Index and pressure analysis

The Natural Capital Index (NCI) has been developed by the Liaison group on Biological Indicators of the Convention on Biological Diversity (UNEP 1997, UNEP 1997b, UNEP 1999b). Its purpose is to assess changes in biodiversity, by looking at changes in the mathematical product of the size of nature areas (quantity) and a measure of their biodiversity (quality). As geographically explicit data on ecosystem quality are often lacking, an environmental pressure index may be used as substitute to indicate ecosystem quality. The assumption is made that the lower the pressure, the higher the probability of high ecosystem quality and vice versa. The methodology for this index was used earlier for UNEP's first Global Environment Outlook (Bakkes and van Woerden, 1997), and for the European Union (van Vliet and others 1999) and the OECD (ten Brink 2000).

In keeping with the focus of this report, only the pressure component is evaluated here. First of all, each pressure type is graded using a linear scale from pressure level 0 (assumed to have no effect) to pressure level 1000 (very high and assumed to lead to strong ecosystem deterioration) based on ecologically relevant maximum tolerable levels (see Table 4.1). It should be noted that the five environmental pressures taken into account form a subset of all relevant pressures (factors not included are, for instance, fragmentation, freshwater pollution and depletion). Particularly at local levels specific problems might dominate.

Table 4.1: Pressures on biodiversity considered and scaling values used

	Low pressure (lower threshold value) Pressure level = 0	**High pressure (maximum on scale) Pressure level = 1000**
Rate of temperature change	< 0.2°C change in 20 years	> 2.0°C change in 20 years
Human population density	< 10 persons per km^2	> 150 persons per km^2
AcidificationDeposition	< critical load	Deposition > 2.5 x critical load
Eutrophication	Deposition < critical load	Deposition > 2.5 x critical load
Exposure to high ozone concentration	AOT40 < critical level	AOT40 > 5 x critical level

Note: AOT40 is the time-weighted ozone concentration exceedence of the 0.04 ppm eight-hour average level.

For each grid cell of 0.5x 0.5 degree the pressure scores of all pressure indicators have been added, to arrive at an indication of their combined pressure on biodiversity. In this report, pressures have been calculated for nature areas only, defined as all land excluding all human-dominated, cultivated land such as urban areas, and agricultural land. Current land use and changes in the 1990-2010 period have been derived from the IMAGE Baseline A scenario (Alcamo and others 1996). This scenario, also used to depict environmental changes under climate change in Chapter 3, is based on similar changes in economic and demographic drivers as the current baseline scenario.

that the higher the pressure on biodiversity the lower the probability of high biodiversity will be (Box 4.1). The analysis is an adapted implementation of the Natural Capital Index (NCI), a method recently developed by the Liaison group on Biological Indicators of the Convention on Biological Diversity (UNEP 1997; UNEP 1999), described and used by ten Brink (1997), van Vliet and others (1999), WMCM (1999) and ten Brink (2000).

Figure 4.6 shows the result in terms of environmental pressure on terrestrial biodiversity for 1990[19]. Since this assessment technique is relatively crude, the maps should be interpreted only in terms of the broad spatial patterns they reveal. As could be expected, high environmental pressure is found in Western and Central Europe – particularly in comparison with other parts of the world (not shown here). This is, for instance, consistent with results of the recent pan-European environmental assessment, which concludes that most of the old, almost untouched, nature areas in the Region are now only to be found in the Former Soviet Union (EEA 1998). Environmental pressure on biodiversity can, more locally, be high in Eastern Europe and Central Asia as well, e.g. certain areas west of the Urals, parts of Central Siberia and the southern parts of Central Asia.

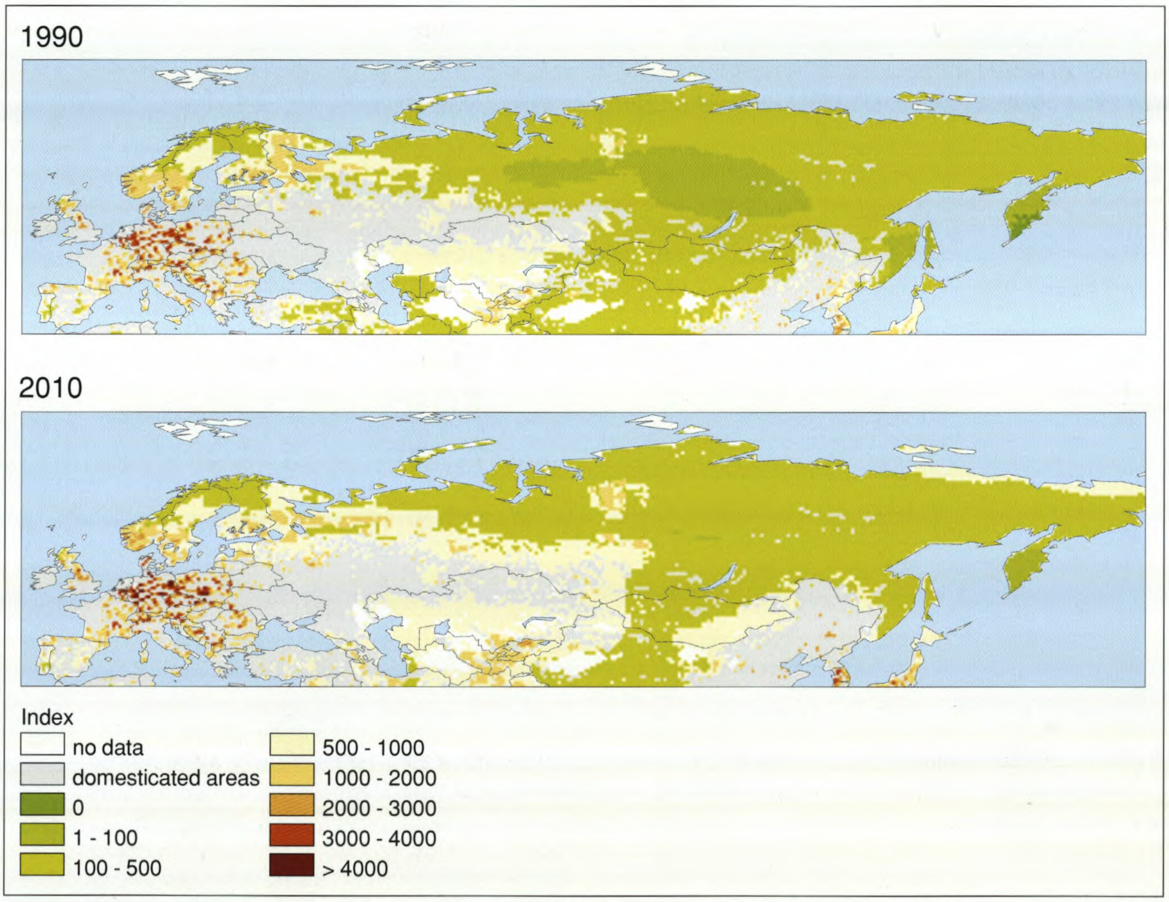

Figure 4.6: Selected pressures on biodiversity in natural areas: spatial patterns
Environmental pressures on terrestrial biodiversity are highest in parts of Western Europe and Central Europe.
Note: Pressure is rated according to the method described in Box 4.1

[19] A similar analysis has been carried out for countries of the EU by van Vliet and others (1999) using more detailed data sets. The geographical patterns of the two methods in the overlapping areas are similar.

In the period 1990-2010, current trends and policies are expected in most of the European Region to lead to small increases in total nature area (forests and other nature areas). This could increase the 'Natural Capital' of the Region. In contrast in Central Asia and parts of Central Europe (in particular, the Anatolyan Peninsula) the total nature area is expected to decrease.
In addition, Figure 4.7 shows the overall trend of the pressure to be upward in all subregions. Figure 4.8 shows the location of the changes, but again, the map should be interpreted only in terms of broad geographical patterns.

The increase of the pressure shown in Figure 4.7 is brought about mainly by climate change and summer smog. Acidification and eutrophication pressures decrease slightly in Western and Central Europe (very important in Scandinavia, for instance), but increase locally in other subregions (e.g. Central Siberia around Norilsk). Some parts of Western and Central Europe feature considerably lower environmental pressures than the rest of these two subregions; this is shown in the right-hand side of Figure 4.7. Pressures in Scandinavia and the Anatolyan Peninsula are about half the pressures in the other, central areas of Western and Central Europe. The overall increase of pressures in Central Europe is dominated by developments on the Anatolyan Peninsula. For the eastern part of Central Asia and Central Siberia strong increases in the pressure index are projected, as a result of population growth, climate change and summer smog. In addition, land conversion can also have a large negative impact on natural capital here. Nevertheless, the overall pressure on terrestrial biodiversity in these subregions remains lower than in the western parts of the Region. On balance, the conclusion must be that under the baseline scenario pressures on biodiversity will further increase in all subregions.

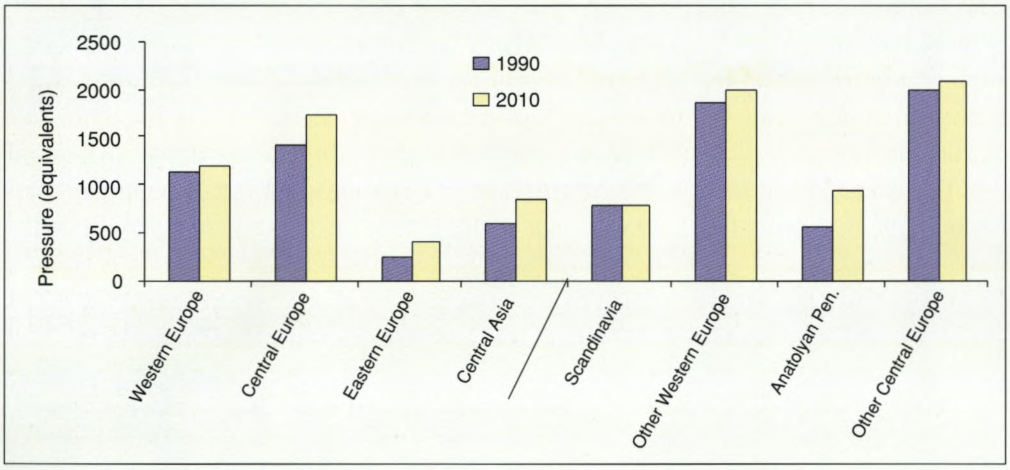

Figure 4.7: Selected pressures on biodiversity in natural areas: subregional aggregates
The pressure on terrestrial biodiversity increases in all four subregions.
Note: The left half of the figure shows the averages for the four subregions, while the right half decomposes the values for Western and Central Europe. Other Western Europe and Other Central Europe represent the average of the respective subregions excluding Scandinavia and the Anatolyan Peninsula.

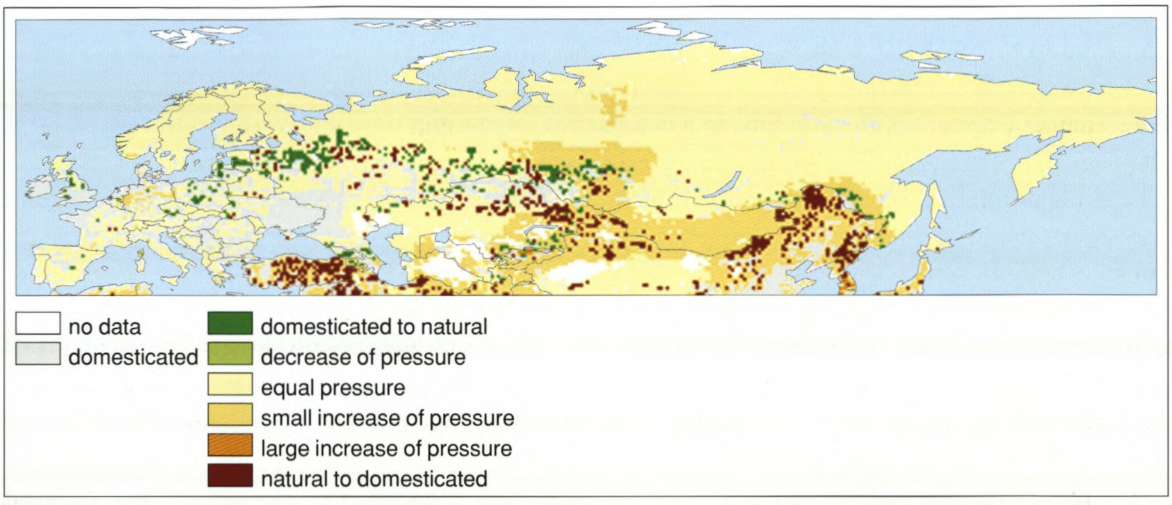

Figure 4.8: Changes in selected environmental pressure on biodiversity, 1990-2010
Increases in pressure on biodiversity dominate over decreases in pressure, in particular in the southern parts of Central Europe, Central Siberia and the eastern parts of Central Asia.

4.3 Main findings

The analysis in this chapter indicates the following:

- While public health and biodiversity are influenced by energy-related environmental factors, their development over time is inextricably linked with many other changes in the region. On balance, biodiversity can be more directly influenced by environmental policies than public health can be influenced by these policies.
- The contribution of environmental factors to the overall disease burden in Western Europe is modest but certainly not negligible (up to 5 per cent of the total disease burden). In particular, air pollution by particulate matter and summer smog contribute to morbidity and mortality. In Central Europe, Eastern Europe and Central Asia, the contribution of environmental factors is larger – not only due to much higher exposure levels to urban air pollution but also to remaining traditional risk factors.
- Under the baseline scenario the disease burden of urban air pollution in Western Europe is expected to shrink by 10-30 per cent. Similar reductions can be expected in the other three subregions.
- Pressures on biodiversity were, on balance, found to increase for all four subregions under the baseline conditions.
- Environmental pressures on terrestrial biodiversity are already very large for the central parts of Western and Central Europe. But the largest increases are expected for the Anatolian Peninsula and Central Asia. Climate change, population growth and tropospheric ozone contribute to this.

5. POLICY OPTIONS

This chapter explores options to induce a deeper and more rapid transition towards energy patterns that are environmentally less burdensome. The orientation of this chapter is qualitative. In addition, Chapter 6 provides a scenario-based sketch of what difference accelerated policies could make to the environment in the Region. The category of measures explored is best characterised as 'moderate'. This is not a precise definition and it does not have the same meaning across the four subregions. In general terms, it includes measures that are not only environmentally but also economically attractive, or measures with very low costs and considerable impacts. One should be aware that costs are often neither the only nor the most important consideration for businesses, governments and consumers when deciding whether to adopt measures (compare RIVM 1996). Above all, even more than the presumed changes in the baseline scenario, the feasibility of the measures hinges on well-functioning governments and markets, as well as earnest political commitments.

The analysis in this study focuses on energy. Obviously, the five environmental problems analysed in this report are also affected by driving forces other than energy conversion and use (for example, agricultural activities). However, this remains outside the scope of this chapter. We will first briefly give attention to the notion of energy efficiency, as most of the discussions will focus on more efficient energy use. Next, options will be identified to stimulate further and faster reduction in energy intensity and to make the energy system more sustainable. Finally, several additional measures to reduce environmental pressure will be discussed.

5.1 General remarks on energy efficiency

Efficient use of energy is in many respects a key element in a country's economy. It has implications for the competitiveness of companies, the stability and vulnerability of the economy, and the environment. Improvement in energy efficiency can thus often bring about 'win-win' solutions, i.e. environmental and economic benefits at the same time. The concept of energy efficiency relates the output of a system and the energy put into it (IEA 1997). For an automobile, for instance, this can be expressed in litres of fuel per km travelled. For economies as a whole, the amount of energy used per unit of GDP, called energy intensity, is often used as an indicator (a higher energy intensity implies less energy efficiency). In a strict sense, however, energy intensity is not a very good indicator of energy efficiency, as: 1) the denominator GDP does not represent all activities for which energy services are demanded, such as house heating, and 2) the indicator does not account for specific circumstances such as cold climate)[20]. Nevertheless, the indicator is used - with care - in this report.

Figure 5.1 shows the energy intensity of selected countries in the different regions and the regional averages. It clearly indicates that countries in Central Europe, Eastern Europe and Central Asia are much more energy intensive than countries in Western Europe. Based on purchasing power parity 'exchange rates', energy intensities in Western Europe vary around 8 GJ/ppp$ and around 20 GJ/ppp$ in Central Europe, and in the range of 20-50 GJ/ppp$ in Eastern Europe and Central Asia.

[20] Another limitation is formed by the large uncertainties in energy statistics and national accounts for Eastern Europe and Central Asia. This relates in particular to unrecorded parts of GDP, different methods of statistical presentation and severe difficulties of statistical systems in the transition period.

If allowance were to be made for unrecorded GDP, energy intensity in Eastern Europe and Central Asia would most probably be in the order of 20-30 GJ/$. This is still 2 to 4 times as high as the average in Western Europe. This observation is backed up by more technical data concerning energy efficiency.

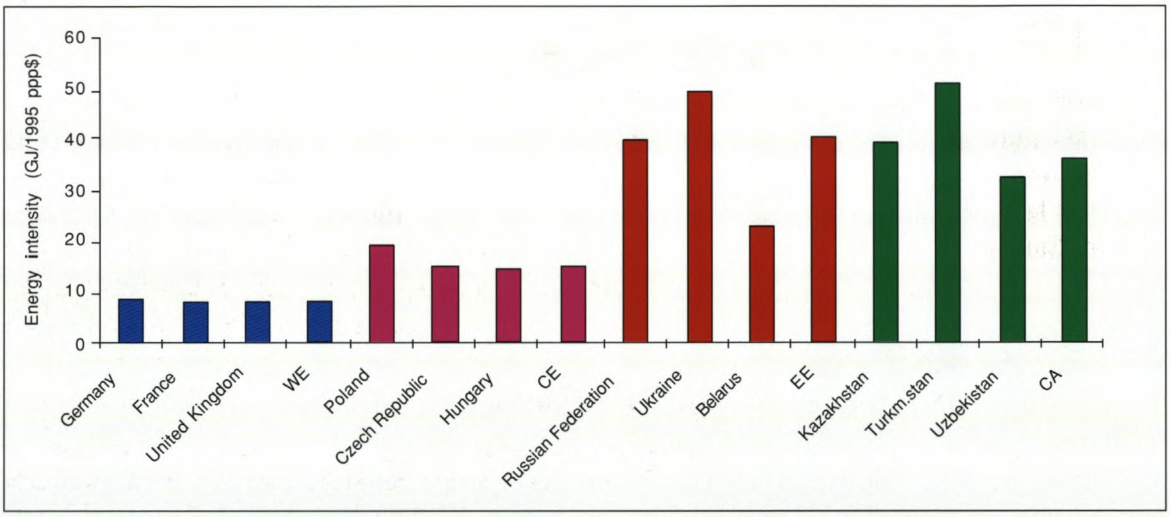

Figure 5.1: Energy intensity in 1995

Energy intensity in Eastern Europe and Central Asia is high compared with Western Europe, partly because of inefficient energy use.

Source: World Bank 1999

High energy intensity in Central and Eastern Europe and Central Asia is due to a combination of factors. In general, the economy has been weighted heavily towards industry, with a relatively small service sector (see also Chapter 2 and Figure 2.4). Another reason was the availability throughout Central and Eastern Europe and Central Asia of cheap (mainly Russian) energy resources, which spurred on the development of inefficient, energy-intensive industries and housing structures. With the low energy prices and limited payment structure there has been little incentive to invest in efficient technologies – resulting in the use of out-of-date equipment by the energy economy.

5.2 Moderate measures for energy-related environmental problems

This section briefly discusses a few promising options to accelerate the transition towards a more efficient and therefore more sustainable energy system. Several studies indicate that specific choices depend on national circumstances, which clearly differ significantly from country to country, even within our subregions. Broadly speaking, however, indications can be given. The focus here will be on subregional differences and opportunities for mutual support. The following categories are discussed:

- Price reform, including reform in subsidies and market mechanisms.
- Energy efficiency in the building sector.
- Energy efficiency in industry.
- Policies for the electricity sector and use of renewable energy.
- Policies on transport.

Attention is also given to emissions trading and joint implementation, instruments allowed under the Kyoto Protocol to reduce overall costs of carbon dioxide emission reductions.

Most of the available studies discuss options for a more sustainable energy systems in terms of different types of 'potentials'. These generally include the 'technical potential' (the impact of all technically achievable improvements without consideration of costs), the 'economic potential' (impact of measures with larger benefits than costs from a societal point of view) and 'market potential' (impact of measures that are cost-effective from an investor's point of view). As the objective of this study is to look at the possible impact of moderate measures, the focus here will be on the second and third type of measures. Certainly not all measures that are cost-effective from a macro-economic perspective will be implemented without additional policies. Several barriers prevent the implementation of existing potential. Some that need to be overcome are discussed in Box 5.1. Additional measures, as will be discussed in this section, are meant especially to implement a larger share of the macro-economically attractive potential by trying to overcome the barriers mentioned above.

Box 5.1: Barriers for energy efficiency improvement

There are several reasons that not all energy efficiency measures which are attractive from a macro-economic point of view are actually implemented. One of the first reasons is that measures that are attractive from a macro-economic perspective are not necessarily economically attractive for an individual enterprise or household. However, other factors play a role as well (e.g. Jaffe and Stavins 1994):

- Lack of incentives: The prices paid by firms or households might be much lower than the true macro-economic prices, as a result of subsidies and non-payment. Particularly in Central and Eastern Europe energy prices are still lower than economic costs. In some cases, incentives have even encouraged energy use. In the residential sector theabsence of monitoring and control equipment (metering) implies that there is hardly an incentive for energy efficiency. Measures for price reform (section 4.2.1) attempt to overcome this barrier.
- Lack of capital: One of the important barriers for energy efficiency improvement in Eastern Europe and Central Asia in the study period could be capital availability – certainly in the context of the transition process. But also in more general terms, capital for energy efficiency improvement is often scarce and investments need to compete with other investments.
- Profitability barriers: Investors sometimes use stricter criteria for their decisions than optimal from a social-economic perspective. Reasons for this can be uncertainty or the availability of other more attractive investment options. In many studies priority is found to be given to investments in mainstream business.
- Information barriers and lack of expertise: Often, cost-effective energy efficiency measures are not invested in because of a lack of information. This is especially important for households. However, lack of information can also play a role in the industrial sectors. In Eastern Europe, the lack of know-how to improve energy efficiency has been identified as a major obstacle to improvement (Fromme 1996).
- Lack of willingness to invest: Firms or households may not be interested in energy efficiency improvement. For example, for most industries and firms energy costs constitute only a very small share of total costs, making efforts in this area of only minor importance. In addition, financing bodies often prefer large projects to a multitude of small ones because of the lower transaction costs. Measures to improve energy efficiency tend to be small and diffuse.

In general terms, there is a whole range of policy options to make economies more energy-efficient, with a particular focus on the Europe and Central Asia region (see, for example, IEA 1996, Capros and Kokkolakis 1996, Blok and others 1996, IEA 1997 and Phylipsen and Blok 1998). The next sections will reflect that for Western Europe price reforms such as removing subsidies, reforming tax facilities and eliminating institutional barriers are the most intensely discussed reforms nowadays. Effective introduction could improve efficiency by speeding up the penetration of combined heat and power schemes and high-efficiency appliances and cars. Market liberalisation too could stimulate energy efficiency and renewable energy sources, but it may also induce counteractive effects. Long-term significant decreases in energy-intensity in addition to the baseline scenario can only be expected as a result of effective and sustained R&D programmes.

Box 5.2: Carbon dioxide emission reduction costs in Western, Central and Eastern Europe

A large number of studies has tried to assess the costs of reducing carbon dioxide emissions by measures such as energy efficiency improvement and fuel switching. Obviously, these studies suffer from simplifications and partial information. Moreover, their results are quite sensitive to basic assumptions, for instance, with regard to discount rate or transaction costs. Large differences are therefore found between different studies for one specific region or country. Notwithstanding these shortcomings, when taken together these studies provide at least a rough indication of the costs involved.

One important observation is that emission reduction costs differ between countries and between regions. Especially in Central and Eastern Europe, large emission reductions are feasible at no or even negative costs. This is illustrated by Figure 5.2 which results from aggregating several emissions reduction curves for 2010 for several countries.

According to the cost curves, the costs of emission reductions in Western Europe are relatively low for reductions up to 20–30 per cent above to baseline trends. Beyond this, reduction costs seem to increase sharply, although this part of the cost curves is based on very few data points. In contrast, in Central and Eastern Europe emissions reductions up to 40–50 per cent are feasible at costs below US$30 per ton of carbon dioxide. The potential for reductions in Central Europe is even slightly larger than in Eastern Europe because of the potential for shifting from coal to natural gas. Differences in emissions reduction costs explain the interest in instruments such as joint implementation (JI) and emission trading.

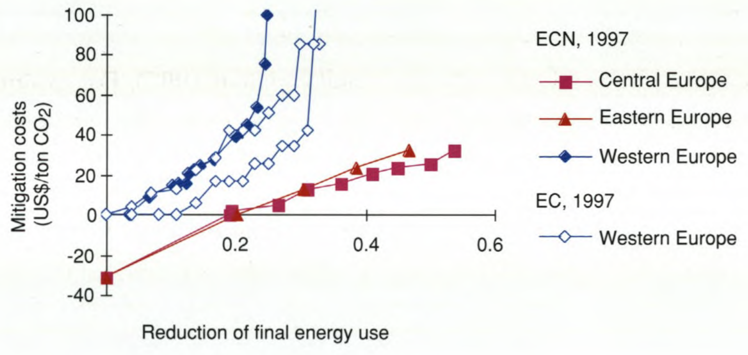

Figure 5.2: Carbon dioxide mitigation costs

Average costs for mitigation of carbon dioxide emissions in Central and Eastern Europe are considerably lower than in Western Europe.

Note: the cost curves from the European Commission (EC 1997) have been added to illustrate the uncertainty involved; these curves are based on the POLES and Crash models.

Source: ECN 1997; EC 1997

For the economies in transition such as those in Eastern Europe and Central Asia and, to a lesser extent, Central Europe, reform to make prices reflect production costs is probably among the most important measures. This, however, can only be introduced in accordance with the rise in incomes of households and firms and requires a stable financial and social infrastructure. In addition, the high energy intensity in the region (and thus the large potential for improvement) justifies additional effort in demand-side management. In an optimistic view this has the potential for very high rates of technological change, by stricter control of standards for new process equipment, appliances, cars and power stations. Conceivably, this would involve co-operation with Western European governments and firms.

Large opportunities are available in the electricity sector, where the replacement of old plants by state-of-the-art plants and the upgrading of existing combined heat and power schemes could form the basis of a truly energy-efficient economy. Another, though more distant option, is to steer the development of transport infrastructure in less energy-intensive directions. Finally, there are many good housekeeping measures which could reduce energy use at hardly any cost.

The differences in energy efficiency and in energy supply mix between Western, Central and Eastern Europe and Central Asia certainly have consequences for the price of emission reduction. Box 5.2 gives some indication of this.

5.1.1 Price reform and market mechanisms

Getting the prices right is a fundamental instrument of environmentally benign energy policy. For certain forms of energy in many countries in the region, prices are still below the levels that would result from proper pricing principles for full costs of supply. This is, for instance, related to subsidies for social purposes. Some approaches to adequate price setting in the different subregions are discussed below. In addition, different forms of taxation might be applied to the energy sector. Currently, these measures take many different forms depending on the country.

Energy subsidy reform
Increasingly, governments are under pressure to reconsider the use of direct and indirect subsidies for energy, food and transport activities (de Moor and Calamai 1997). For example, coal subsidies in Germany will become more transparent as a result of EU regulation to finance these subsidies directly from the budget. Similarly, governments in Central and Eastern Europe have made bold steps in bringing energy prices more in line with world market levels – demanding large sacrifices from parts of the population and running the risk of payment deferral. However, there is room for more. Appendix 2 illustrates the subsidy levels in selected countries in each of the four subregions.

In Western Europe, reform of coal subsidies qualifies as an important option, although other energy carriers (gas, electricity) in some countries are subsidised as well. The subsidy to coal production comes through an array of measures that have been established for various reasons, most important, to combat unemployment. Phasing out coal production subsidies would effectively bring about a shift towards more environmentally-friendly fuel. A necessary condition is careful long-term management of regional employment and welfare policies of which the subsidies are now an element; in other words, de-linking the local social support mechanism from coal production.

In Central Europe, the move towards market prices for energy hides important differences in the subregion. Several governments in some countries aim to reduce subsidies but are constrained by the presence of large groups in society that can hardly afford to pay higher domestic energy prices. In this situation, it should be acknowledged that possibilities for higher prices and efficiency improvements are largely dependent on economic recovery. In countries that are preparing for accession to the European Union, the remaining energy subsidies are typically 25 per cent (1996 data, analysis published in 1998; see appendix 2). As part of their convergence to Western European energy policies, the challenge for 'accession countries' is to reduce end-use subsidies and at the same time to phase out coal subsidies.

In Eastern Europe, the picture is dominated by the Russian Federation. Traditionally, a large variety of hidden subsidies existed (see appendix 2). Given the difficult circumstances, it has achieved impressive results in reforming the energy sector and reducing subsidies, but remaining subsidies still amount to 30 per cent of market prices. One outstanding and growing problem for energy efficiency improvement in Eastern Europe (and in Central Asia) is payment arrears. In fact, the effects of price reform in Eastern Europe have been undone by large-scale non-payment of energy bills in the industrial and government sectors[21]. Rough estimates suggest that in the Russian Federation in 1994 about 50 per cent of the energy bills were not paid, with state enterprises as the main defaulters. Payment arrears have become a major form of market distortion with similar results as subsidies. Obviously, specifically for the domestic sector we have to realise that the average wage in Eastern Europe and Central Asia (certainly after the economic decline) is much lower than in Western Europe. Moreover, many households do not even have an option to respond to increasing prices given the lack of heat control and metering. However, in the context of improving possibilities for price-induced energy efficiency, it is clear that re-establishment of payment discipline is very important, certainly outside the domestic and transport sectors. The problem of payment arrears also needs to be solved out of economic necessity. On balance, in the alternative policies scenario, it is assumed that a solution to the problem of payment arrears, as an element of moderate policies, will begin to have an effect on energy efficiencies. If cushioning the effect of price increases is desired for social reasons, it would be preferable that the support goes to increase energy efficiency rather than to reduce prices.

In Central Asia, like in Eastern Europe, solving the problem of non-payment of energy is a key necessity (collection rates here seem to be even lower than in Eastern Europe). In our analysis, we have assumed the same effectiveness as in Eastern Europe, i.e. some extra improvement of energy efficiency by 2010. However, the rate of change may differ greatly between countries in one subregion. This as is illustrated by a short account of Kazakhstan and Kyrgyzstan in appendix 2.

Energy and carbon taxation

Earlier studies found that economic instruments such as energy and carbon taxes could be appropriate to reaching cost-effectiveness. The main advantage of 'fiscal policies' is that from a purely economic standpoint such polices are deemed the most economically efficient. Moreover, they have the advantage of relative ease of implementation as most collection mechanisms are already in place. At the same time at the level of the EU, taxation has been the subject of considerable dispute, in particular because of the expected negative effects on international competitiveness.

It should be noted that another aspect of energy taxation is its role in helping to prevent take-back effects. This means that, supposing energy efficiency measures gradually reduce the costs of energy-services such as fuel costs per distance travelled, businesses and consumers could as a reaction increase the demand for energy services. The initial reduction in primary energy use is then 'reclaimed' through an extra increase of activity (Blok and others 1996). Therefore, even a policy package that stimulates more efficient energy use largely through non-price measures could benefit from a tax on energy in order to consolidate the gains.

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[21] This is not to mention frequent and complex barter schemes that make the relation between payment and energy at best diffuse. Van Beers and de Moor (1998) characterise the situation by saying that "In the energy sector in Russia and the Ukraine, money has almost completely lost its role as a means for payment in the energy sector".

Other market mechanisms

Relative newcomers among market-oriented polices are proposals for domestic emission trading (international emission trading is discussed later on in the chapter). Theoretical analyses suggest that this approach, like taxes, is an economically sound method for cost-effective reducing emissions. There is, however, only very limited actual experience with this instrument.

Table 5.1 gives an overview is given of potential measures in the category 'price reform and taxation' in each subregion that could be part of a moderate measure strategy.

Table 5.1: Potential moderate price reform and taxation measures

Western Europe	Central Europe	Eastern Europe	Central Asia
• Reform of coal subsidies • Possible introduction of regulatory energy taxation	• Additional reduction of energy subsidies, in particular, coal	• Reduction of energy subsidies • Solving problem of payment arrears • Abolishment of flat rates and introduction of individual metering	• Reduction of energy subsidies • Solving problem of payment arrears • Abolishment of flat rates and introduction of individual metering

In each subregion, price reform could provide an important stimulus for energy efficiency.

5.1.2 Energy efficiency in energy consuming sectors (industry and buildings)

Energy efficiency can be improved by retrofit measures, technology in newly built installations and good housekeeping. In addition, material efficiency improvement and changes of consumption patterns can improve energy efficiency. In the context of moderate measures, good housekeeping measures are especially attractive since most of these can be taken at no, or very limited costs. Options for good housekeeping are related to the operation and maintenance of existing technology. Often this can be improved without hindering productivity or comfort. Energy-saving programmes in Western Europe have revealed many such options, both in the production sectors and in households.

In Central and Eastern Europe and Central Asia, as a result of a lack of incentives in the past and related, relatively wasteful, production methods, extensive energy savings can be achieved through good housekeeping measures. Studies indicate that in this way between 8 and 15 per cent of consumed energy could be saved with little or no capital investment (Hlobil 1997). Also, through measures additional to good housekeeping, considerable energy savings can be obtained. Many studies indicate that the costs of energy efficiency improvement are very low in comparison to costs in Western Europe. For a considerable number of measures, the overall costs are even negative (Chandler and others 1996; Lueth and others 1997; IEA 1997). Even taking into account that the full technical potential for energy savings is unlikely to be achieved in the near future, it is estimated that moderate policy measures could achieve energy savings up to 40 per cent over current trends (Hlobil 1997).

An intra-regional dimension is to step up exchange programmes with countries that already have successful training programmes in environmental management and public awareness campaigns. Especially in Eastern Europe and Central Asia, information provision and training of specialists in industry can have an important impact on the dissemination of energy efficiency technology. For example, a project in the Russian Federation found that demand for information on energy efficiency programmes far exceeds supply (Avdiushin and others 1997b).

Focussing on the industry sector, most studies indicate that the largest potential for energy efficiency can be found here. Reasons include its large share in total energy use (32 per cent in Western Europe to around 40 per cent in Central and Eastern Europe), the relative ease of implementation and large potential of cheap options available particularly in Eastern Europe and Central Asia. Moderate options that could have a large contribution in the period to 2010 include housekeeping and maintenance programmes, energy management and accounting systems and improved equipment and procedures for existing production methods. There are several instruments available to implement this. The last years have shown that negotiated, voluntary agreements have been very effective in some sectors in parts of Western Europe in reaching true commitment at enterprise level and high savings in resource use (Blok and others 1996). Obviously, such programmes cannot always be directly applied to other situations. But on the basis of experience, positive results are not unlikely, especially in Central Europe in the coming years. The most promising sector for this is heavy industry, which consists of a limited number of large enterprises, thus making it relatively easy to target specific policies.

Formal ISO 14000 and EMAS schemes presumably form an excellent option for a number of industrial sectors in Central European countries, with their relative open economies. In addition, a less formal and more focused initiative could also be considered, especially for Eastern Europe. Such an initiative could aim at sector-level regional collaboration in the most energy intensive[22] industrial sectors in Eastern and Western Europe.

In the buildings sector (residential and commercial sector), many energy efficiency solutions are well known, but insufficiently applied. One of the reasons is that consumers are a large and fragmented group – with limited capital availability and a lack of awareness of what can be achieved. This is the case in Western Europe, where efficiency measures can reduce energy consumption by 25-30 per cent with payback period of five year or less, but even more so in Central and Eastern Europe and Central Asia.

One of the focuses of any energy efficiency programmes in Central and Eastern Europe and Central Asia should be improvement of space heating. This in particular concerns the district heating systems which play a big role in most of the countries in these subregions (e.g. 65 per cent of all households in the Russian Federation and 30-50 per cent of all households in Central Asia)[23]. Many of these district heating systems have very high transmission and distribution losses. Moreover, consumers connected to these systems often cannot control the temperature. Studies indicate that updating district heating systems not only could lead to energy savings but also to financial savings after a pay-back period often of only one or two year(s). A project in one single district of the town of Chelyabinsk in Russia, for instance, identified a potential to reduce carbon dioxide emission by

[22] These are steel, aluminium, fertilisers and plastics.
[23] As district heating is limited to urban areas, the percentage varies among things with the share of rural population.

about 40,000 tons per year. This could be achieved by simple measures such as introducing heat metering, installing adjustable speed drives at pump motors and replacing insulation of heat pipelines. Not only would these measures reduce carbon dioxide emissions, they would also have a pay-back period of less than two years and improve comfort in buildings served by the heating system. Such measures could probably be applied to centralised systems in most large cities in Russia (Avdiushin and others 1997b). Similar findings are reported about Poland (WEC 1995). Improvement of the heating systems can be combined with introducing individual control and metering – which by itself can reduce energy consumption by 10 per cent. The challenge will be to find ways to make capital available from collective sources – as investments will in general be too high to be made by consumers alone.

Other moderate measures in the building sector in the region as a whole could include e.g. window-improvement, heat pipe insulation, introduction of more efficient lighting and attic insulation. Finally, one should realise that buildings often have a life-time of more than thirty or forty years. For future energy efficiency it will be very important to promote ambitious building codes for new buildings now so that additional costs can be integrated in the total building costs. Table 5.2 gives an overview of potential measures in the industry and building sectors.

Table 5.2: Examples of moderate measures to stimulate energy efficiency in the industry and building sectors

Western Europe	Central Europe	Eastern Europe	Central Asia
• Energy saving programmes targeted at all energy use sectors, including for instance building codes, progressive energy standards for appliances and energy audits of existing buildings. • (Voluntary) agreements with the industrial sector	• Direct negotiations and ISO 14000 / EMAS schemes for heavy industry • In case of new investments: choose the most energy efficient technology • Awareness programmes for households • Further training and education of engineers	• Sector-level regional collaboration in heavy industry • Awareness programmes for households • Introduction of metering • Improving district heating • Further training and education of engineers	• Sector-level regional collaboration in heavy industry • Awareness programmes for households • Introduction of metering • Improving district heating • Improving regulatory framework

5.1.3 Policy options for the energy production sector

Potential gains in electricity generation are considerable. For example, some Eastern European coal-fired power plants feature overall fuel efficiencies of not more than 28 per cent, while a modern natural gas-fired combined cycle plant can reach efficiencies of 50 to 60 per cent. Also modern coal-fired plants have much higher efficiencies in combination with much lower fly-ash and nitrogen oxides emissions.

Combined generation of heat and power (CHP) opens yet another path to improving overall efficiency. CHP is already used more often in some Central and Eastern European countries than in

Western Europe. The heat produced by CHP can be delivered by pipelines to homes, offices and industrial plants. In some Western European countries (Denmark, the Netherlands and Finland) programmes to encourage CHP have led to considerable energy savings. Accelerated introduction in other Western European countries seems to be an attractive option for further energy savings (Blok and others 1996).

Another moderate strategy is to facilitate a faster increase in the share of modern (preferably gas-fired) power plants. As previously pointed out, in Central Europe this development will largely depend on government considerations on import dependency and balance of trade. Therefore, a possible policy element is help for the Central European subregion to stabilise gas prices for power generation or to compensate price changes.

So far, electricity producers in most countries in transition (in Central Europe, Eastern Europe and Central Asia) have been strongly supply-oriented. The introduction of new approaches in the electricity sector such as Integrated Resource Planning and Demand Side Management might reveal a large potential of more cost-effective ways to supply energy services (Schipper and Martinot 1993). One necessary step for this is the introduction of a regulatory framework allowing, and even encouraging such approaches, for example rules with regard to public sector spending.

Renewable energy sources, such as hydropower, biomass, wind energy and solar-based energy can in the short-term up to 2010 only have a limited effect on reducing the environmental impacts of energy production in comparison with, for instance, energy efficiency improvement. However, for further reduction in environmental pressures after 2010 it will be important that further investments in these technologies are made, especially in Western Europe. The contribution of renewable energy sources to the environmental problems discussed in this report is very low. At the same time, however, it should be realised that renewable energy sources can have negative consequences for other environmental problems that should be taken into consideration. This is particularly important for large-scale hydropower which leads to large changes in terrestrial and aquatic ecosystems.

Another moderate strategy could be labelled 'builder-determined standardisation'. This means that the key international suppliers of larger power plants uphold 'de facto' a standard of highly efficient plants. This is not inconceivable given the fact that this would involve no more than five to ten major producers, some of whom are already actively moving in this direction. The bottom line of this approach is to remove the extra costs of fuel efficiency by rapidly outdating the fuel-wasting alternative.

An important supporting element of this last strategy is access to capital at moderate or nominal interest. For example, without such support, innovation in the electricity sector in the Ukraine would at the moment still be unattractive at annual interest rates of 20 per cent. A second and related supporting element is that such a de facto standard be included in the work of multilateral banks and international collaborative programmes. Assuming that many Central European countries are moving towards EU standards anyway, the 'builder-determined standardisation' strategy applies in particular, although not exclusively, to the Eastern European and Central Asian subregions.

In Table 5.3, an overview is given of the moderate measure included in the energy management scenario, subdivided by policies on improving energy efficiency and energy supply.

Table 5.3: Examples of measures in the energy production sector

Western Europe	Central Europe	Eastern Europe	Central Asia
• Stimulation of combined heat and power (CHP) • Further introduction of renewable energy	• Installation of modern power plants • Introduction of demand side management • Upgrading or replacing district heating • Reducing transmission losses • Further introduction of renewable energy, e.g. biomass	• Installation of modern power plants • Introduction of demand side management • Upgrading or replacing district heating • Supplier normalisation • Reduction of transmission losses • Further introduction of renewable energy, e.g.	• Installation of modern power plants • Introduction of demand side management • Upgrading or replacing district heating • Supplier normalisation • Renewable energy (off-grid) • Reduction of transmission losses

5.1.4 Policy options for transport

The baseline scenario indicates that an increase in transport throughout the region will be inevitable. Therefore policy responses consisting of moderate measures would first of all be directed to mitigating the effects of such an increase especially in Central and Eastern Europe, and Central Asia. Several studies have looked at the potential for reducing environmental pressures from transport – including the recent studies on environmentally sustainable transport in OECD countries and Central Europe (see Box 5.3; CEI 1999, OECD 2000). Although the aim of these studies was far more ambitious than the 'moderate measures' studied in this report, there are several lessons to be learnt from these reports. First of all, they indicate that no single approach exists that on its own will significantly reduce energy consumption in transport: good policies need to be a combination of stimulating technological options and behavioural changes (such as use of collective and non-motorised transport). Secondly, implementation of non-regret options only can reduce the growth of energy consumption in transport – but will not be able to stabilise consumption at 1990 levels (or lower). As this means that more radical measures are required for an environmentally sustainable transport system, increasing public awareness is a crucial step of any policy.

There are several options available that could classify as more moderate measures. First, stimulating up-to-date technology for new passenger vehicles. One conceivable strategy is based on stimulating joint ventures or other enterprise-level collaboration between car manufacturers in Western European, and especially Eastern European and Central Asian, countries. Obviously, such a strategy has to be supplemented with an array of specific measures (e.g. on imports of used cars) to actually harvest environmental benefits. Several authors indicate that considerable energy efficiency improvements can be attained – up to 50 per cent for new cars by about 2010 (e.g. Blok and others 1996; DeCicco and Ross 1993; Trafico 1998).

Secondly, under baseline conditions the relatively well developed public transport systems, especially in Central and Eastern Europe, are likely to lose market shares as incomes rise and car ownership, reflecting status, rises with it. An important measure, therefore, is to maintain and even upgrade the present public transport systems in these subregions. That overall energy efficiency in transport can indeed deteriorate while vehicles become more efficient has been demonstrated in the United Kingdom between the mid-1970s and the mid-1990s (HMSO 1996).

A third option for economies in transition is pro-rail policies in goods transport. The baseline scenario reflects 'usual development' as production and consumption grow, with the growth in international transport is even larger. The three eastern subregions will have developed the modal split that is now common in Western Europe, where 85 per cent of transport goes by road. Freight transport by air shows a double digit annual growth. This is of immediate relevance to Central Europe, with already open economies (CE 1997), potential for EU accession (see Box 3.3) and, in some countries, a possible strategic decision to develop a role as transit country (UN-ECE 1997). Whether pro-rail policies can indeed be labelled 'moderate' is open to discussion, considering the investment levels involved. At any rate they belong to the domain of strategic government decisions about infrastructure. In this respect, the economic changes in Central Europe and closer linkages with the EU are not only the driving forces behind the projected increase in goods transport but constitute a unique window of opportunity as well.

Fourth, the total distance travelled by cars in urban agglomerations can be reduced. Experiences in north-west Europe (e.g. Germany) have shown that the most effective way to do so is by introducing parking restrictions[24] for cars and introducing Park-and-Ride schemes. Careful and planned introduction has proven to be essential. Compensation, e.g. in the form of reduced rates for the inhabitants of the area, is often considered necessary to get the measures accepted by the public. Experience has shown that the total distance travelled by car can drop by 50 per cent in inner cities. The most affected group are shop owners who can experience up to a 20 per cent drop in turnover

Box 5.3: Environmentally sustainable transport in Europe

In Chapter 2 we discussed that under baseline conditions transport in Europe is expected to grow strongly – and that there are strong concerns about the increasing adverse environmental impacts caused by this. The same observation has been one of the reasons for the OECD to initiate a project with the objective to characterise how an alternative, environmentally sustainable transport (EST) system should look like and to establish guidelines for policies whose implementation could lead to attainment of EST (OECD 2000). The definitions of EST have been set at a very ambitious level: it would, for instance, require an emission reduction for carbon dioxide in 2030 of 80 per cent compared to 1990 (and thus, would go far beyond the 'moderate measures' set central in this report). Nevertheless, the main conclusion from this project, so far, is that EST is attainable, although only with a broad-based and concerted commitment. It became also clear that it would require both technical measures and changes in behaviour. In general, the instruments included were mostly: 1) directed at private transport rather than freight, 2) regulatory rather than fiscal and 3) directed at achieving mode shifts. The overall economic effects of a transition towards EST were estimated to be slight – the changes in policies orientation, however, need to be very large as present transport practices have a formidable momentum.

Connected to the OECD project, a similar project has been undertaken by a group of Central European countries. This project sought to use the advantage that Central and Eastern European countries have of a currently already more sustainable transport system. This advantage, however, has to be used quickly because it will be rapidly eroded if current shifts are continued. In general terms, the Central European project led to the same conclusions as the OECD project: it is possible to come to an EST system – but it will require action from several parts of society (CEI 1999).

[24] Generally under implementation in two ways: by reducing the number of parking places and by increasing the parking price per hour, the latter often resulting in net benefits for the municipal authorities.

during the first six months after introduction of the measures. However, the greatest part of this loss is usually recovered when consumers get used to the measures. Such measures seem particularly applicable to several inner cities in Central Europe as part of a conceivable economic orientation towards tourism.

Other relatively moderate measures that could support a transport policy include tax exemptions for more sustainable transport forms (including car sharing), enforcing speed limits, training for truck drivers and aviation-efficiency measures.

In Table 5.4 an overview is given of potential moderate measures, targeted at the transport sector.

Table 5.4: Examples of measures for energy and the environment in the transport sector

Western Europe	Central Europe	Eastern Europe	Central Asia
• Joint ventures or other enterprise-level collaboration between car manufacturers • Corporate average fuel standards • Discouraging car use in city centres • Taxation of petrol • Tax exemptions for more sustainable transport modes	• Discouraging car use in city centres • Pro-rail policies • Maintaining and upgrading the public transport system • Tax exemptions for more sustainable transport modes	• Discouraging car use in city centres • Pro-rail policies • Maintaining and upgrading the public transport system	• Discouraging car use in city centres • Pro-rail policies • Maintaining and upgrading the public transport system

5.1.5 Added environmental measures

A third 'tier in the cake' of moderate measures relates to pollution prevention and further reduction in greenhouse gas emissions.

Climate change

In addition to the measures discussed above, energy-related carbon dioxide emissions could be further decreased by removing carbon dioxide and storing it, for example in natural gas fields after they have been exhausted. Claims have been made that this method can be economical in comparison with other measures to decrease carbon dioxide emissions and can for instance be combined with enhanced recovery of methane (Hendriks 1994). However, this option is still innovative and its role in the short term is limited. Furthermore, research into the technical and economic feasibility and environmental impact is still required (see Hendriks 1994). Therefore this does not seem an option in the context of this study.

Energy-related emissions of other greenhouse gas emissions can also be decreased. Blok and de Jager (1994) and van Amstel and others (1993) present an overview of measures to prevent methane emissions related to energy production. Economically attractive measures include leakage prevention and gas flaring. Total technical potential for emission reduction is estimated at 50 per cent.

Acidification

In addition to more energy efficiency, emissions of acidifying compounds can be significantly decreased by pollution prevention proper. For instance, such measures include limits on the sulphur content of gas oil, nitrogen oxide emissions standards for stationary sources, cars and light duty trucks, and measures directed at fertiliser use and the use of low nitrogen cattle feed to reduce ammonia emissions.

It should be noted that the emission reductions agreed upon in the Sulphur and Nitrogen Oxides Protocols to the Convention on Long-range Transboundary Air Pollution have already been included in the baseline scenario for the countries that have signed the protocols. Moreover, implementation is assumed to be 100 per cent effective. This means that the most cost-effective measures for reducing emissions have already been implied in the baseline scenario.

However, due to the higher sulphur content of domestic fuels and the low current energy efficiency, the potential for fuel and technology switching and energy saving measures in Central and Eastern Europe and Central Asia remains generally large. As a consequence, sulphur emissions reduction costs in Central and Eastern Europe (no calculations available for Central Asia) are 50 to 70 per cent lower than in Western Europe. In Western Europe, similar types of measures have already been almost exhausted; more expensive measures will be required to achieve further reductions.

In view of the above factors, only a limited set of additional measures of moderate cost relative to GNP can be part of the moderate measures. Similar to EU policies, regulation can be the main implementation approach.

Tropospheric ozone

The baseline scenario includes the required emission reductions in Western, Central and Eastern Europe under the protocols of the Convention on Long-range Transboundary Air Pollution and EU directives. These reductions already include the provisions of the Volatile Organic Compounds (VOC) Protocol under the Convention on Long-range Transboundary Air Pollution.

Further measures possible for all subregions include:

- modification and substitution of industrial and non-industrial paints, glues, inks and other solvent use in order to reduce VOC emissions (when applicable);
- vapour recovery units for the chemical industry and refineries;
- additional application of catalysts to reduce nitrogen oxides and decrease VOC emissions from cars; and
- measures to decrease emissions from tankers and loading facilities.

Urban air pollution

In addition to energy efficiency, emissions of polluting compounds can be significantly decreased by end-of-pipe measures. Such measures include, for instance, limits on sulphur content in gas oil, and nitrogen oxide emissions standards for stationary sources and cars. Most of the general measures are, however, already agreed upon at national and international levels (EU or UN-ECE legislation/protocols) and therefore are already included in the baseline scenario. Further tightening of emissions standards for nitrogen oxides and/or particulate matter in Western and Central Europe after 2003 for diesel-fuelled traffic is possible for all transport modes and will further reduce emissions considerably. As a consequence, there will be less exceeding of air quality standards.

Another cost-effective measure against air pollution by particulate matter, especially in Central Asia, is paving roads in and near large populated areas (compare WHO and UNEP 1992).

A general ban in Europe on high-leaded petrol can reduce lead in the air to far below WHO standards in all European cities. In a large part of Europe[25] low-leaded or lead-free petrol already dominates the market. According to a World Bank report (Lovei 1996), leaded petrol is responsible for 90 per cent of lead emissions to the air. There are hardly any technological obstacles to the production of low-leaded petrol (0.05-0.15 grams of lead per litre of petrol), and practically all cars built since 1970 can drive on it. A comparative study conducted in the European Union showed that low-leaded petrol will have to be cheaper than leaded petrol to successfully gain market share.

Nuclear risks

Nuclear power plants in Central and Eastern Europe currently dominate the risks due to nuclear accidents over the whole region. Unfortunately, for the current limited analysis, no information is available on the separate effect of only moderate measures to reduce the risks of major accidents.

The most effective measure to reduce nuclear risks is to close all 27 most unsafe reactors (most of them in the Russian Federation) and replace them by reactors that meet West European standards. The costs of decommissioning a nuclear power plant vary widely between countries, but are generally in the range of hundreds of millions of dollars. The decommissioning of a 330 MW nuclear power plant in the United States in 1993 amounted to 300 million dollars and the decommissioning of a 1000 MW plant in Scotland cost about US$175 million (EQE 1993; TLG 1998). The costs of premature replacement is, in addition, a matter of interest rates. If a nuclear power station is replaced earlier than planned, the costs for decommissioning (and building a new power station) are advanced to an earlier date. For example, premature replacement (10 to 15 years) of the two Ingalina plants in Lithuania is estimated to increase the cost of power supply by about US$500 million (INSC 1998). The Ukraine government is estimated to require US$750 million to repair the sarcophagus of the Chernobyl-4 plant and to decommission Chernobyl-3 (Reuters 1998). Decommissioning plants is thus very costly and requires foreign investment, but is probably the most effective measure.

Alternatively, a good energy conservation strategy and the use of other types of power production could reduce the need for Central and Eastern European countries to rely on nuclear power. In addition, modifications can be made to overcome the most important deficiencies in unsafe reactors. Many safety studies have been conducted for Eastern European power plants in the framework of the PHARE and TACIS programmes. Measures that were taken as a result of the studies often resulted in a substantial lowering of the core melt probability. Measures to achieve a reduction of core melt probability by a factor of 10 were often relatively low-cost, for instance when only changes in procedures were required. Safety studies needed to find out which measures should be taken, however, typically cost five to ten million dollars. For some of the older plants further measures are necessary. These consist of modification programmes concerning redundancy in cooling systems, emergency cooling systems, renewal of materials in connection with corrosion and brittle break. These programmes typically cost ten to hundreds of million of dollars. In these cases also, core melt probability could be improved up to a factor of ten. In addition, measures can be

[25] Low-leaded and lead-free petrol have been realised in all Western countries and some of the countries in Central and Eastern Europe (such as Slovakia, Hungary and Poland) (Lovei 1996).

taken to minimise the emission in case of a core melt. However these measures are even more costly than the measures discussed above, almost as costly as building a new plant.

Other measures which could reduce nuclear risks are the following.
- International co-operation and inspection (for example, by International Atomic Energy Agency and the Nuclear Safety Account) can significantly reduce the risk of accidents.
- General third party liability protection would greatly facilitate hiring Western contractors for technical improvements to unsafe nuclear power plants. At the time of writing, neither Russia nor Ukraine has ratified the Vienna Convention, which would have ensured that the responsibility for damage caused by a nuclear accident is channelled to the plant operator. In the absence of ratification, liability protection remains to be arranged via cumbersome government-to-government agreements.

Thus, structural measures to reduce nuclear safety in Eastern and Central Europe by either replacing or restructuring existing plants are costly. Alternative measures aimed at improving management and development of accident procedures have much lower costs but can reduce risks in power plants to a more limited degree.

In Table 5.5, an overview of the additional measures for environmental protection and nuclear safety is presented.

Table 5.5: Examples of moderate measures targeted at improving environmental protection and nuclear safety in nuclear power generation

Western Europe	Central Europe	Eastern Europe	Central Asia
	• Additional measures to reduce acidifying emissions • Modification of existing nuclear plants • International cooperation and training	• Simple measures to reduce acidifying emissions • Discouraging the use of leaded fuel • Modification of existing nuclear plants • International cooperation and training	• Paving unpaved roads near city centres • Discouraging the use of leaded fuel • Simple measures to reduce acidifying emissions

5.3 Adding it all up: energy-related measures

It would be interesting to know the total potential of moderate measures that could be taken in each of the regions. However, although many scenario studies exist at the level of the subregions, most of the studies looking at specific measures focus on the national level (with the exception of Western Europe). Therefore in the context of this study a compilation has been made of several country-specific energy efficiency studies for Poland (Central Europe), the Russian Federation (Eastern Europe) and Kazakhstan (Central Asia) (Grootscholten and others 1999). The results of this study are discussed here briefly to give some indication of the total potential for measures. It should be noted that not all measures need to be taken in the subregion itself. With regard to climate change, in particular, the Kyoto Protocol has introduced new flexible instruments that account for measures taken in other subregions. Box 5.4 discusses some of the consequences this might have.

The purpose of compiling country-specific technology-oriented energy efficiency studies was to underpin the macro-level scenarios discussed in the next chapter. As some of the three country specific studies focused on specific sectors, an attempt has been made to estimate the total potential. Of the measures they describe, it was possible to select from the studies those options that could be considered 'moderate', i.e. cost effective (using a pay-back time of 2-3 years) and relatively easy to implement (implementation period of 2-5 years). Table 5.6 summarises the highest savings potential on the basis of moderate measures found for each of the three countries as well as our estimate for the total savings potential on the basis of selected options.

Table 5.6 indicates considerable scope (between 25-35 per cent in the three countries looked at) for improving energy efficiency by means of specifically identified moderate measures. Similar conclusions are reached in other studies for the region, e.g. Hlobil (1997), who indicates that between 20 and 40 per cent energy savings are realistically achievable by the year 2010 through cost-effective measures. In contrast with expectations on the basis of energy efficiency, the savings potential seems to decrease going from Poland to Russia to Kazakhstan. However, this could be caused by the fact that more and more comprehensive studies were available for Poland.

Table 5.6: Savings potential by means of 'moderate' energy efficiency options in specific countries – baseline years between 1990 and 1995

	Sources	Largest potential in dividual studies	Estimated combined potential
		%	
Poland (Central Europe)	IEP 1996,	30	35
	Gaj and others 1997		
Russia (Eastern Europe)	Bashmakov and Chupyatokov 1992,	26	30
	Avdiushin and others 1997b,		
	IEA 1996	26	
Kazakstan (Central Asia)	Pilifosofa and others 1997	11	25

Already under the baseline scenario considerable energy intensity improvement of around 20 per cent is realised in the 1995-2010 period. Part of this improvement will come from the potential for energy efficiency as identified, while the rest will be the result from macro-economic changes. Obviously, for estimates of the scope for further reductions over the baseline scenario, the part of the total potential that is already used in the baseline scenario needs to be subtracted. Based on country-specific information, the total potential mentioned in Table 5.6 and the description of the baseline scenario, we estimate that by means of 'moderate measures' in Central Europe about 10-15% of total energy use can be avoided relative to the baseline. Note that in Central Europe the baseline scenario already assumes a large improvement of energy efficiency. In Eastern Europe and Central Asia, this percentage is about 15-20%. The scenarios discussed in Chapter 6 comply to these potentials.

There are more studies in Western Europe on the total potential of emission reduction measures. Most focus on identifying sufficient reduction options for meeting the reduction targets required under the Kyoto Protocol. The outcomes of several of these studies have been summarised by Phylipsen and Blok (1998) and the European Environment Agency (1999). This shown in Tables 5.7 and 5.8. It must be concluded here that even in Western Europe potential is available for additional moderate measures in the energy system, although often at higher costs than in other subregions.

Table 5.7 indicates that an annual 800 Mtonne emission decrease could be put together (Phylipsen and Blok 1998) to be achieved by relatively low-cost measures in the energy system. The 800 Mtonne reduction equals approximately 20 per cent of the baseline emissions. Phylipsen and Blok indicate that only limited part of this will be implemented by current policies (baseline) – implying considerable scope for alternative policies. The scenario discussed in Chapter 6 corresponds to the potentials for further savings in Western Europe indicated here.

Table 5.7: Overview of policies and measures to decrease emissions of carbon dioxide in Western Europe

	Potential effect	**Required policies**	**Expected effect of present stage of implementation**
	Mtonne CO_2 avoided per year		
Energy efficiency of appliances and buildings	50-100	⇨ Building standards ⇨ Dynamic efficiency standards	Limited
Energy efficiency in heavy industry	100	⇨ Voluntary agreements, including targets and monitoring	Part of potential
Energy efficiency in transport standards	100	⇨ Agreements or fuel economy	Part of potential
Energy taxation	50	⇨ Uniform taxation level	Very limited
Renewable energy	200	⇨ Renewable-energy obligation ⇨ Budget for campaign for take-off	Limited
Combined generation of heat and power	100	⇨ Agreement on CHP obligations	Part of potential
Other	150-200		
Total	**800**		**200**

Source: Phylipsen and Blok 1998

The European Environment Agency has also identified considerable potential for additional measures in Western Europe, which in total could lead to 770 Mtonne less carbon dioxide equivalents being emitted annually. Of these avoided emissions, about 60 per cent could come from measures in the energy system (see Table 5.8). Most studies seem to agree that reductions in the near term (approximately as up to 2010) will have to come mainly from energy efficiency improvement. In addition, emissions can be decreased by fossil fuel switch (partly already included in the baseline scenario) and renewable energy.

It should be noted that in view of technological development and implementation processes, technically-oriented studies tend to identify larger possibilities to decrease carbon dioxide emissions in the long term (up to 2040). However, to realise the implementation of this potential in the long term, early action is required in many instances.

Table 5.8: Potential of measures to decrease emissions of greenhouse gases in EU-15, 2010

	Emission decrease	Average costs	
		Very low	Low (below 50 US$/tonne)
	Mtonne CO_2 equivalent		
Carbon dioxide			
Transport, increased car fuel efficiency	145	X	X
Industry	66		X
Buildings	33		
Power generation			
- fossil fuel switching	86		X
- CHP	31		X
- Renewables	79		X
Methane			
Agriculture (improved manure management)	34	X	
	20		X
Waste (landfill gas recovery)	23		X
	23		X
Energy (reduction gas leakage)	4	X	
Dinitrogen oxide			
Agriculture (reduced fertiliser application)	24	X	
Waste	1	X	
Industry	86		X
Energy	8	X	
Halogenated gases			
HFC	46		X
PFC	4		X
SF6	7		X
Total	**770**		

Source: EEA 1999

Box 5.4: The Kyoto Protocol – the implications of the new flexibility instruments

During the third Conference of Parties to the Framework Convention on Climate Change in December 1997, the so-called Kyoto Protocol was adopted. This Protocol defines new commitments for developed country (Annex B) parties to reduce their overall greenhouse gas emissions by an average of at least 5.2 per cent of their 1990 levels in the 2008–2012 period. The reduction commitments differ among the Annex B parties. The EU will decrease its emissions by 8 per cent. Of the Central European countries listed under Annex B most have shared the EU reduction target, while Russia and the Ukraine have only committed themselves to stabilising emissions. How the resulting emission reduction targets for Western, Central and Eastern Europe will relate to the assumed baseline emissions is shown in Figure 3.2.

In addition, the parties to the FCCC have introduced three new instruments under the Protocol for realising these commitments:
(1) Emission trading between Annex B countries;
(2) Joint Implementation (JI) between Annex B countries and
(3) the Clean Development Mechanism (CDM), enabling Annex B countries to gain emission reduction credits by financing projects in non-Annex B countries.

The main consideration for introducing these instruments is to reduce the costs of emission reductions, as these are generally lower outside OECD countries (see, for instance, Figure 5.2). In this way, a higher overall emission reduction target could be reached during the Kyoto negotiations. The CDM was also introduced to enhance the effectiveness of emission control by promoting early emission control in non-Annex B countries. However, the rules for using these instruments have not yet been clearly defined. As a consequence, the implications of the new instruments cannot yet be easily assessed. An important question concerns the conditions for the use of the different instruments. The Kyoto Protocol states that the contribution of emission trading and JI should be "supplemental" to national measures; however, what is meant by "supplemental" has not been specified. During the Kyoto negotiations the EU argued for limiting on the contribution of emission trading to meeting the commitments under the protocol (e.g. to less than 50 per cent of the total emission reduction from the baseline scenario). Many other Annex B parties, however, do not want any quantitative limitations. One reason for limiting the contribution of emission trading is to prevent trade in "hot air reductions", that are not a result of policy measures but stem from baseline emissions by 2010 being below 1990 levels, as in the case of Eastern Europe (see Figure 3.2).

Potentially, the CDM could make a major contribution as there are many low-cost options for emission reductions in developing countries as part of sustainable development projects. Moreover, the Protocol allows for gaining credits from such projects from 2000 onwards, while emission trading and JI between Annex B parties are confined to the first budget period (2008–2012). However, both organisational and verification problems could pose major obstacles for realising the CDM potential.

Although the results are dependent on the assumed baseline emissions, it can be concluded that thanks to the flexibility instruments, the Kyoto Protocol commitments can be met in Europe and the Central Asia region with moderate policies and are likely to stimulate economic development in Central and Eastern Europe. However, to limit the risk of 'hot air' trading and to foster efficiency improvement in Central and Eastern Europe, some limiting of emission trading in favour of the joint implementation instrument could be beneficial.

The introduction of flexibility instruments has substantial positive implications for the costs of implementing the Kyoto Protocol, as discussed in more detail in the next chapter. This can be illustrated by the results of an assessment of the economic effects of using emission trading to meet the Kyoto Protocol targets (Gielen and Koopmans 1998). The analysis shows that emission trading within Annex B results in a reduction of 75 per cent in the marginal costs of CO_2 reduction in 2010 for the EU (from about US$80 to US$20 per ton of carbon). As a result, the macro-economic impacts are reduced from 0.25 to 0.10 per cent loss compared to baseline GDP. Moreover, for Central and Eastern Europe, emission trading results in a substantial increase in real GDP by 2010 (0.5 per cent for Central Europe and 1.35 per cent for Eastern Europe (FSU)) because they will be able to sell a substantial amount of emissions avoidance to other Annex B parties.

5.4 Main findings

In all subregions there is scope for a more rapid transition towards energy patterns that are environmentally less burdensome. In fact, reductions in carbon dioxide emissions of 25-35 per cent by

measures in the energy system seem to be possible at relatively low costs (or 15-20 per cent over the baseline). By the way of illustration, table 5.9 gives a rough indication of the contribution that various options can make to decreasing carbon dioxide emissions, of their costs and of limiting factors.
Based on the discussion, the following more detailed conclusion can be drawn:

- Large-scale improvements can be obtained only as a result of concerted policy actions to foster investment and behavioural changes. As environmental and energy policies are closely related to other policy areas such as urban planning, tax policies, alternative policies for energy efficiency and sustainable energy systems need to be integrated with the overall aims of other policies.
- Getting prices right and the use of market mechanisms form the key to cost-effective responses in all four subregions. This includes, for instance, subsidy reform: in Western Europe involving several supply-side subsidies; in the other three subregions mainly involving demand-side subsidies and solutions for the payment arrears.
- In the short term up to 2010, improving energy efficiency in the end-use sectors will be an important aspect of additional policies. Instruments to improve energy intensity in the industry and building sectors, for instance, could include voluntary agreements, building standards and improvement of district heating systems in Eastern Europe and Central Asia.
- Additional measures for the transport sector should be a policy priority, in view of its growing importance in environmental problems. Moderate measures are probably only able to slightly mitigate the growth of transport energy use – and are certainly not enough to facilitate a transition to more environmentally sustainable energy systems. Strategies that are able to facilitate such transition before 2030 have been identified, and require action to be taken in the near future.
- Another important sector is the power sector. Here, fuel switching and efficiency improvement are short-term options. European cooperation is very important in this sector, in view of the high investment costs, ongoing liberalisation and the strategic decisions involved.
- The new flexible instruments under the Kyoto Protocol have the advantage of reducing implementation costs and stimulating economic development in Central and Eastern Europe (more attention is paid to this in the next chapter).
- Several low-cost options are available to slightly improve nuclear safety in Central and Eastern Europe. However, structural measures to reduce nuclear safety in Eastern and Central Europe by either replacing or restructuring existing plants are costly.
- International cooperation within the region will be very important; it helps to share experiences and overcome certain capital constraints.

Table 5.9: Potential contribution of various technology clusters to decreasing the emissions of carbon dioxide

	Near-term potential contribution to emission decrease	Costs	Main barriers
Efficiency improvement	Large	Varying	Implementation
Fossil Fuel switch	Large	Low	Supply security
Removal of CO_2	Small-medium	Medium	Acceptance; technology
Renewables	Medium	High - decreasing	Costs
Nuclear	Medium	Low	Waste, nuclear risks, acceptance

Source: ECN 1997

6. ENVIRONMENTAL GAINS OF ACCELERATED POLICIES

This chapter sketches what difference accelerated policies could make to the environment in the Region. It does so by re-analysing existing studies and data underlying them, in order to address the environmental impacts of a scenario that matches the general characteristics outlined in the previous chapter. It organises the results according to the central question of this report, in particular the second part: *What can be achieved by additional moderate energy and environmental policies, and will this achievement be enough?* Policies as discussed in the previous chapter are typical for such a scenario: moderate, mostly low-cost energy options, including energy efficiency improvement and fuel switching, if necessary in combination with moderate emission control measures.

Although this chapter draws on a diversity of existing studies, its analytical framework is to assess the effect of accelerated policies when applied *as a package*. Therefore, we will first discuss effect on energy demand and supply, and next, the environmental impacts.

In order to highlight the uncertainties involved, the chapter discusses effects of more than one measure and/or study. Obviously, this could only be done when enough information was available. In fact, for urban air pollution and nuclear risks, no information was available to analyse the impact of moderate policies in the entire Region. Nevertheless, in order to give an impression of the range of possibilities, this chapter does include a discussion on alternative policies for urban air pollution and nuclear risks but it is based on the potential environmental gains of more ambitious environmental policies.

6.1 Impacts of accelerated policies on energy demand and supply

Even without alternative policies, energy intensity for each sub-region is projected to improve significantly (Chapter 2). In addition, policy options capable of boosting this improvement with only moderate measures (as described in Chapter 5) could be identified. In order to estimate the effect accelerated policies would have on energy demand and supply, this chapter bases itself on projections of IEA, of IIASA and of NTUA[26]. In terms of developments in energy intensity the Accelerated Policies scenario described in this study and the IIASA calculations correspond very well to the IEA projections. Furthermore, information from technology oriented studies at the country level has been used to test whether our projections remain within the boundaries of realism (see Section 5.3).

Table 6.1 and Figure 6.1 summarise the Accelerated Policies scenario. Table 6.1 shows that in each sub-region accelerated policies are expected to further decrease (that is: improve) the overall energy intensity and carbon factor, compared with the baseline scenario[27].

[26] These studies are the IEA/OECD projections for the World Energy Outlook (IEA 1996), IIASA calculations made in the context of the EEA environmental assessments (Cofala and others 1999) and calculations made by NTUA (RIVM and others 2000). The latter in particular have been taken into account because the results meet the Kyoto commitments. The 1996 IEA/OECD projections are important as this study has paid attention to the potential gains of cost-effective technologies in reference to a business-as-usual scenario in Central Europe and the former Soviet Union (Eastern Europe and Central Asia).

[27] Energy intensity is energy consumption divided by GDP, here measured in purchase-power parity. This ratio is often used as an indicator of the efficiency of energy consumption - the limits and use of this indicator have been discussed in Chapter 5. The carbon factor is the ratio between carbon dioxide emissions and energy consumption, and is influenced by a shift from high carbon-containing fuels (e.g. coal) to low or no carbon-containing fuels. (e.g. natural gas or renewables).

Table 6.1: Changes in energy demand and supply, 1995-2010, accelerated policies assumed

		WE	CE	EE	CA
		% per year			
Change in energy intensity	Without accelerated policies	- 1.4	- 2.4	- 1.4	- 1.5
	With accelerated policies	- 2.3	- 3.3	- 2.6	- 3.0
Change in carbon factor	Without accelerated policies	- 0.3	- 0.2	- 0.0	- 0.1
	With accelerated policies	- 0.6	- 0.4	- 0.3	- 0.3

The improvement between baseline scenario and accelerated policies is largest in Central Asia, but also considerable in each of the other subregions (Table 6.1). In the whole Region the carbon factor decreases, mainly as a result of a more than proportional decrease in the use of coal and a further shift towards the use of natural gas. These changes lead to developments in primary energy consumption as shown in Figure 6.1. Details per subregion are briefly discussed below.

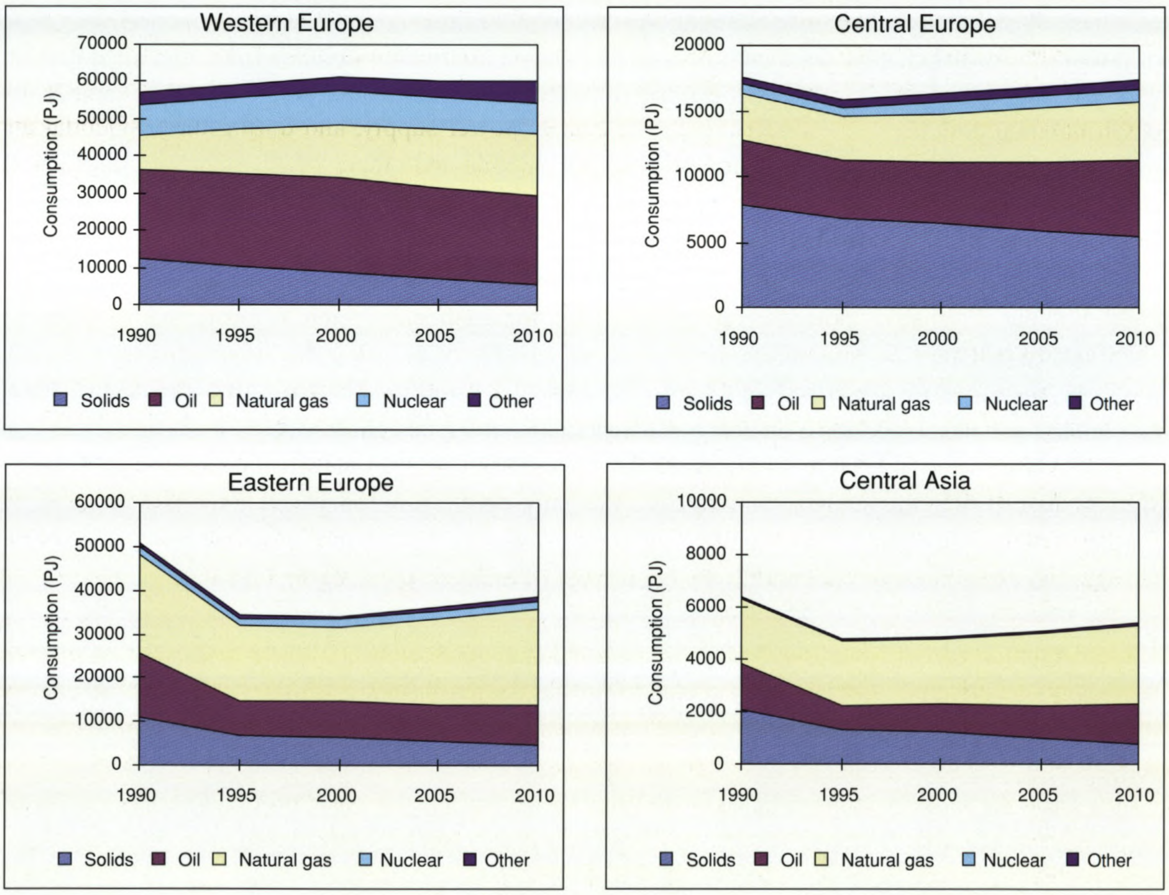

Figure 6.1: Consumption of primary energy, accelerated policies assumed

In comparison with the energy developments under the baseline scenario (chapter 2) accelerated policies reflect more energy efficiency and less use of solid fuels.

Note different scales.

Western Europe

Energy use in the Western European subregion is efficient compared to the other European subregions. Nevertheless, accelerated policies can still tap a considerable potential for efficiency improvement beyond that of the baseline scenario. This can be illustrated with recent studies (see, for instance, RIVM and others 2000 and EEA 1999), which show that the Kyoto target for the EU can be met by emission reduction *within* the European Union at average costs of US$ 50-60 per ton of carbon[28]. Approximately a third of this would be achieved by further reducing the share of solid fuels. Another 20 per cent would come from increased use of renewable energy sources. Finally, about half the change would come from accelerated improvement in energy efficiency and from changes in the structure of the EU economy. We have assumed this as an elaboration of the accelerated policies for Western Europe formulated in Chapter 5.

Central Europe

In Central Europe, the technical and economic potential for energy efficiency improvement is relatively large, while the social and economic conditions would seem to enable this potential to be harnessed. It was found that by using cost-effective measures it would be possible to reduce the growth in energy consumption so that by 2010 it would be about 10-15 per cent less than in the baseline scenario (IEA 1996). In line with IIASA we assume that accelerated policies are able to stimulate the improvement in energy intensity to the range of 3 to 3.5 per cent decrease per year, during the 2000 – 2010 period (Cofala and others 1999). This is an optimistic assumption. However, the *additional* gains compared to baseline remain modest, because assumedly significant improvement will already occur without accelerated policies (Chapter 2). Considerable environmental benefits can also be expected from moving away from the extensive use of coal in power supply, and during the residential and service sectors towards natural gas and oil use[29] (see Cofala and others 1999). However, such a shift requires significant imports to the subregion and given the economic situation there is a considerable amount of coal that is not likely to be substituted before 2010. Therefore we have only assumed a modest change in the share of coal in energy supply.

Eastern Europe

Eastern Europe has considerable room for energy efficiency improvement, as the national economies are among the most energy intensive in the world. Based inter alia on IEA's 1996 World Energy Outlook – which concentrated on the potential for energy efficiency improvement in the former Soviet Union - we have assumed that accelerated policies might be able to speed up improvements in energy efficiency to around 3 per cent a year (IEA 1996; Cofala and others 1999). A significant portion of the energy savings come from industry – where efficiency improvement rates between 3 and 5 or 6 per cent are considered possible. In the residential sector much less improvement is likely up to 2010 due to slow replacement of the building stock and increasing consumption. On the other hand, several republics in the subregion do not have domestic energy resources; macro-economic pressures could lead these countries to enforce more vigorous energy intensity improvement than the subregion's average. Finally, further environmental benefits could come from an increase of the market share of natural gas (Cofala and others 1999). This strongly depends on the energy (supply and export) strategies of Russia and the Ukraine – but in principle fuel switching could provide a cost-efficient option.

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[28] The lower estimate assumes a more than proportional decrease in the emission of other greenhouse gases than carbon dioxide. Costs of abatement are expressed in US dollar (in 1997) per ton of carbon dioxide equivalent.

[29] In our scenario we assumed the amount of nuclear power generation under accelerated policies to be equal to the baseline scenario.

Central Asia

Energywise, assumptions for accelerated policies in Central Asia resemble those for Eastern Europe. However, there are two important considerations to be taken into account here. First, the economic outlook in the Central Asian countries seems to be better than for Eastern Europe (see Chapter 2) which implies higher investments rates and thus potentially faster rates of energy efficiency improvement. On the other hand, energy intensity improvement can be assumed to occur more slowly in the energy-exporting countries in this subregion, as heavy industries are likely to remain the dominant activity in terms of energy use. On balance, we assume the improvement of energy intensity to average 2.8 per cent per year between 1995 and 2010.

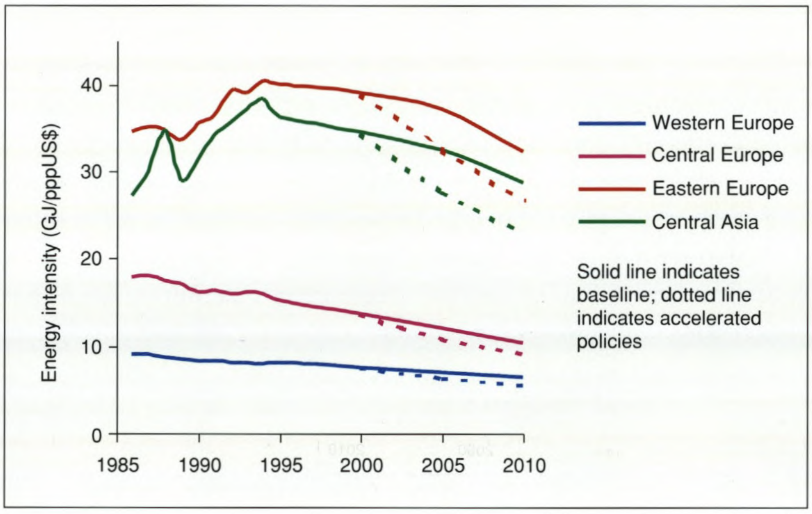

Figure 6.2: Energy intensity

Accelerated policies can decrease energy intensity by 10-20 per cent compared to baseline.

How energy intensities would evolve under accelerated policies has been summarised in Figure 6.2. The figure shows that energy intensity is projected to improve considerably in Eastern Europe and Central Asia, although remaining significantly above Western European levels. In proportion to 1990, the largest improvement is expected for Central Europe. However, most of this improvement was already assumed under baseline conditions, that is without accelerated policies.

6.2 Climate change

In this section we will first of all consider the consequences of the energy scenario laid down in the previous section in terms of greenhouse gas emissions. This scenario assumes that all subregions either use locally available potential to meet their Kyoto targets (Western Europe and Central Europe) or will implement alternative policies for other environmental or economic reasons. Next, we will discuss the possible consequences of emission trading for climate change emissions within the Region. Finally, we will discuss the potential impacts of the scenario discussed here, using the Safe Emission Corridor concept. Most of the figures and calculations here concentrate on carbon dioxide – as it is by far the main greenhouse gas (about 70 per cent of all emissions in terms of greenhouse gas equivalents). In terms of emission reductions, in particular in Western Europe, methane and nitrous oxide emissions might be reduced more than proportionally but this does not significantly alter the figures shown.

Emissions under the Accelerated Policies scenario

Figure 6.3 shows the emission that would result from the Baseline and Accelerated Policies scenarios. Assuming the energy pathways described in the previous section, greenhouse gas emissions from Western and Central Europe are expected to drop by about 8 per cent and 5 per cent, respectively, compared to 1990, which means that both subregions will meet their Kyoto targets. In Eastern Europe and Central Asia emissions could decrease significantly spurred by moderate energy measures (see previous section).

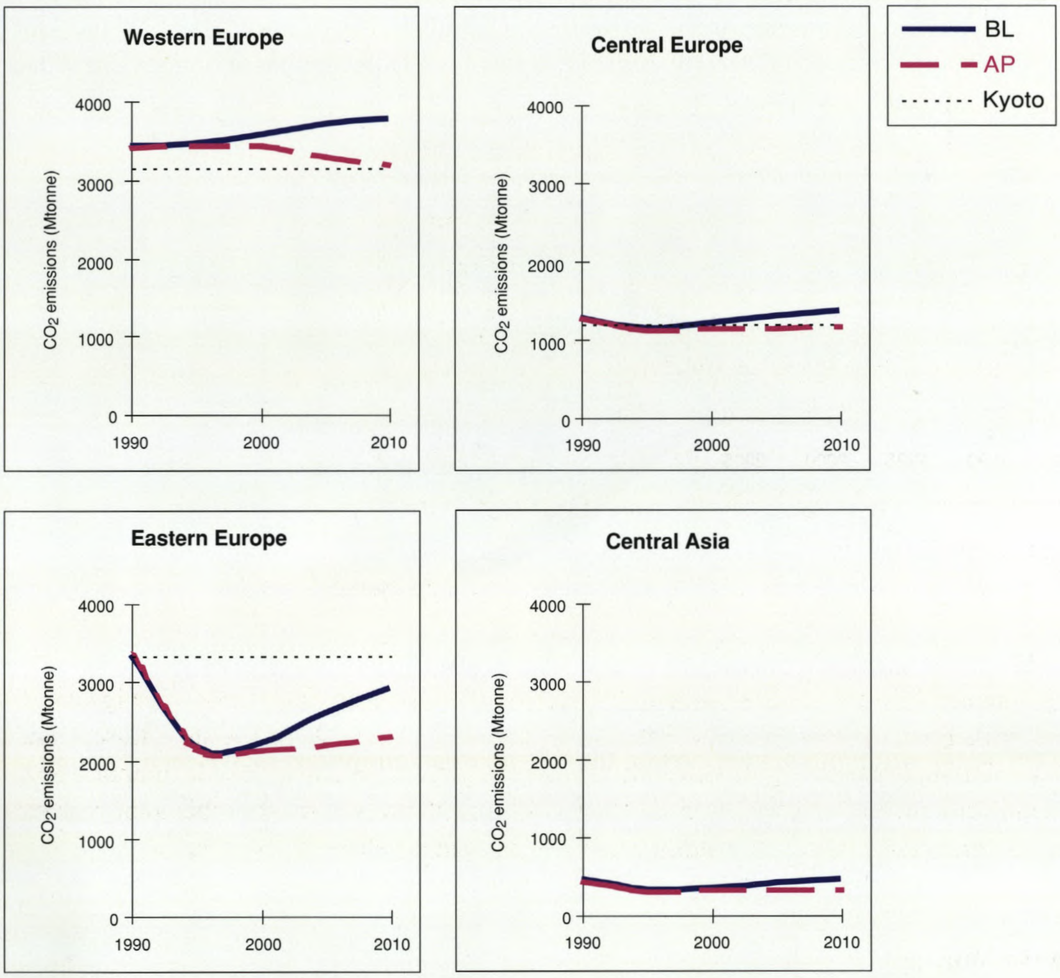

Figure 6.3: Emission of carbon dioxide

Accelerated policies could reduce emissions throughout the region.

(BL : Baseline; AP : Accelerated Policies; Kyoto indicates the target agreed upon under the Kyoto protocol for the 2008-2012 period.)

In Western Europe, the difference between emissions under the baseline scenario and the Accelerated Policies scenario is about 600 Mtonnes of carbon dioxide equivalents per year. Table 5.8 (from EEA 1999) gives some indication of the potential for measures in Western Europe. Figure 6.4 shows the contribution of various abatement options assumed for carbon dioxide within the accelerated policies scenario. On the basis of Table 5.8 and other calculations (RIVM and others 2000) it can be expected that between 60-85 per cent of the decrease of greenhouse gas emissions are obtained by decreasing carbon dioxide emissions – while the remainder will mainly come from decreasing methane and nitrous oxide emissions. In total, abatement costs are expected to amount to 30 US$ per tonne carbon (e.g. RIVM and others 2000; EEA 1999)[30]. Consequently, the macro-economic costs are expected to total between 14 and 24 thousand million US$ (RIVM and others 2000). For Central and Eastern Europe and Central Asia it can be expected that costs are significantly lower than mentioned for Western Europe. At the margin, implementation costs of the type of scenario laid down here are expected to be less than 10 US$ per ton carbon in Central Europe (based on ECN 1997). Similarly, the overall costs of this scenario come to several thousand million of US dollars at maximum for Eastern Europe, between 1 and 2 thousand million US dollars in Central Europe and below one thousand million US dollars for Central Asia. In the latter subregion, the average costs could even be negative as there is a large number of options that reduce energy consumption and save money.

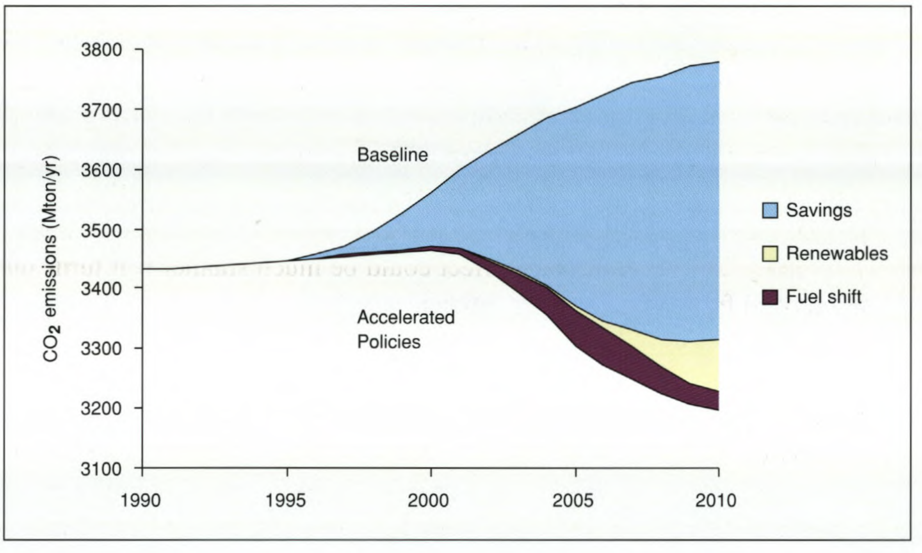

Figure 6.4: Contribution of various carbon dioxide abatement options in Western Europe
Most of the reduction comes from efficiency improvements. In addition, fuel switch and renewables contribute to decreasing carbon dioxide emissions.
Source: Based on Figure 6.1.

Emission trading

As a partial alternative to domestic emission reductions, the Kyoto Protocol allows implementing countries with relatively high reduction costs (like Japan, USA and the countries in Western Europe[31])meet their Kyoto commitments by buying credit for emission decreases abroad. As emission reduction costs are thought to be lower in other Annex B countries[32], in particular Central

[30]One tonne carbon corresponds with 3.67 tonne carbon dioxide. Therefore 30 US$ per tonne carbon corresponds to 8.2 US$ per tonne carbon dioxide.

[31]Large differences in marginal reduction costs also exist among countries within the European Union. The Kyoto Protocol allows for emission trading or alternative reduction targets within the European Union to reduce overall costs. The numbers shown in this report assume such a cost-efficient implementation of reduction targets.

[32]Annex B countries are those countries that have been assigned emission targets under the Kyoto Protocol.

and Eastern Europe, such a trading scheme could reduce overall costs of climate policies. Under such trading, part of the action in the energy field would be moved to other subregions. We will look into the consequences by comparing the following two variants:

- *'Unilateral implementation of Kyoto commitments'*, assuming that all subregions with Kyoto commitments will meet these commitments by solely implementing locally available potential;
- *'Full trade implementation of Kyoto commitments'*, assuming that the Kyoto commitments are achieved by allowing full trade among Annex B countries. Thus, the mitigation costs are fully minimised for all Annex B countries. We have only assumed trade in credit for carbon dioxide emission reductions as this is by far the most important greenhouse gas.

In the first variant, the Kyoto commitments are met only by decreasing emissions within the relevant subregions – while other subregions take no measures at all. This is similar to the Accelerated Policies scenario for Western and Central Europe, but similar to the baseline in Eastern Europe and Central Asia. This would lead to relatively high costs in Western Europe, low costs in Central Europe and, as no measures are required, no costs in Eastern Europe and Central Asia[33]. In addition to relatively high implementation costs per unit this scenario could have another disadvantage. Large differences in costs could lead to 'carbon leakage' – meaning that some energy-intensive activities could move from subregions with high costs (Western Europe, but also USA and Japan) to subregions where no measures are required (non-Annex B countries and the former Soviet Union). This effect is visible in Figure 6.4 as a small increase of the emissions from Eastern Europe and Central Asia (about 8 per cent) compared to baseline emissions. It should be noted that these calculations using the WorldScan model are characterised by assuming very rapid interactions between regions – so that in reality the carbon leakage effect could be much smaller if it turns out that activities are less easily moved from one region to another.

In contrast, the second variant assumes that Annex B countries (for this study, in particular Western European countries) could buy as much emission reduction credits from other Annex B countries as is economically attractive. This extreme case will result in equal reduction costs per unit in all subregions. It was found to be cost-effective for Western Europe to reduce domestic emissions by about 5 per cent in comparison to baseline in 2010 and to obtain the remaining 10 per cent reduction by buying reduction credits from other Annex B countries – mainly from the Ukraine and Russia. By the same token, carbon dioxide emissions from Central and Eastern Europe would decrease significantly compared to the 'unilateral case'. Considering that both Japan and the USA are expected to be involved in trading, this could result in an emission reduction of 30 per cent in Central Europe and even 50 per cent in Eastern Europe in comparison to 1990. Because of lower overall compliance costs per unit, the effect of 'carbon leakage' can be assumed to be lower. On the other hand, part of the trading scheme is the so-called hot-air (the difference between the Eastern European emission target and its likely emissions under the baseline scenario). Obviously, trading of these unconsumed 'emission rights' does not reduce the global total of greenhouse gas emissions. On the other hand, trading can never result in total emissions exceeding the sum of the emission targets agreed upon in the Kyoto Protocol.

[33]The costs have been estimated using the WorldScan macro-economic model. They amount to 60-70 US$ per tonne carbon for Western Europe and 1-2 US$ per tonne for Central Europe. This is higher than the costs mentioned for the Accelerated Policies scenario.

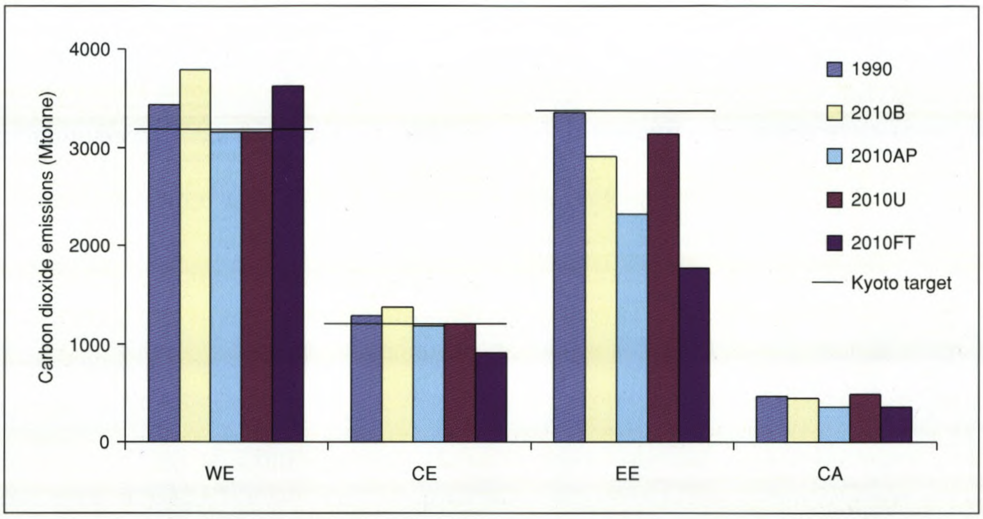

Figure 6.5: Emissions of carbon dioxide, assuming the Accelerated Policies scenario and two variants

In the accelerated policies scenario carbon dioxide emissions are decreased in all four subregions. The variants show that trading in 'emission credits' will mean a smaller decrease in Western Europe and a much larger decrease in the rest of the Region, in particular in Eastern Europe.

(2010 B : Baseline; 2010 AP : Accelerated Policies; 2010 U : Unilateral variant; 2010 FT : Full trade variant.)

Source: This report and Bollen and others, 1999

WorldScan calculations show the total costs to be reduced considerably as result of emission trading (by about 60-70 per cent) – which makes this a very cost-effective instrument for implementing the Kyoto Protocol. At the same time, however, there is considerable uncertainty with regard to emission trading, for example related to liability and consequences for long-term mitigation potential. In any case, abating carbon dioxide emissions 'at home' also decreases in most cases the emissions of other pollutants – which needs to be taken into consideration when analysing gains from international emission trading. In the section on acidification we will pay more attention to this.

Climate impacts

In this section we will focus on the consequences of the central 'Accelerated Policies' scenario. The differences in environmental impacts between the baseline scenario and the accelerated policies scenario could well be discussed in terms of the concept of 'safe emission corridors' (Alcamo and Kreileman 1996). The reason for this is that many of the environmental impacts of climate change are expected to occur in the second half of the 21st century – while the scenarios discussed here are formulated for much shorter time scales. The 'emission corridor' concept relates long-term climate protection goals to allowable ranges of emissions in the short term. If global emissions are too large in the year 2010, there is little chance that long-terms climate protection goals can be met, even taking account of the possibility for making course corrections further on in the century. On the other hand, emissions cannot be extremely small in 2010 because this would require reduction rates that are economically and technologically unfeasible.

The 'emission corridors' concept is elaborated as follows. The overall long-term objective with regard to climate change is to prevent 'dangerous anthropogenic interference with the climate system'[34]. In order to make this objective more operational, we assume a set of provisional limits that more-or-less comply to this objective:

- A maximum temperature increase of 2 degrees Celsius in 2100 over pre-industrial levels, thus a 1.5 degrees Celsius increase between 1990 and 2100 (EU objective);
- A maximum sea level rise of 30 cm in 2100 (compare Rijsberman and Swart 1990);
- A maximum temperature increase of 0.1 degree Celsius per decade after 2020 (compare Krause and others 1989; Leemans and Hootsman 1998). This rate of temperature increase could be regarded as a limit to reduce ecological risks (but it is not a no-effect level). The current rate of change of about 0.15 degrees per decade is substantially above this level; therefore this goal is only taken into account after 2020. In addition, we assume that it is not possible to reduce global emissions by more than 2 per cent per year.

Allowable emission ranges have been calculated on the basis of these assumptions (using the IMAGE 2.1 model). The upper corridor indicated in Figure 6.6 shows the range of different global emission paths that comply with the targets mentioned above. As it has been agreed upon in the Kyoto Protocol that until 2010 non-Annex B countries will not be required to control emissions, a separate corridor has been calculated for Annex B countries by assuming that non-Annex B countries will follow emissions as indicated in a baseline scenario[35]. The European Region makes up slightly less than half the emissions from Annex B countries.

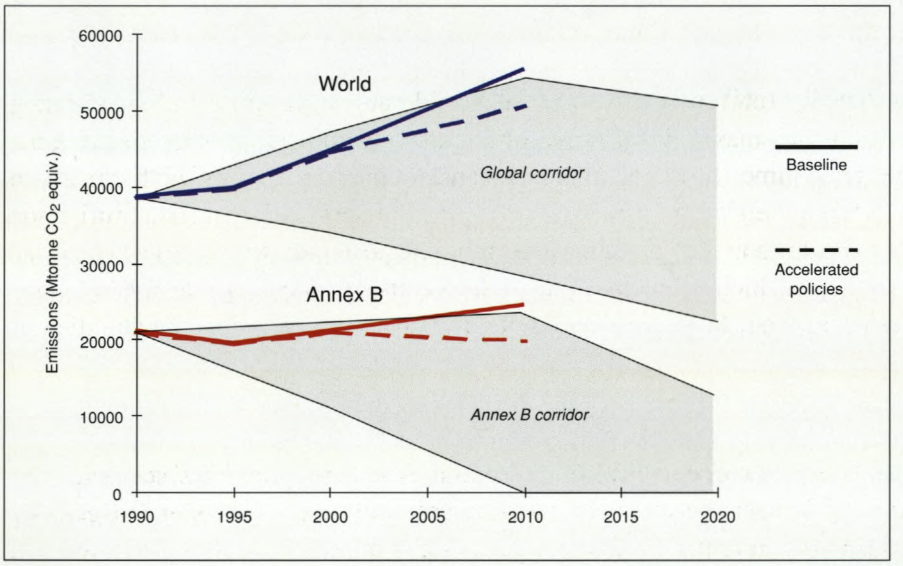

Figure 6.6: Greenhouse gas emissions compared to Safe Emission Corridors
The accelerated policies scenario just manages to keep greenhouse gas emissions within chosen climate change limits.

The emissions under the baseline scenario have been shown here as the solid lines. In the period 1990-1995, global emissions grew only slowly, mainly as a result of the transition process in

[34]Article 2 of the United Framework Convention on Climate Change (UNFCCC), adopted by almost all countries in the Region.
[35]The IMAGE Baseline A scenario (Alcamo and others 1996) has been used as baseline scenario.

Central and Eastern Europe and Central Asia. However, following our baseline scenario global emissions are expected to increase by about 2.2 per year per cent and by 2010, the emissions are projected to be just outside the safe limits. This implies that the limits selected will be violated if the world does not manage to decrease emissions sharply from 2010 onwards. The situation is even more worrisome for the Annex B situation, where the baseline scenario leads not only outside the corridor but would also require a stronger correction to stay at least close to the corridor after 2010.

The dotted lines show the Accelerated Policies scenario (all Annex B countries follow the Kyoto targets; Eastern Europe and Central Asia also reduce emissions, while non-Annex B countries follow their baseline emissions). This scenario stays within the emission corridor. However, the figure also shows the policy challenges in Annex B and non-Annex B countries for the period after 2010 to remain considerable.

6.3 Acidification

In Chapter 3 we discussed future emissions and environmental impacts, assuming that current policies in the year 2010 are fully implemented. Emissions of sulphur dioxide, nitrogen oxides and ammonia were projected to decrease, compared to 1990 in all European subregions west of the Urals. Consequently, the share of ecosystems receiving acid deposition in excess of their critical loads was expected to decrease from 16 per cent in 1990 to 3 per cent in 2010 on average in the Region[36]. But in parts of Western and Central Europe exceedances were projected to remain seriously widespread. Moreover, the situation was expected to become worse east of the Urals.

What difference would an accelerated policies scenario make for acidification? This section seeks an answer to that question on the basis of calculations using the RAINS model by IIASA (Cofala and others 1999). Unfortunately, the available information only covers Western and Central Europe and Eastern Europe west of the Urals. Most of the IIASA scenarios try to meet ecosystem and health targets by typical end-of-pipe measures. The available IIASA calculations do allow us to compare the impacts of the energy-oriented accelerated policies scenario (described in section 6.1) with the impacts and costs of typical end-of-pipe measures. Figure 6.7 shows:

a) Emissions following the negotiated ceilings of the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone in Europe but with additional control measures in Western Europe to comply to the EU acidification strategy (Protocol and EU Strategy);
b) Emissions on the basis of energy-efficiency improvement of the Accelerated Policy scenario in combination with measures in Western Europe to meet the EU acidification strategy (AP);
c) Emissions following a maximum application of control technology, but no energy measures (MCT).

As the same pollutants contribute to acidification, eutrophication and summer smog, strategies to abate these environmental problems can be most cost-effective if they consider emission ceilings for these pollutants simultaneously (sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia). All variants discussed here are based on this principle, expect for the 'maximum application of control technology' case. The results are shown in Figure 6.7, Figure 6.8 and Table 6.2 and discussed in the next paragraphs.

[36]Although not focused on in this report, IIASA calculations indicate that the European ecosystems suffer even more from eutrophication (e.g. Cofala and others 1999).

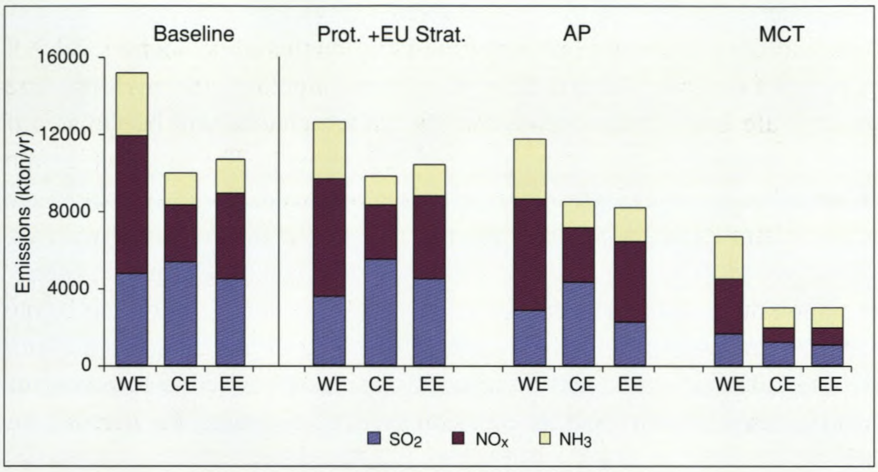

Figure 6.7: Emission of acidifying compounds in 2010, following the Accelerated Policies scenario and variants

Acidifying emissions can be reduced significantly compared to baseline.

(Prot. + EU Stat : The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone in Europe + EU acidification strategy; AP : Accelerated Policies; MCT : Maximum application of Control Technology).

Case a: 1999 UN-ECE protocol in combination with the EU acidification strategy

At the end of 1999, the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone was agreed. In this protocol many European countries committed themselves to decrease acidifying emissions beyond the baseline scenario. The objective of the protocol is to improve the environmental situation simultaneously for acidification, eutrophication and for summer smog. If the protocol targets are met, the total of acidifying European emissions are decreases by an additional 4 per cent. The largest reductions will take place in Western Europe. Analysis using the RAINS model shows that this improvement would by 2010 have reduced the share of ecosystems receiving acid deposition above their critical load in Western and Central Europe by an additional 1 per cent. This is obviously an improvement but comparing the results of this scenario with other scenarios shows that there is scope for further reduction. In fact, further emission reduction is necessary to meet the environmental targets of the acidification and ozone strategies of the EU (compare, for instance, Cofala and others 1999).

The general target of the EU acidification and ozone strategy is to have at least 50 per cent less ecosystem area exposed to acidification in the EU by 2010. For the EU as a whole, this target implies that a maximum of about 3 per cent of the ecosystems will be exposed to acidifying deposition exceeding their critical load. Based on calculations using the RAINS model, Cofala and others (1999) indicate that the environmental targets of the EU acidification and ozone strategy can be met on the basis of emission control measures only (see the 'Protocol and EU Strategy' bars in Figure 6.7). However, the control costs of this combination of strict environmental targets and absence of accelerated energy policies are relatively high – up to 64 thousand million US$ per year (Table 6.2). This assumes that countries outside the EU would simply follow the 1999 UNECE Protocol. Despite the strict targets of the EU strategy, the resulting 2010 impacts on ecosystems in Western Europe are significantly higher than the EU target: 3.8 per cent of the ecosystem area remains exposed to acidity in excess of critical loads (see the 'Protocol and EU strategy' bars in Figure 6.8). This is primarily caused by the remaining deposition on the sensitive ecosystems in

Norway (part of the Western European subregion but not of the EU). On the other hand, Figure 6.8 reveals the additional measures taken in Western Europe to also improve the environmental situation in Central Europe.

Case b: Accelerated Policies

The environmental targets for acidification and summer smog can be met at much lower costs than in the previous variant if implemented in combination with measures taken to improve energy efficiency and to decrease carbon dioxide emissions.

In particular, energy related measures in Central and Eastern Europe can decrease the emissions of acidifying compounds significantly without specific emission control measures. In contrast, in Western Europe even with the decrease in energy use under the Accelerated Policies scenario, additional emission control measures are required to reach the target of the EU acidification strategy, be it at significantly lower costs. A first assessment for Western Europe indicates that the additional costs would be halved to approximately US$ 5 thousand million per year, relative to the baseline (see Table 6.2). This is in line with more detailed studies for Central European countries that find that a combined strategy for decreasing transboundary air pollution and for complying with the Kyoto Protocol could optimise the use of energy efficiency and fuel-switching (van Harmelen and others 1995). Because emissions are decreased throughout Europe, the accelerated policies scenario also achieves significant improvement in Scandinavia, reducing the number of ecosystems in Western Europe at acidification risk to about 3 per cent by the year 2010. In Eastern Europe the share of ecosystems at risk could even be reduced to about 0.25 per cent. (Figures 6.7 and 6.8, 'Accelerated Policy' bars.)

In the section on climate change we discussed the situation in which the required greenhouse gas emission reductions are met partly by means of *emission trading*. It should be noted that meeting

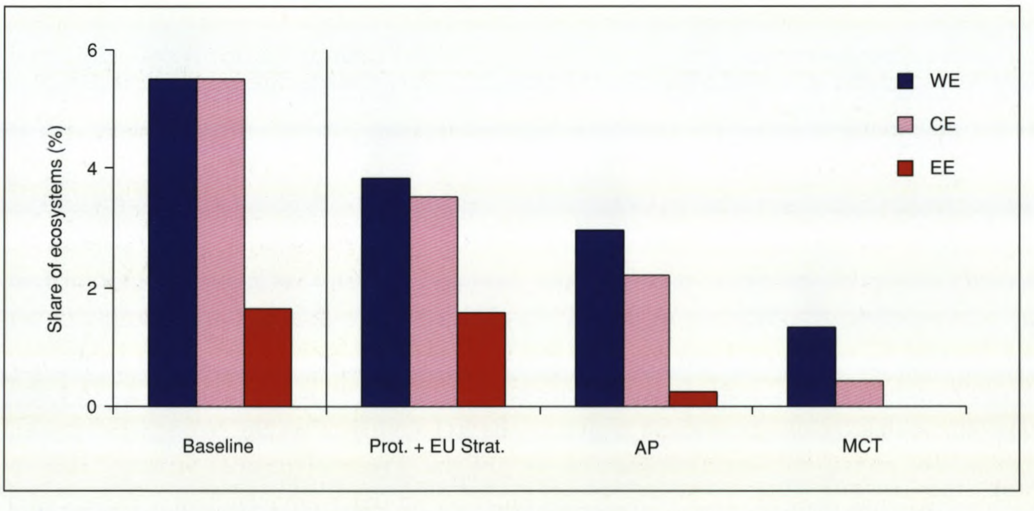

Figure 6.8: Ecosystems at risk from acidification in 2010, accelerated policies scenario and variants

The area of ecosystems at risk in Europe can be halved by a combination of end-of-pipe and energy efficiency measures.

(Prot. + EU Stat : The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone in Europe + EU acidification strategy; AP : Accelerated Policies; MCT : Maximum application of Control Technology).

Kyoto targets by emission trading obviously also moves the accompanying gains in decreasing pollution to elsewhere. Therefore, as Western Europe pursues climate policy objectives by buying emission reduction credits, more effort will be required to achieve acidification targets. Conversely, less effort will be required in Central and Eastern Europe. This is clearly shown in the study for Western Europe carried out by RIVM and others (2000). In fact, a study for Sweden showed that if the Swedish government would simultaneously try to meet its objectives for greenhouse gas emissions and acidifying compounds it would be in its own interest (in terms of costs) to decrease carbon dioxide emissions nationally by means of energy efficiency and fuel switching instead of engaging in seemingly low cost trading (Nilsson and Huhtalla, 2000).

Case c: Maximum application of end-of-pipe technology

This variant indicates the technical potential if only control measures are taken into account. Maximum application of end-of-pipe technology can improve the environmental situation significantly, but it will not be sufficient to meet the no-damage levels everywhere (see Figure 6.8). Obviously, in combination with energy measures as included under 'Accelerated Policies' even slightly lower emissions could be achieved, but that is not analysed here. Obviously, the costs of implementing this are enormous (in the region as a whole more than 150 thousand million US$ see Table 6.2).

To summarise, the following observations are made on this analysis:

- Table 6.2 gives a rough indication of the costs of the Accelerated Policy scenario and of the variants discussed. The table shows the annual costs of implementing the baseline scenario in Western Europe to already be around 55-60 thousand million US$. In addition, the Accelerated Policies scenario features measures to address both acidification and summer smog, and in fact the lion's share of all costs are to abate the latter.

Table 6.2: Rough indication of emission control costs for transboundary air pollution, including both acidification and summer smog

	Baseline	**Protocol and EU strategy**	**AP**	**MCT**
	million US$ per year			
WE	55000	65000	60000*	102000
CE	6000	7000	6800*	27000
EE	1000	1100	800*	25000

* Excluding additional costs in the energy system for 'Accelerated Policies' [37]

Note: Protocol and EU Strategy : The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone in Europe in combination with the EU acidification strategy; AP : Accelerated Policies; MCT : Maximum application of Control Technology.

[37]These costs, mostly necesary to meet the Kyoto targets for greenhouse gas emissions, have been indicated under climate change; they are estimated with considerable uncertainty at 14-24 thousand million for Western Europe, around one thousand million for Central Europe and a maximum of several thousand million in Eastern Europe.

- The costs of reducing acidification and summer smog beyond the improvements in the baseline scenario depends to a large extent on the regional strategy to decrease greenhouse gas emissions. If the ecosystem targets (and health targets for the summer smog) of the EU acidification strategy are to be met by typical end-of-pipe measures, this may lead to additional costs around US$10 thousand million per year (Amann and others 1998). However, if the acidification and summer smog targets are met in combination with the energy measures of the 'Accelerated Policies' scenario, additional costs for acidification and summer smog could be as low as US$ 5 thousand million per year – in combination with improved results on environmental impacts. Similar estimates are given for Central and Eastern Europe (Table 6.2) in line with individual country studies for countries in Western and Central Europe.
- The costs of maximum application of end-of-pipe technology are, as could be expected, extremely high in every subregion. This variant would reduce the share of ecosystems at risk even further but will not be sufficient to meet no-damage levels everywhere.

6.4 Summer smog

As apparent from the previous section, a strategy to reduce summer smog should be fully integrated with strategies to reduce acidification and eutrophication in order to be as cost-effective as possible. Therefore the estimations shown here regarding summer smog are completely based on measures discussed in the previous section.

Just as in Chapter 3, we use the time-weighted ozone concentration exceedence of the 0.06 ppm eight-hour average level, corresponding to revised WHO air quality guidelines for Europe (see section 3.4 for more information). The long-term goal would be to eliminate all exceedances of this level by 2010.

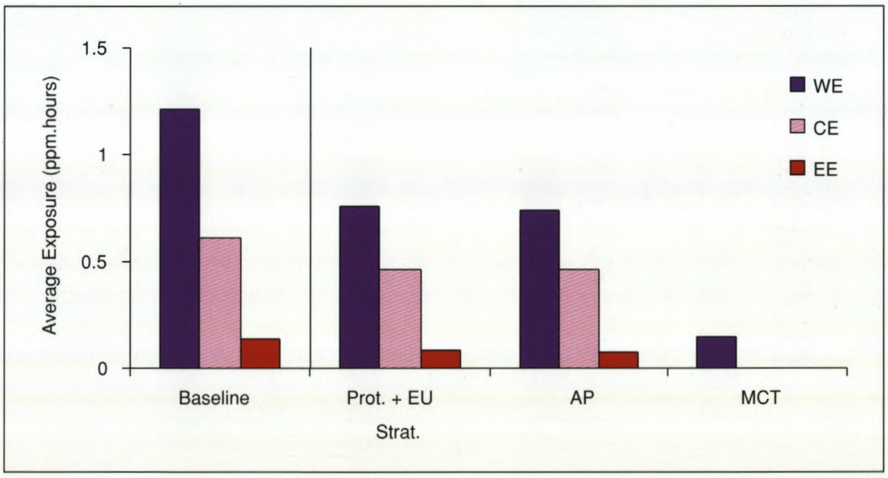

Figure 6.9: summer smog exposure, exceedence of the AOT60 level
Cost-effective accelerated policies could go some way in decreasing the occurrence of summer smog in Western Europe. However, they would not do away with the problem completely in any of the European subregions.
(Prot. + EU Stat : The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone in Europe + EU acidification strategy; AP : Accelerated Policies; MCT : Maximum application of Control Technology).

In the baseline scenario, the situation with regard to summer smog was projected to improve considerably (by 40 to 60 per cent). However, the baseline scenario could seriously underestimate transport growth and effects of growing consumption, in particular in Central and Eastern Europe. In addition, growing emissions outside the Region could offset improvements within the region.

Both the UNECE 1999 Protocol in combination with the EU acidification strategy and the acceleration policies scenario can improve the situation with regard to summer smog about 30-40 per cent beyond the improvements of the baseline. This is shown in Figure 6.9. For comparison, Figure 6.9 also shows that maximum application of added technology (as opposed to energy-oriented measures) can almost completely solve summer smog problems in Europe. However, as has been pointed out in the previous section, the price tag of such a solution would be extreme (see Table 6.2 under MCT).

6.5 Urban air pollution

For urban air pollution, the baseline scenario already includes most of the available moderate end-of-pipe measures because they are agreed upon as part of national or regional policies. In Chapter 3 we introduced an indicator for urban air pollution: the share of urban population exposed to air pollution above the WHO or EU health guidelines for sulphur dioxide, nitrous oxide, benzene, particulate matter and benzo(a)pyrene. Under the baseline scenario, this indicator was projected to improve by approximately 55, 15 and 45 per cent in Western Europe, Central Europe and Eastern Europe, respectively. However, most or all of these improvements could be neutralised if transport increases more than official projections currently tell us – see, for instance, section 2.3.

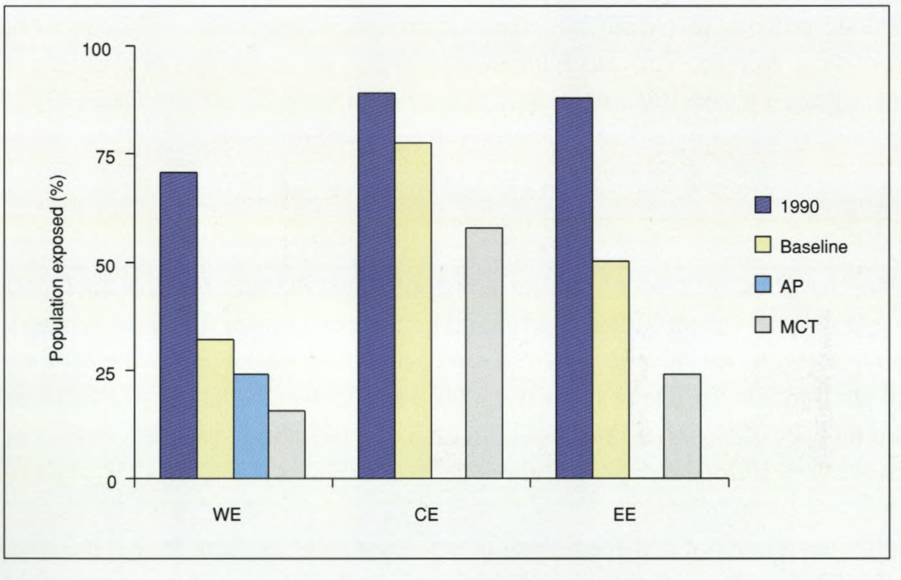

Figure 6.10: Share of the population of large European cities exposed to urban air pollution exceeding health guidelines.

Even under maximum application of emission control technology a significant share of the European population will be exposed to urban air pollution in 2010.

Note: Indicated is the average fraction of the urban population exposed to air pollution above the WHO or EU health guidelines for sulphur dioxide, nitrous oxide, benzene, particulate matter and benzo(a)pyrene (See Chapter 3).

AP : Accelerated Policies; MCT : Maximum application of Control Technology.

There is scope for further improvement. In Western Europe where meeting the climate change and acidification targets requires more effort than elsewhere in the Region such policies would somewhat decrease urban air pollution as well. Population exposure to nitrogen oxide decreases considerably; exposure to particulate matter decreases slightly. Figure 6.10 shows the overall effect. Improvement beyond this requires more ambitious measures as described in 4.1.4. However, the environmental effect of such policies can only be quantified for Western Europe. For the other subregions the available information is too fragmentary to generalise.

However, we can develop a feeling for the potential impacts of more ambitious abatement of urban air pollution in all four subregions based on the decrease in emissions that would result from the maximum application of emission control measures to acidification and summer smog (compare section 6.3). This involves emission control measures only, and assumes no changes in the energy system. The latter is particularly important for Central Europe as the high share of solid fuels in the fuel mix of this subregion causes large emissions of several urban pollutants. Emission control measures could improve the urban air pollution indicator in Western and Eastern Europe by about 50 per cent compared to baseline and in Central Europe by about 25 per cent. The most important improvements occur for sulphur dioxide and benzo(a)pyrene. But in Western Europe, pollution by particulate matter would remain a problem, exceeding the Air Quality Guideline for about 35 per cent of the population living in large cities. Also in Central and Eastern Europe particulate matter remains the most important pollutant, exceeding the Guideline for about 85 and 50 per cent of the population[38]. The large difference between Central Europe, on the one hand, and Western and Eastern Europe, on the other, emphasises the potential gains from changing the fuel mix. Although not assessed, measures for energy efficiency and fuel shares in Central Europe could be much more effective than emission control measures.

But on the whole, moderate policies to reduce the effect of growth in transport are bound to be eroded by the rapidly growing volume. This has happened in Western Europe and is probable in Central Europe in the near future, especially where there is accession to the European Union.

6.6 Nuclear risks

In Chapter 3 it was shown that accident risks of nuclear power plants in the total Region, including Western Europe, are to a large extent determined by a limited number of Eastern European reactors. In the accelerated policies scenario we have assumed that measures will be taken for the 19 most unsafe plants in Central and Eastern Europe in order to reduce the accident probability to less than 10^{-4} per year. This would reduce risks considerably (see Figure 6.11): in Central and Eastern Europe up to 90 per cent and in Western Europe by around 50 per cent.

The costs of this are highly uncertain but considerable and vary from plant to plant. In fact the costs for the actual measures may vary from some tens of thousands of US dollars if only procedure changes have to be implemented, to several hundreds of million US dollars per plant for some older plants (Stoop and others 1998). In the latter cases, replacement – although costlier – might be more

[38]The limit used to evaluate particulate matter in this study is an annual average concentration of 30 µg/m³ (as explained in Eerens and others 2000). In Western Europe, a stringent target for 2010 of 20 µg/m³ has been formulated - but this target will be re-evaluated in 2003. The stringent target is very difficult to achieve because in many countries the natural background concentrations already exceed this level.

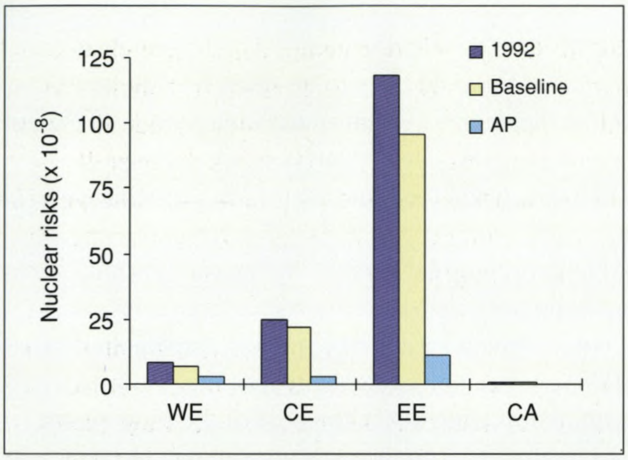

Figure 6.11: Average excess risk for cancer deaths due to accidents in nuclear power plants
Policies targeted at the 19 most unsafe nuclear plants in Central and Eastern Europe could improve the risk situation everywhere in Europe by more than 50 per cent.
Source: Slaper and Stoop 1998

attractive to reduce risks. The figure shows the reduction of risks in Western Europe to clearly hinge on the safety of the nuclear plants in Eastern Europe, making this a case for continued regional co-operation.

6.7 Main findings

Figure 6.12 summarises for three subregions how environmental impacts develop under the baseline scenario and under accelerated policies. The plots show the values for each indicator relative to the highest level in any of the subregions. Central Asia could not be included in this figure due to lack of data for some of the impacts. The figures shows that the Accelerated Policies scenario results in improvement in the environmental situation across the board.

Above all, this study indicates that important linkages exist between the environmental issues discussed and between the subregions.

- As all environmental problems discussed in this report are at least partly related to energy use, there are important linkages in terms of solving them. This is in particular the case for acidification, climate change, summer smog and urban air pollution. Emissions and additional emission control costs for these issues depend to a large extent on the development of the energy system. Integrated strategies could lead to environmental benefits at reduced costs.
- For all five environmental problems covered in this study, the four subregions are connected. This is even the case for urban air pollution, which is increasingly determined by transboundary background air pollution, as well as by regional scale driving forces such as EU enlargement. For acidification (in particular, for Western and Central Europe and part of Eastern Europe), a significant share of the total deposition originates from emissions in the other subregions. For summer smog, the increasing background concentration of ozone in the northern hemisphere contributes to summer smog in all four subregions. Climate change is a global problem by its very nature but an additional inter-regional link is now provided by the potential for emission trading. These linkages underline the importance of environmental co-operation at the regional level, something that is already happening to some extent.

- The 'accelerated policy scenario' can lead to considerable improvements. This is true even for Western Europe, where relatively expensive measures would have to be taken because ambitious environmental targets have been accepted, while the energy system is already relatively efficient. In fact, a comprehensive cost-benefit analysis of the same accelerated policies scenario as analysed in this study (RIVM and others 2000) concludes the scenario for Western Europe to be cost-effective.
- For climate change, we found that the Kyoto targets could be reached by measures within each subregion. But the implementation costs can be reduced considerably by trading emission reduction credits. However, in that case the environmental gains of climate change policies for other environmental issues ('ancillary benefits') are smaller in the subregion that buys its reduction credit elsewhere. On the longer term, that is after 2010, the goal of the Framework Convention on Climate Change to 'prevent dangerous interference with the climate system' will in any case remain a considerable policy challenge.
- For acidification and summer smog the costs of more ambitious policies were found to depend strongly on policies for climate change. For instance, meeting Kyoto targets *without* climate emission trading will reduce the costs of the EU acidification and summer smog strategy by several thousand million US$ per year. This does not completely wipe out the gains from trading – but this conclusion emphasises the importance to take ancillary benefits into account when considering climate change and energy policies.
- For urban air pollution, considerable improvement appears possible in all subregions west of the Urals. Improvement was found to be more difficult for particulate matter than for other pollutants, in part because the target is stringent (a re-evaluation will take place in 2003). Particulate matter was found (Chapter 4) to be the most important environmental factor causing loss of human health. Particularly in Central Europe, measures in the energy system are expected to significantly decrease urban air pollution.
- Nuclear safety can be improved by 50-90 per cent in the whole Region by measures for a limited number of nuclear power plants in Eastern Europe. As it is not likely that Eastern European countries will take these measures on their own, this again presents a case for close regional co-operation.

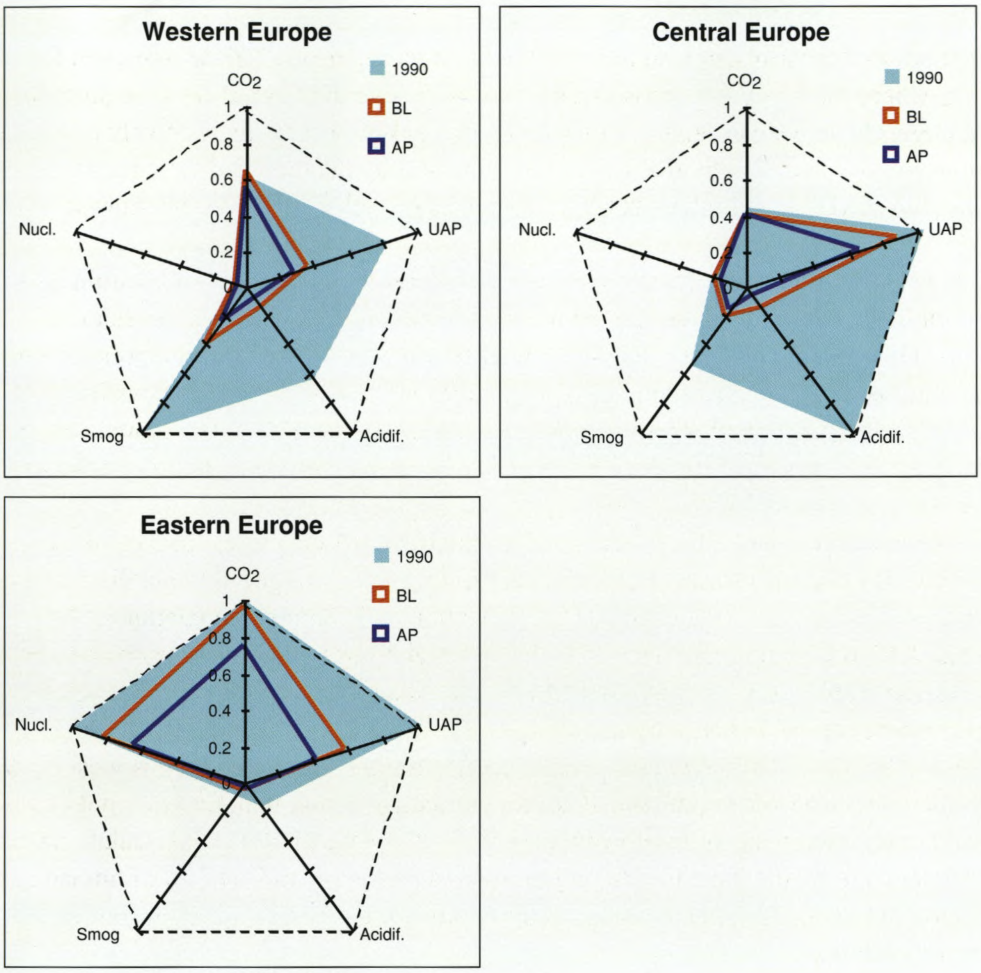

Figure 6.12: Overview of environmental impacts with and without accelerated policies.

Note:

- The plots show the values for each indicator relative to the highest levels in any of the subregions and time periods (=1.0).
- Climate Change (CO_2): Carbon dioxide emissions per capita
- Urban Air Pollution (UAP): Share of population exposed to nitrogen oxide levels exceeding WHO air quality guidelines. As indicated in Section 6.5, for Central Europe and Eastern Europe only the baseline emissions (BL) and emissions under maximum application of control technology (MCT) were available. Here, we have assumed that the Accelerated Policies scenario will result in an improvement halfway BL and MCT, based on the information for Western Europe. This is probably an underestimate.
- Acidification (Acidif.): Share of ecosystems exposed to acidifying deposition exceeding critical loads.
- Summer smog (Smog), average time-weighted exceedence of the 0.06 ppm eight-hour average level by ozone background concentration.
- Nuclear: Average risk per person due to potential nuclear accidents in power plants. The figures shown correspond to the assumptions made in Section 6.6.

7. SUMMARY AND CONCLUSIONS

This report has focused on five environmental problems directly related to the production and consumption of energy, i.e. climate change, acidification, summer smog, urban air pollution and nuclear risks. First of all, a baseline scenario for the 1990-2010 period has been sketched and, based on this, an approximate answer has been given to the question on what could be achieved for these environmental problems through full implementation of accepted environmental policies in the European region. Next, an attempt has been made to indicate what energy-oriented moderate measures could contribute to solving the environmental problems even further. This has been done on the basis of available information on policies and measures, and through analysis of a second scenario, called accelerated policies. The changes in environmental impacts under the baseline scenario and accelerated policies are summarised in Table 7.1 and Table 7.2.

7.1 Baseline trends

The baseline scenario depicts possible developments in the region assuming a world that can be characterised by steady economic growth and increasing international relationships. The scenario is not one without policy effort. For the trends described for the eastern parts of the region, institutional and financial reforms are an absolute requirement. Secondly, the scenario assumes full effectiveness of currently formulated environmental policies. In some cases, we have indicated possible pitfalls which could lead to less positive developments. In the scenario, energy consumption is assumed to grow by 16, 25, 35 and 47 per cent over 1995 levels in Western, Central, Eastern Europe and Central Asia, respectively. In combination with implementation of all policies in place and in the pipeline, the analysis of impacts on five selected environmental issues leads to the following conclusions.

- With the adoption of Western lifestyles and access to the European Union (leading to sharply increasing trade), transport and electricity use will become important driving forces of environmental problems in Central Europe. Comparable trends can be expected in Eastern Europe and Central Asia, but less pronounced and later.

- Greenhouse gas emissions will increase considerably in all European subregions. Kyoto commitments will not be met in Western and Central Europe under the baseline scenario.

- Acid deposition in Europe west of the Urals will have decreased considerably by 2010, although it will not have disappeared. Considerable effort will be required to achieve the projected decrease, especially when considering expected increases in the transport sector. Acid deposition in Central Asia and some parts of Siberia could become the largest acidification problem in the Region, assuming no new control policies.

- The occurrence of summer smog will have been cut by one-third in the most exposed subregions by 2010 if current policies are fully implemented. However, even then WHO guidelines are exceeded more than occasionally, especially in Western Europe. In addition, summer smog in Central Asia increases rather than decreases. Consequently, sharper reduction in emissions of volatile organic compounds and nitrogen oxides will be necessary to protect ecosystems and people from exposure to excess ozone at ground level.

- Urban air quality remains a problem in all four subregions. In Western Europe, mobile sources have become the major cause of urban air pollution. A similar trend is likely to occur successively in Central Europe, Eastern Europe and Central Asia.

- In the baseline scenario, accident risks in nuclear power generation remain much higher in Central and Eastern Europe than in other subregions.

- The contribution of environmental factors to the overall disease burden in Western Europe is modest but certainly not negligible (up to 5 per cent of the total disease burden). Air pollution by particulate matter and summer smog, in particular, contributes to morbidity and mortality. In Central Europe, Eastern Europe and Central Asia, the contribution of environmental factors is larger – not only due to much higher exposure levels to urban air pollution but also to remaining traditional risk factors. Under the baseline scenario the disease burden of urban air pollution in Western Europe is expected to shrink by 10-30 per cent. Similar reductions can be expected in the other three subregions.

- With regard to biodiversity, pressures were found to increase on balance for all four subregions under the baseline conditions.

In general terms, this means that although the environmental situation seems to improve slightly if all current environmental policies are implemented under baseline scenario conditions,

Table 7.1: Changes in environmental impacts under the baseline scenario, 1990-2010

	Western Europe	Central Europe	Eastern Europe	Central Asia
Climate change	Emissions increase, Kyoto target not met. Climate impacts expected to become worse.	Emissions increase, Kyoto target not met. Climate impacts expected to become worse.	Emissions increase, Kyoto target met. Climate impacts expected to become worse.	Emissions increase, no Kyoto target. Climate impacts expected to become worse.
Acidification	Less ecosystems are exposed – but EU strategy is not met.	Less ecosystems are exposed.	Emissions decrease west of Urals but increase east of Urals. Ecosystem area exposed about constant.	More ecosystems are exposed
Summer smog	Lower exposure to summer smog – but EU strategy is is not met.	Lower exposure to summer smog, but significant exposure remains.	Emissions decrease west of Urals. Lower exposure to summer smog.	More exposure to summer smog.
Urban air poll.	Lower exposure but insufficient decrease.	Lower exposure but insufficient decrease.	Emissions decrease west of Urals. Lower exposure but insufficient decrease.	Emissions increase. Exposure has not been assessed.
Nuclear risks	Nuclear risks remain almost constant.	Nuclear risks remain almost constant.	Nuclear risks remain almost constant.	Nuclear risks remain low.

improvement is, in most cases, not sufficient to meet the existing environmental targets. This is particularly the case for carbon dioxide emissions in Western and Central Europe. It should be noted that in the baseline scenario we have not included the environmental effects of accession of Central European countries to the EU. However, a qualitative assessment has been made of the potential impacts – which indicates that accession could have benefits for some of the traditional environmental problems such as acidification and air pollution by sulphur dioxide. However, on the other hand accession might be expected to increase other problems such as carbon dioxide emissions and transport-related pressures.

7.2 Alternative policies

Table 7.2 summarises the changes in environmental impacts under the accelerated policies scenario. Based on the discussion, the following conclusions can be drawn.

Available options:

- For all subregions there is scope for a more rapid transition towards environmentally less burdensome energy patterns. In fact, reductions in carbon dioxide emissions of 15 to 20 per cent compared to baseline seem to be possible at relatively low costs. However, the policies to implement this potential are currently insufficient. In the relatively short term up to 2010, improving energy efficiency in the end-use sectors will be an important aspect of additional policies. Western Europe has, in general, fewer options left for moderate measures than other subregions.

Table 7.2: Changes in environmental impacts under accelerated policies, 1990-2010

	Western Europe	Central Europe	Eastern Europe	Central Asia
Climate change	Emissions decrease, Kyoto target met. Climate impacts expected to become worse.	Emissions increase, Kyoto target met. Climate impacts expected to become worse.	Emissions increase, Kyoto target met. Climate impacts expected to become worse.	Emissions increase no Kyoto target. Climate impacts expected to become worse.
Acidification	Less ecosystems exposed – but EU strategy is met.	Less ecosystems exposed.	Emissions decrease west of Urals Share of ecosystems exposed becomes very low.	
Summer smog	Lower exposure to summer smog – but EU strategy is is not met.	Lower exposure to summer smog, but significant exposure remains.	Emissions decrease west of Urals. Lower exposure to summer smog.	
Urban air poll.	Exposure decreases but remains above WHO guideline.	Exposure decreases but remains above WHO guideline.	Exposure decreases but remains above WHO guideline.	Emissions increase. Exposure has not been assessed.
Nuclear risks	Nuclear risks decrease.	Nuclear risks decrease.	Nuclear risks decrease.	Nuclear risks are low and decrease.

- Getting prices right and the use of market mechanisms are key factors to cost-effective responses in all four subregions. This includes, for instance, subsidy reform. Further reform of the large variety of energy subsidies offers ways to induce more energy savings and increase the market share of cleaner fuels in all four subregions. Such reform might, of course, consist of the complete removal of subsidies. Alternatively, it could mean replacing subsidies with direct and transparent support for specific groups, sectors or territories.

- Important efficiency gains that reduce environmental pressures can be achieved in the electricity sector. Key players are national governments (especially in Central Europe) and commercial builders of power plants (especially in Eastern Europe and Central Asia). Technical assistance and cooperation between Western European countries and countries in the other subregions can be greatly expanded, for example on demand side management.

- Additional measures for the transport sector should be a policy priority, in view of its growing importance in environmental problems. Moderate measures are probably only able to slightly mitigate the growth of transport energy use– and certainly not enough to push off a transition to more environmentally sustainable energy systems. For passenger transport, the growth of environmental problems can be somewhat reduced through modern car technology in combination with urban management. But this is clearly not enough. For the environmental problems of goods transport a more ambitious strategy for Central Europe is conceivable, but will require long-term decisions fairly soon.

- In Eastern Europe and Central Asia, the lack of financial rigour is an important obstacle. In particular, non-payment for energy services in the industrial sector remains a key problem. Removal of this obstacle should be a central element of any strategy in these subregions, both in the reinstatement of incentives that discourage inefficient use of energy and in the generation of capital for the utility sector to invest in modern efficient technology.

- Trade in emission reductions can help to reduce the cost of climate change policies for industrialised countries, assuming a good implementation mechanism. Part of the price paid by the importing countries is that the accompanying decreases in energy-related pollution also take place abroad.

Environmental impacts of accelerated policies

- As all environmental problems discussed in this report are related to energy use, there are important linkages in terms of solving them. Emissions and additional emission control costs for these issues depend to a large extent on the development of the energy system. Integrated strategies could lead to environmental benefits at reduced costs. For instance, a combined strategy for reductions in the framework of both transboundary air pollution (sulphur dioxide, nitrogen oxides and volatile organic compounds) and the Kyoto Protocol (greenhouse gases) could optimise the opportunities for energy efficiency and fuel-switching.

- The four subregions are linked for all five environmental problems covered in this study. These linkages underline the importance of environmental co-operation at the regional level, something that is already happening to some extent.

- The 'accelerated policy' scenario can lead to considerable improvements. This is true even for Western Europe, where relatively expensive measures will have to be taken because ambitious environmental targets have been accepted.

- For climate change, we found that the Kyoto targets could be realised with measures within each reduction credits between the subregions and even within subregions. Emission reduction costs for methane and nitrous oxide are often lower than for carbon dioxide. In the longer term, that is after 2010, the goal of the Framework Convention on Climate Change 'to prevent dangerous interference with the climate system' will in any case remain a considerable policy challenge and will require the development of a comprehensive strategy.

- For acidification and summer smog the costs of more ambitious policies were found to depend highly on policies for climate change.

- For urban air pollution improvement was found to be more difficult for particulate matter than for other pollutants. In Central Europe, in particular, measures in the energy system are expected to decrease urban air pollution.

- The reduction of risks in nuclear power generation in Western Europe hinges on measures for nuclear plants in Central and Eastern Europe.

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APPENDIX 1: SHORT DESCRIPTION OF THE METHODS AND DATA USED

A sizeable amount of statistical data and several environmental models have been used for this report. Key data sources include World Bank Development Indicators, especially for economic data (World Bank 1997a), UN-DESIPA (population prospects) (UN-DESIPA 1997), UN-ECE/IIASA (energy data for Central and Eastern Europe) (UN-ECE 1996; IIASA 1997), BP (energy data for 1990 and 1995) (BP 1997) and RIVM data sets (climate, land use).

Economic and energy scenarios

Baseline scenario

The economic scenario is based on the 'High-Growth' and 'Low-Growth' scenarios as described in the OECD study 'Towards a New Global Age' (OECD 1997a). The analysis in the present study is based on – among several other sources – calculations with the WorldScan model (from the CPB Netherlands Bureau for Economic Policy Analysis; CPB 1999). More detailed data with regard to the High-Growth scenario have been taken directly from calculations with this model (CPB, pers. comm. 1997). The WorldScan model and the OECD study distinguish three subregions in the Europe and Central Asia Region: OECD Europe, Central Europe and the Former Soviet Union. In applying the OECD material, we have divided outcomes for the Former Soviet Union into the two subregions 'Eastern Europe' and 'Central Asia'. The baseline scenario as used in the present document follows a path in between the two OECD scenarios.

The baseline GDP projections for Western Europe are only indirectly based on OECD. In fact, in order to maintain maximum comparability between GEO and the simultaneous study on priorities for EU environmental policy (RIVM and others, 2000) GDP projections for Western Europe have been taken from Capros (National Technical University of Athens) (Capros and others 1997). These projections are consistent with a growth path in between OECD High-Growth and Low-Growth; the difference is that they have first been translated into projections for individual countries and sectors by the National Technical University of Athens' GEM-E3 model. These detailed projections have been re-aggregated for Western Europe. Similarly, projections for final energy demand and production by fuel and sector for all European Union countries have been taken from the same source, based on the PRIMES model (Capros and Georgakoupolos 1997).

For Central and Eastern Europe, the baseline energy scenarios are based on the Official Energy Pathways as published by ECE (UN-ECE 1996; IIASA 1997). These pathways are projections reported by individual European countries to UN-ECE. Using these projections rather than deducting our own energy projections from the OECD material had the important practical advantage, apart from basing our analysis on officially reported government data, that our impact analysis could be based on standard projections by IIASA with the RAINS model (IIASA 1997) and therefore was comparable with the aforementioned study on priorities for EU environmental policy (RIVM and others 2000). For Central Asia, the energy scenario is based on a combination of the available energy data and the trends included for Eastern Europe in the Official Energy Pathways. Because the energy and GDP scenarios come from different sources, their consistency has been analysed by comparing the apparent developments in energy intensity with scenario studies in the literature and by seeking advice from RIVM experts. As reported in Chapter 2, we found the combination plausible.

Accelerated policies scenario

For Western Europe, the accelerated policies scenario is based on similar calculations using the PRIMES model as reported by RIVM and others (2000) and the connected background reports. For Central Europe, Eastern Europe and Central Asia a 'spreadsheet' energy scenario has been constructed directly based on several comprehensive studies for these regions. These are the IEA/OECD projections for the World Energy Outlook (IEA, 1996) and the IIASA calculations made in the context of the EEA environmental assessments (Cofala and others 1999). The link with the 1996 IEA/OECD projections is important as this study in particular paid attention to the potential gains of cost-effective technologies in reference to a business-as-usual scenario in Central Europe and the Former Soviet Union (Eastern Europe and Central Asia). The 'spreadsheet' was used to ensure consistency with the baseline scenario.

Climate change

Carbon dioxide emissions in Europe and Central Asia in the period 1990—2010 have been directly calculated from the energy scenarios. Carbon dioxide emissions scenarios in other global regions and for the time period after 2010 have been set using published global scenarios consistent with the assumptions in this study (baseline A scenario as described by Alcamo and others 1996). If no additional information was available these other scenarios have also been used for other greenhouse gases, such as methane and nitrogen oxides. For the European subregions, scenarios for methane and nitrogen oxides have been based on Hendriks and others (1998) and the EDGAR database (Olivier and others 1996).

Corresponding impacts have been estimated using the IMAGE 2.1 model. The IMAGE 2.1 model is a multi-disciplinary, integrated model designed to simulate the interactions of the global society-biosphere-climate system (Alcamo 1994). Assumptions about population and economic activity drive the scenarios. Based on these assumptions, the IMAGE 2.1 model computes future emissions from energy and industry, shifts in land use and land cover, and changes in the fluxes of greenhouse gases between the biosphere and the atmosphere. These lead to changes in the atmospheric composition of various gases, resulting patterns of zonal-average temperature and precipitation and, finally, climatic impacts on agricultural and natural vegetation.

Acidification and summer smog

Acidification and rural concentrations of tropospheric ozone in the European Region west of the Ural mountain range have been estimated using the IIASA integrated assessment model, RAINS 7.2. The underlying estimations of current and future emissions of sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds and ammonia were based on the energy and economic scenarios as described in this report and on the emission factors derived from the CORINAIR emissions inventory. Databases on critical loads and critical levels provided the basis to assess the proportion of ecosystems in Europe where critical loads of sulphur and nitrogen-based acidity is exceeded, (Alcamo and others 1990; Amann and others 1997). Several scenarios have been used (RIVM and others 2000, Cofala and others 1999).

The overview projection of acidification and summer smog in the whole of the European and Central Asia region is based on a study using the STOCHEM model (Meteorological Office, UK) (Stevenson and others 1998). This model calculates the deposition and surface concentration of several tropospheric air pollutants on a 5° x 5° grid for the world as a whole, based on emissions from fuel combustion, biomasss burning and emissions from agriculture. Existing model outcomes for scenarios that correspond to the assumptions in this study were used in particular the 2015-Current Policy Scenario (CRP) for the baseline scenario calculations. The deposition data have been combined with data on ecosystem sensitivity as described by Bouwman and Van Vuuren (1999).

Urban air pollution

For the analysis of urban air pollution, an inventory of current and projected emissions of heavy metals, persistent organic pollutants, particulate matter and other atmospheric pollutants has been made in the context of the study on priorities for EU environmental policy (RIVM and others 2000) and the 1998 State of the Environment Report of the European Environment Agency (EEA 1999). The emission projections are among others on the basis of the RAINS results discussed under acidification. The long-range transport model EUTREND was used for the calculation of annual average mass concentrations of heavy metals, particulates (TSP, PM_{10}, $PM_{2.5}$) and secondary aerosols (SO_4, NO_3, NH_4) over Europe on the basis of the emissions inventoried. The EUTREND model describes both short- and long-distance transport of gases and particles; it takes into account both point sources of various heights and area sources of various shapes and heights. The results of the EUTREND model have then been used to compute the air quality of 55 major European cities (Eerens and others 2000).

Nuclear risks

The risk posed by potential nuclear accidents in large nuclear power plants has been evaluated using the RISKA model. RISKA calculates location-dependent probabilistic death risk for the whole of Europe and the Central Asia region. This relates to excess cancer mortality due to excess radiation exposure of the population in the case of accidents. Short term deaths in the immediate vicinity of an accident site are not included.

The nuclear power reactors have been classified in four accident probability classes, ranging from 10^{-3} per year to 10^{-6} per year. The approach involves a probabilistic evaluation of the chain sources-dispersion-exposure-risk. Risk estimates are provided for an adult rural population, eating fresh products with a food consumption which is regarded at the high end of the consumption range. It has to be noted that the resulting risk maps in no way reflect the situation following a specific accident. They provide a probabilistic view of the risks involved, and the major areas at risk.

For the assessment of current risks all nuclear power plants larger than 50 MW have been taken into account. The nuclear energy scenario for 2010 was based on the following assumptions:

- Nuclear power plants have a typical commercial life span of 30 to 40 years. Therefore, it is assumed that nuclear power plants that became commercially operational before 1975 are closed in 2010.
- All nuclear power plants that currently have been ordered or are being built are assumed to be operational in 2010.
- In addition, governmental decisions that have been made official, e.g. the nuclear phase-out in Sweden, have been incorporated in the scenario.

The inventory of currently operational power plants, or currently under construction or ordered, has been taken from the March issue of the journal ATW (this issue describes the situation on 1 February, 1998). Site coordinates were obtained from the PRIS database of IAEA. Because the risks posed by Central and Eastern European plants are at present dominant, nuclear safety policies only refer to improvement measures taken in a limited number of reactors in these subregions (Slaper and others 1994; Slaper and Stoop 1998; Stoop and others 1998).

Assumptions for other aspects than energy

The calculations for acidifying deposition and summer smog with the RAINS model (covering Europe west of the Ural mountains range) also take into account non-energy factors. The tables below show agriculture-related assumptions included in the RAINS model. Although these assumptions are not completely consistent with the overall scenario (for example, on accession of central European countries to the EU), the effect of this difference on the projections for acid deposition and summer smog can only be small.

Assumptions for agricultural livestock

Agriculture is a major source of ammonia emissions. Therefore the development of the animal stock is an important determinant of future emissions. The IIASA assumption for livestock development is based on a large number of sources as described in Amann and others 1997. The forecast for the EU is based on the assumption that the Common Agricultural Policy will essentially consist of MacSharry-like policies until 2005, and that after 2005 the EU will gradually liberalise its agricultural policy. The underlying assumptions in the other subregions have not been explicitly reported.

Table A1.1: Projection of livestock

	Cows		Pigs		Poultry	
	1990	**2010**	**1990**	**2010**	**1990**	**2010**
	million		*million*		*million*	
Western Europe	94	91	123	118	962	978
Central Europe	35	35	63	68	463	538
Eastern Europe	76	53	58	59	804	649

Source: Amann and others 1997

Nitrogen fertiliser use

Projections for nitrogen fertiliser use are also based on the assumption of no important change in the Common Agricultural Policy in the short-term and liberalisation in the long-term for Western Europe. For many of the Central European countries, accession to the European Union is assumed by 2005–6.

Table A1.2: Projections of nitrogen fertiliser use

	1990	2010
	1000 tons of nitrogen	
Western Europe	10400	9300
Central Europe	3800	4700
Eastern Europe	6200	4500

Note: rounded at 100 tons

Source: Amann and others 1997

APPENDIX 2: ENERGY SUBSIDIES

This appendix summarises the situation with respect to energy subsidies in the four European subregions on the basis of a review by van Beers and de Moor (1998). Given the rate of changes, the situation with regard to energy subsidies may well have changed by the time this background report to GEO-2000 is published. Therefore, especially this appendix should be used as an account of the inputs used to estimate the potential of subsidy reform as an element for scenario construction. It is not necessarily the most up-to-date description of the state of affairs.

1. Western Europe

In Western Europe, coal production is subsidised in some countries while in others, other energy carriers (gas, electricity) are subsidised as well. The support to coal production comes through an array of measures that have been established for various reasons: deficit payments to miners' pension funds, subsidies for early retirement schemes, 'adjustment' aid to control water contamination or to prevent land subsidence from closed mines.

Table A2.1: Coal subsidies in selected EU countries

	1991	1992	1993	1994	1995	1996
	US$ 1000 million					
Germany						
Producer Subsidy Equivalent	6.9	8.1	6.9	7.9	8.4	7.2
Non-producer Subsidy Equivalent	7.0	7.8	8.2	8.1	8.9	8.5
Total	13.9	15.9	15.1	16.0	17.3	15.7
Spain						
Producer subsidy Equivalent	0.7	0.7	0.6	0.9	1.1	1.5
UK						
Producer Subsidy Equivalent	2.0	1.8	0.3	0.3	0.2	n.a.
Non-producer Subsidy Equivalent	1.2	1.5	0.9	0.6	0.2	n.a.
Total	3.2	3.3	1.2	0.8	0.4	n.a.
Subsidies per ton coal						
US$ per ton						
Germany, total subsidy equivalent	191	221	236	278	294	295
Spain, producer subsidy equivalent	39	39	34	47	66	85
UK, total subsidy equivalent	17	20	20	13	11	n.a.

Note: The Producer Subsidy Equivalent measures the value of monetary transfers from consumers and/or taxpayers to producers in a given year as a result of public policy. A description of how this and related subsidy indicators are composed can be found in OECD (1997b).
Source: van Beers and de Moor 1998

2. Central Europe

In Central Europe, coal and oil subsidies have on average halved since 1991. The cause of this change is twofold. First, since 1991 Eastern European oil and gas suppliers have been charging world prices and demanding payment in hard currency. Second, reduction of subsidies and raising energy prices have been part of the move into a market economy.

However, the average halving of energy subsidies that has been achieved hides important differences in the subregion. Some countries are lagging behind in the transition towards a market economy, mainly as a result of political developments in the first half of the 1990s. Current governments in, for example, Bulgaria and Romania aim to reduce subsidies but feel constrained by large groups in society that can hardly afford to pay higher domestic energy prices.

Table A2.2: Energy subsidy rates in selected central European countries

	Coal		Oil		Natural gas		Total	
	1991	1996	1991	1996	1991	1996	1991	1996
	%							
Poland	63	26	28	1	40	6	50	18
Czech Republic	29	28	n.a	n.a	39	29	24	22
Romania	80	33	27	2	64	54	54	37
Bulgaria	65	33	43	24	27	23	54	29
Hungary	n.a	n.a	2	2	28	34	13	16
Total	53	26	22	4	48	37	42	23

The subsidy rates are expressed as the gap between domestic and world market prices.
Source: van Beers and de Moor 1998

3. Eastern Europe

For Eastern Europe, changes in energy subsidies during the 1990s are partly reflected in Table A2.3, where a reduction of Russian energy subsidies from US$73 to US$52 million is shown; however, this decrease can probably be explained by the decline in GDP. Indeed, energy subsidies in Russia as a percentage of GDP remained constant in 1996. The main forms of subsidy at the time of writing are:

- large direct budgetary subsidies for coal;
- reduced energy prices for households through local government budgets, and cross subsidies between sectors as a result of differences in their effective energy prices;
- constraints on domestic oil prices; and
- use of oil and gas revenues to cross subsidise undervalued domestic oil and gas supplies.

However, given the difficult circumstances, Russia has achieved impressive results in reforming the energy sector and reducing subsidies. But, remaining subsidies still amount to 30 per cent of market prices.

Ukrainian official coal prices have been raised but at the time of writing still cover only 10 per cent of official costs, which do not even include capital costs. Not surprisingly, the energy intensity of the Ukrainian economy is very high and notwithstanding its rich resources of coal, oil and gas, the country imports large amounts of fossil fuels. Ukrainian energy policy seems directed at continuing to subsidise household energy use (although fuel prices for transport have been liberalised). The artificially low prices prevent producers from investing in modern efficient equipment and consumers do not have an incentive to economise on their energy use.

Table A2.3: Energy subsidies in the former Soviet Union and Russia, 1991 and 1996

	Coal		Oil		Natural gas		Total	
	1991	1996	1991	1996	1991	1996	1991	1996
Subsidy rates	%							
Former Soviet Union[a]	55		61		88		70	
Russia[b]	48	25	38	16	67	42	45	31
Russia: industry[c]	70		69		70			
Subsidies	*1000 mln US$*							
Former Soviet Union[a]	16-30		66-86		43-64		125-180[d]	
Russia[c]							73	52
Share of GDP	*% Relative to GDP*							
Russia							8.4	8.4

a) Based on Larsen (1994).
b) Based on World Bank (1997). Note that Russia is only a part of the former Soviet Union.
c) Based on OECD (1997d). Subsidy rates are for 1990 and are relative to the average OECD energy price.
d) Excluding subsidies for electricity use amount to US$ 34 to 39 thousand million. Compare Larsen (1994).
Source: van Beers and de Moor 1998

4. Central Asia

The averages of the Central Asian subregion are dominated by the size of Kazakstan. Unfortunately, no reliable figures on the Kazak energy sector were available, but as economic policies, rules and regulations were unchanged from the Former Soviet Union until early 1994, it is fairly plausible that subsidy rates, or the problem of payment arrears, also do not differ much. However, in order to get an impression of possible dynamics, it is interesting to look at subsidy rates in Kyrgyz Republic. Here, economic reform has been introduced at the highest rate in the subregion. Oil and gas are imported and taxed, and the resulting prices are above world market level (negative subsidy rates in Table A2.4). Coal prices have been liberalised (zero rate in Table A2.4). However, here too one problem remains: while gas for industry is hardly subsidised, gas deliveries for domestic use are not metered, which in practice amounts to a 50 per cent subsidy. The result is a distorted supply and shortage of financial means for the utilities sector.

Table A2.4: Energy subsidies in the Kyrgyz Republic, 1993/1994

	%
Petroleum products	
Gasoline/petrol	-32
Diesel	-58
Fuel oil	19
Natural gas	
Industry	6
Residential	48
Coal	0–20
Electricity	
Industry	77–86
Residential	77–86

Source: van Beers and de Moor 1998