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Technical Report on Socio-Economic Trends, Macro-Economic Impacts and Cost Interface

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This Report has been prepared by RIVM, EFTEC, NTUA and IIASA in association with TME and TNO under contract with the Environment Directorate-General of the European Commission.

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Abstract

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

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

This report is one of a series supporting the main report: *European Environmental Priorities: an Integrated Economic and Environmental Assessment*. The areas discussed in the main report are fully documented in the various *Technical reports*. A background report is presented for each environmental issue giving an outline of the problem and its relationship to economic sectors and other issues; the benefits and the cost-benefit analysis; and the policy responses. Additional reports outline the benefits methodology, the EU enlargement issue and the macro-economic consequences of the scenarios.

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This report is one of a series supporting the main report titled *European Environmental Priorities: an Integrated Economic and Environmental Assessment*

Reports in this series have been subject to limited peer review.

Section 1 to 9:

Evaluation of Macroeconomic Implications of Environmental Scenarios

Prepared by NTUA, Prof. P. Capros

Section 10:

Environmental expenditure inputs to GEM-E3

Prepared by TME

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1. Introduction

The objective of this chapter is to present the analysis of macroeconomic implications of sets of environment improving actions in the European Union. The analysis is quantitative, covers all EU member-states[1] and draws from the results of the general equilibrium macroeconomic model GEM-E3.

The macroeconomic implications are effected through direct and indirect costs that the economic agents incur as a consequence of willing meeting targets about the quality of the environment. The targets concern a set of prominent environmental problems of Europe, such as climate change, urban stress, waste management, chemical risks and others. By using specialised environmental models, the study grouped those targets into few inherently consistent sets, which, considered as policy scenarios, are further analysed as regards their consequences.

Through further micro-level analysis, the study determined the direct expenditures that would be necessary to undergo within each policy scenario. Either through least-cost allocation, or by applying a polluter-pay principle, the study attributed the expenditures to economic agents that are firms in economic sectors, government and households.

The role of the GEM-E3 model was then to determine the changes that those expenditures would imply for economic growth, production, employment, foreign trade and prices. These changes, conceived as deviations from a baseline growth pace, entailing losses and gains for the economic agents, signify the overall costs of meeting the environmental targets. By comparing with the benefits from improving the quality of the environment, as associated to the same targets, the study performs a cost-benefit analysis. This helps to further set the priorities for environmental action.

In using the GEM-E3 model, the study neither considered nor evaluated policy instruments that would be necessary for the targets to be met. It must be mentioned however that allowing international trade of pollution permits in one of the scenarios could be interpreted as a policy instrument; however in the model this instrument operates ideally without transaction costs and policy failures.

The analysis with GEM-E3 covers the European Union member-states, linked together under the EU Single Market, and their relations to the rest of the World, which is considered as a single trade partner. Since deviations from a baseline growth pace matter for policy analysis, the study started by constructing a reference scenario, termed baseline. This is characterised by the inclusion of the effects of all policies in place and in the pipeline as set before considering the environmental targets, which are under evaluation in the study. The baseline scenario does include actions that directly or indirectly might positively affect the quality of the environment, but those actions are not enough to meet the targets.

Those additional targets are grouped in two policy scenarios:

1. The Technology Driven (TD) scenario
2. The Accelerated Policies (AP) scenario, which is further subdivided in two policy scenarios depending on the way flexibility mechanisms would be employed so as to help the EU to meet the climate change target
    a. Accelerated Policies under No Trade for Climate Change (AP-No-Trade)
    b. Accelerated Policies under Full Trade for Climate Change (AP-Full-Trade)

The environmental problems are linked to each other, so are actions that improve the quality of the environment. For example, when reducing greenhouse gas emissions through changes in the mix of energy fuels and forms, other environmental pressures reduce in an indirect way. Therefore, consistency of actions under each scenario had to be carefully verified. In the study, RIVM coordinated a set of specific model-

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[1] Except Luxembourg because of technical reasons related to the model.

using environmental analyses (also involving NTUA, IIASA, TME and others) in order to establish consistency across the various environmental problems, the setting of targets and the nature of actions to be undertaken. Subsequently, TME undertook the quantitative estimation of additional expenditures that the agents have to make for the targets to be met and the actions to be implemented under the policy scenarios. The data used sourced, in addition, from a large variety of micro-level studies. Then, NTUA imposed those expenditures to all agents represented in the GEM-E3 model and let the model evaluate the indirect and equilibrium consequences.

For actions involving climate change targets (as in the AP scenarios), the analysis of macroeconomic implications with the GEM-E3 model has not started from expenditure data, as in the case of other environmental targets. Instead, an emission reduction constraint was imposed, letting the model itself suggest how the agents internalise such a constraint into their cost structures and choices[2]. The emission constraint was imposed in different ways to reflect the different trading regimes, under the AP-No-Trade and AP-Full-Trade cases[3].

The analysis with GEM-E3 is dynamic and covers the period beyond 2000. The horizon of the targets is set for 2010. It is assumed that the economic agents are known with certainty, early enough so as to effectively internalise those targets into their cost structures. Therefore the agents undertake expenditures that improve the quality of the environment, in a gradual way, before 2010, starting even from 2000. The macroeconomic effects evidently affect the dynamics of growth well beyond the target period of 2010. Also, the environment improving effort continues beyond 2010. For this reason, the GEM-E3 model runs up to year 2030 so as to report on the longer run implications of continued action for the environment.

The rest of this chapter is organised as follows. Section 2 provides more detail on the way the analysis is implemented in modelling terms. Section 3 reminds the basic assumptions and trends under baseline. The next three sections (4, 5 and 6) present the analytical results for the policy scenarios and section 9 does the same for one variant. Sections 7 and 8 discuss limitations, uncertainties and the conclusions. Finally section 10 presents how the study derived the environmental cost data and used them in the macroeconomic assessment.

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[2] In parallel, NTUA carried out a similar evaluation for climate change targets by using the energy system model PRIMES for the European Union. This model, focusing only on energy markets, is not covering general equilibrium. The merits of PRIMES lie on providing engineering evidence about the economic behaviour of agents in the energy demand and supply. On the other hand GEM-E3, ignores such engineering features, but provides a representation of economic behaviour that is consistent with the general economic equilibrium. Evidently the two models are complementary for policy analysis, but in a sense concurrent to each other. For example, when dealing with a global emission constraint, they both suggest a least-cost allocation of effort to sectors and countries. Those allocations, however, might differ. There is no technical way to formally link the two models and obtain the same suggested allocation.

Therefore, the analyst has to combine information provided by the two models in order to draw policy recommendations.

[3] It must be mentioned that measures aiming at reducing non-CO_2 greenhouse gases are also included into the AP policy scenarios. Such measures are represented through direct expenditures of agents.

2. Overview of Methodology

2.1 Brief Overview of the GEME-E3 Model4

GEM-E3 is an applied general equilibrium model for the European Union member states providing detailed projections of economic growth, sectoral activity, trade and their interactions with the environment. It is an empirical, large-scale model, calibrated to a base year using Eurostat statistics. The model computes the equilibrium prices of goods, services, labour and capital that simultaneously clear all markets in the European Union and is consistent with trade with the rest of the World.

GEM-E3 is a multi-country model, treating separately each EU-15 member-state and linking them through endogenous trade of goods and services under assumptions reflecting the regime of the single market. GEM-E3 includes multiple industrial sectors and economic agents, for which it formulates their individual economic behaviour and their interactions as demanders and suppliers of commodities. GEM-E3 provides dynamic, recursive over time, projections, depending on capital accumulation, technology progress, demography and expectations.

In addition, the model covers the major aspects of public finance including all substantial taxes, social policy subsidies, public expenditures and deficit financing, as well as policy instruments specific for the environment/energy system.

The model determines the optimum balance of energy demand and supply, atmospheric emissions and pollution abatement, simultaneously with the optimising behaviour of agents and the fulfilment of the overall equilibrium conditions.

The results of ***GEM-E3*** include projections of detailed Input-Output tables by country, national accounts, employment, capital, monetary and financial flows, balance of payments, public finance and revenues, household consumption, energy use and supply, and atmospheric emissions. The computation of equilibrium is simultaneous for all domestic markets of all EU-15 countries and their interaction through flexible bilateral trade flows.

The latest available version of the GEM-E3 model (version 2.0) represents:

1. All EU member-states.
2. 18 products and sectors: Agriculture, Solid fuels, Liquid fuels, Natural gas, Electricity, Ferrous and non-ferrous metals, Chemical industry, Other energy intensive industries, Electrical goods, Transport Equipment, Other equipment goods, Consumer goods, Building and construction, Telecommunication services, Transports, Service of credit and insurance institutions, Market services, Non-market services.
3. 4 institutional sectors: households, firms, government, and foreign sector.

[4] The GEM-E3 model is a result of multi-year collaborative research partly financed by the European Commission JOULE programme, (DG-XII/F1), involving many institutes, among which NTUA, KUL, ZEW, Erasme. Of course, the use of the model and the results do not necessarily reflect the views of the European Commission. The model has been extensively used for the European Commission, including: The review of the EU Internal Market in 1996 (Capros P., P. Georgakopoulos et al. 1997), Tax reform (DG XXI, 1997), Task Force and effects on employment and competitiveness for Kyoto (results used in the Communication of the Commission before Kyoto), Climate technology Strategy (two books published, 1998-1999). The model has been extensively peer-reviewed in 1998 by external experts appointed by the European Commission. The main scientific publication for GEM-E3 can be found in Capros P. et al. 1997.

4. 13 household expenditure categories: 9 non-durable consumption categories (food, culture, health, electricity, gas, motor fuels, other fuels, transport, house); 3 durable consumption categories (cars, heating systems, electrical appliances).

The model runs following a mixed non-linear complementarity formulation and is solved under GAMS/PATH.

2.2 How Environmental Actions are represented in the Model

The model represents, for each of the 15 countries, in total 19 economic agents that may act on the environment and bear influences from environmental policy. Those agents include one firm representative of each of the 18 model sectors per country, and one household representative of all the households in a country.

In the “pure” economic part of the model, the environment is considered as an external commodity and is ignored in the economic decisions of the agents. The agents by consuming commodities (for final or intermediate consumption) and producing goods affect the environment. An accounting system based on emission factors determines in the model the implications for several pollutants[5], including carbon dioxide.

The internalisation of environmental externalities is accomplished in the model using three main types of policy instruments:

- Reduction of emission by obliging the economic agents to **invest in abatement** technologies or product quality improvement (in relation to the environment). Such an investment does not directly affect the productive capacity of the sector and can be expressed either as an expenditure at a single point in time or as a series of annualised payments. In both cases such expenditure creates demand for goods and services that are necessary for implementing the emission cut. Also, the expenditure represents an additional cost for the agent obliging him to deviate from his original allocation regarding final or intermediate consumption. In the case of firms it also affects unit production costs, further influencing commodity prices, demand prospects, expected rate of return on capital, hence productive investment plans. In the case of households, the environmental expenditure affects their consumption patterns, investment in durable goods and their allocation of utility between labour, leisure and savings.
- **Taxation on pollutants or commodities** (or activities) that relate to pollution. Environmental taxation acts in the model as any other type of taxation. Depending on its exact definition, it affects the relative prices of commodities and implies changes in final and intermediate consumption. Also it influences prices, investment plans and consumer choices. It is also possible to determine a tax level that is necessary to meet an overall emission reduction target.
- The imposition of a **global emission reduction constraint and the establishment of pollution permit market**. Under such a regime, the agents are exogenously endowed with a stock of permits that can exchange in the market at a price. They would sell such permits whenever they perceive that their marginal emission reduction cost is lower than the current permit price and they would buy in the opposite situation. At an equilibrium situation, the prevailing permit price would be representative of the marginal emission reduction costs equalised across all agents. The model allows for defining and grouping the agents that can trade into the so-called bubbles.

The above policy instruments are complemented with options regarding the financing of additional expenditures drawn by environmental policy. Those options include the possibility to reflect government subsidisation, recycling of tax revenues and a variety of fiscal policies accompanying environmental policy. Evidently, such measures have secondary impacts on top of those driven by environmental expenditures.

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[5] The model also evaluates concentration of pollution and damages, even computing environmental welfare in monetary terms. These features are not activated for the present study.

Regarding abatement behaviour and investment, the model formulates decisions at the level of the firm. A firm is conceived in the model as being representative of a sector, including a firm producing non-market services. There is no representation of public (or collective) behaviour in investing in environmental protection infrastructure that would horizontally improve the quality of the environment or reduce the pollution from the agents.

2.3 Design of Model Applications

The analysis with the GEM-E3 model starts by constructing a reference projection of economic growth for the EU. As mentioned, the reference projection does not consider the additional environmental targets that are included in the policy scenarios. The reference projection named baseline scenario, serves as a basis of comparison for the policy scenarios. The next section presents the assumptions underlying the baseline scenario.

The design of the policy scenarios has adopted two different rules. The internalisation of environmental problems is assumed to take place through environment-improving expenditures that the economic agents (producing sectors and the households) undertake on a voluntary basis. Therefore the macroeconomic assessment starts from the direct additional costs the agents incur. The only exception is climate change, and in particular energy-related carbon dioxide emissions, for which the analysis starts by imposing a global or country-specific emission limitation constraint. This is introduced as constraint in the model acting additionally to the baseline scenario assumptions and triggering structural changes and substitutions.

So for all environmental problems, except climate change, the internalisation of environmental targets is effected through obliging the economic agents to undertake expenditures that are additional to those under the baseline scenario. After a thorough micro-level analysis, TME suggested the magnitude of such expenditure in annualised terms for each environmental problem and their allocation to the 19 agents of the model. The annualised expenditures include both annuities for investment and annual operational costs. The allocation to the agents has been based on the "polluter-pay" principle and sometimes has been changed to reflect practicability considerations. The implicit economic assumption behind this representation is that the environmental damages relate to production of firms as a whole or to specific durable goods in case of households. In other words, the relative prices of goods in intermediate consumption (considered as production factors in GEM-E3) are not directly affected by the environmental internalisation.

For climate change, imposing a global emission reduction constraint enables the internalisation of environmental targets. In the model, the shadow value of such a constraint conveys additional costs to the firms and households and associates those costs to final and intermediate consumption goods that emit carbon dioxide. Therefore, the agents face a change in relative costs of using the commodities and production factors. To meet the global emission reduction constraint, and to evaluate as close as possible the effects from an ideal least-cost allocation of the emission reduction effort, it is assumed that a hypothetically ideal pollution permit market is established for energy-related CO_2 emissions. The analysis distinguishes then two cases.

First it assumes that such an ideal permit market is confined to the interior of each EU member state, not allowing for trade of permits within the EU and with the rest of the World and obliging the member-states to meet their commitments exclusively through measures limiting emissions in their territories. This case signifies that each member state takes on board actions to reduce emissions only within its national territory according to an individual emission target. The analysis further assumes that the individual emission reduction targets are different for each Member state and follow the Burden Sharing Agreement decided at the Council of EU Environmental Ministers in March 1998. This first case corresponds to the no trade case of the AP scenario and corresponds to the worst possible case regarding the use of flexibility instruments[6].

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[6] A further worse case could be imagined when a country cannot achieve a least-cost allocation of the emission reduction effort among the sectors within the country's territory. Such a case is of course plausible

The second case, on the contrary, assumes that full trade of CO_2 pollution permits takes place. Therefore, the emission reduction constraint is imposed at the level of the EU (or better at the level of Annex-B[7] taken as a whole) without any particular constraint on national level. So the model will suggest the "optimal" least-cost allocation of the emission reduction effort to sectors and countries. The second case corresponds to the full trade case of AP scenarios and corresponds to the best possible case regarding compliance costs and the use of flexibility instruments[8]. It must be mentioned that again for the trade scenario the establishment of the emission trading market is assumed to be ideal and operating under ideal conditions. In fact, this trading is a modelling means for obtaining the optimal least-cost allocation of the emission reduction effort. In real world such a market could not involve some agents, like households and individual transports and also would lead to side effects ascertained as transaction costs and other failures.

By definition, the two climate change cases differ with respect to the magnitude of the energy-related reduction of CO_2 emissions within the European Union and each member-state territory. Under the full trade case, the analysis has shown that it is more cost-effective for the EU to purchase pollution permits from outside the EU and in particular from the co-called "hot-air" consisting of the capacity of Former Soviet Union and European Eastern Countries to sell pollution permits. If that was the case, the analysis shows that the European Union could face a target for stabilising CO_2 emissions in 2010 at their level of 1990 and undertake the corresponding measures within its territory while meeting the Kyoto commitments. In case of no-trading, the European Union would instead be obliged to undertake more severe measures in national territories, as being committed to reduce emissions in 2010 by -8% compared to 1990. The cost implications of the two cases are largely different because the analysis has identified that a non-linear relationship exists between marginal abatement costs and the volume of emissions targeted for reduction in the national territory.

All policy scenarios incorporate additional expenditures to improve the situation in environmental problems, other than climate change as explained above. Since these expenditures are conceived as additional to those undertaken under baseline conditions, they may vary for one policy scenario to the other. One reason for that is that possible actions undertaken to meet climate change objectives also indirectly affect pollution and the state of the environmental in areas other than climate change. This is called spillover effect from one environmental area to another. In the non-climate change areas the needed additional expenditures might substantially differ if climate changes actions were involved or not. It might be also possible, that for some environmental areas the improvement driven by climate change policy might go beyond the developments under baseline conditions. In this case, these are net economic benefits (or negative costs) in these areas allowing agents to economise environmental expenditures undertaken under baseline conditions.

All environmental expenditures and climate change targets are gradually introduced after 2000 and take their full amplitude by 2010. Beyond 2010 all environmental expenditures that are represented in annualised payment terms continue to charge the agents up to the end of the simulation period, that is 2030. As regards climate change targets, it is assumed that emissions of CO_2 have to stabilise in the period beyond 2010 at the level reached in 2010. So, a corresponding emission constraint is introduced, again throughout the simulation period. Implicitly, these choices about dynamics reflect a continuation of environmental policies at the level of ambition reached in 2010. Of course, as the economy continues to grow and consequently

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in reality, but it corresponds to just a failure of national policy. The study did not consider such cases since any assumption about such a policy failure would necessarily be arbitrary.

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

[8] An even better case couldbe theoretically imagined if all world countries accepted to commit themselves in emission limitation and trading, instead of limiting the effort into the Annex-B set of countries.

pressures from emissions amplify, preserving, in the period beyond 2010, just the level of effort reached at 2010 is equivalent to a relative reduction of the environmental protection effort.

As mentioned before, analysis with the energy system model PRIMES has been carried out in parallel. This analysis has concerned climate change policy in the EU and involved a substantially higher level of detail compared to GEM-E3. The PRIMES model is more accurate than GEM-E3 in the evaluation of energy-related emissions, because of the use of energy balance statistics that represent energy in physical units. Instead GEM-E3 uses Input-Output tables that are more aggregated for energy sectors and use monetary units. Therefore, there is higher confidence on PRIMES for the evaluation of energy-related emissions and energy system implications from climate change objectives. Consequently, emission constraints in physical and absolute terms have been imposed to PRIMES model runs. Then percent deviations from the baseline PRIMES scenario were computed. Subsequently those percent deviations have been transferred to GEM-E3 to determine the dynamic emission constraints to impose on the GEM-E3 baseline scenario. Given that for a model like GEM-E3 (and any other CGE model) only the deviations from baseline matter for policy evaluations, the way those deviations are computed reflect in a consistent manner the emission reduction insights got by using PRIMES.

2.4 Sources of Data and Links to Other Studies

The technical and economic evaluations, which defined the environmental problem areas and the targets for each policy scenario, have used a large set of data sources and models. Other chapters provide detailed information on those sources.

The GEM-E3 model uses data from Eurostat, including Input-Output tables for 1985, National Accounts, investment, consumption, demographic and employment statistics. It uses bilateral trade matrixes also from Eurostat. Environmental statistics come from Corinair, RAINS and several national sources. At some extend they have been also used in PRIMES and the two models have been calibrated to each other, as much as possible.

The environmental expenditure inputs to GEM-E3, as prepared by TME rely on a variety of micro-scale studies (see chapter by TME).

The baseline scenario with GEM-E3 has been co-ordinated with the one constructed with PRIMES. They share a common view about economic growth of countries, sectoral activity, household income, demographics and world energy prices. For the latter, there has been also co-ordination with world energy markets projections, carried out by using the model POLES.[9]

It should be also mentioned that all environmental specific evaluations, for example those that have used a variety of sectoral models, have all shared the same baseline scenario, as constructed with PRIMES and GEM-E3 models.

[9] This activity has been carried out under the TEEM research project of DG XII. The work with POLES is under responsibility of IEPE (Grenoble). The POLES model is a global sectoral model of the world energy system.

3. The baseline scenario

3.1 Introduction

The purpose of building a baseline macroeconomic scenario was to harmonise the assumptions of the various environmental models and studies carried out within the present project. The scenario goes up to 2030 for each EU member states. The present projection aims to consistently delve into considerable detail at the level of sectoral disaggregation demanded by several energy models, such as PRIMES and MIDAS. The assumptions of this scenario were elaborated and checked for internal consistency with the ***GEM-E3*** macroeconomic general equilibrium model.

Deriving projections for the longer term is very difficult given the considerable uncertainties involved. Two are the main difficulties of such an undertaking:

- The first is projecting aggregate regional GDP and population growth. Several studies are available concerning the medium and long term (usually up to 2020) covering the whole planet such as with the LBS-EGEM model (which however does not include Europe) or the world projections within the LINKAGE project, as these where prepared for the OECD, where Europe is just one region. This latter study was the basis for the present projection.
- The second, and perhaps even more elusive, difficulty reflects the sectoral changes. As the past has shown these changes can often be very dramatic and move in different directions in different countries. No study is available at the level of disaggregation needed for the energy models, so this part of the projection after 2000 is original.

The present scenario draws from the macro-economic and sectoral projections available for the short term (up to 2000) and then uses the aggregate world assumptions derived with the World Scan model, extending them to 2030. From a sectoral perspective, there has been attempted to build a separate "story" describing the evolution of each EU country. The projections were made in two steps:

- Assuming gradual conditional convergence of the EU economies in terms of per capita income, the GDP of each country was derived.
- Understanding the present situation of each country and identifying already existing trends, the driving forces of growth for each economy were identified and served to derive sectoral growth.

3.2 Short run projections: 1995-2000

Three were the main sources consulted for the preparation of the projections for the period 1996-2000:

The **DGII projections** for each member state, from which GDP, private consumption, consumers' price indexes, GDP deflator, interest rate and exchange rate were taken.

Sectoral projections were taken from the **DRI study "Europe in 1999 - Economic analysis and Forecasts"**. These projections were only available for 6 EU member states and covered only some of the industrial sectors. Information on services was derived from the **HERMES projections** (again for six countries), which were also used to cross-evaluate the DRI assumptions. Both studies only gave one average figure for the whole 1996-2000 period, so assumptions had to be made about the changes in each particular year. The assumption of a linear trend was mostly followed. For the other EU countries no sectoral forecast where available, so current trends were assumed to continue, in such a way however, that the EU-total for each sector matches the DRI forecasts.

Table 1: GDP projection up to 2000

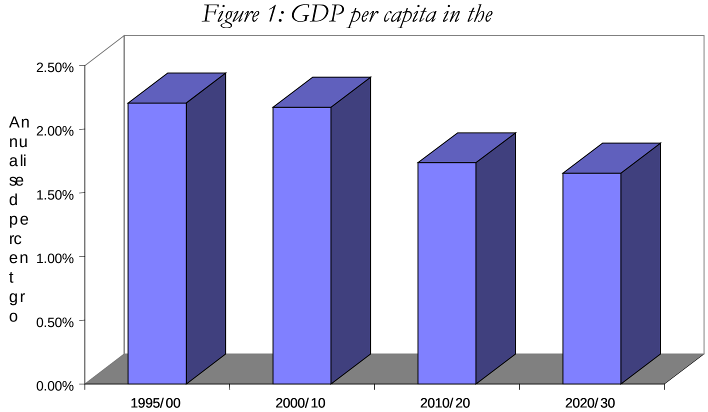
Short run GDP projections (annual growth rates)						
	1995	1996	1997	1998	1999	2000
Austria	2.81%	1.00%	1.60%	2.50%	2.90%	3.10%
Belgium	0.90%	1.40%	2.19%	2.66%	2.90%	3.04%
Germany	1.90%	1.41%	2.16%	2.80%	3.02%	3.21%
Denmark	2.76%	2.08%	3.06%	2.96%	2.86%	3.11%
Finland	4.21%	2.13%	3.67%	3.11%	3.39%	3.56%
France	2.14%	1.09%	2.09%	2.66%	2.85%	3.27%
Greece	2.00%	2.37%	2.51%	2.78%	3.12%	3.51%
Ireland	9.84%	7.75%	5.81%	5.22%	4.79%	4.60%
Italy	2.96%	0.84%	1.44%	2.57%	2.74%	3.03%
Netherlands	2.08%	2.45%	2.77%	2.95%	3.06%	3.07%
Portugal	2.18%	2.51%	2.81%	3.13%	3.48%	3.68%
Spain	2.85%	2.10%	2.67%	3.17%	3.66%	3.71%
Sweden	3.01%	1.72%	2.11%	2.49%	2.78%	2.96%
UK	2.38%	2.31%	3.00%	3.00%	2.94%	2.99%
EU Average	2.4%	1.6%	2.3%	2.8%	3.0%	3.2%

3.3 Long run projections: 2001-2030

3.3.1 Projection of GDP

The assumption about average EU growth was based on the **World projections** performed with the **Linkage** model for the OECD. In this project, a world model (EU was one region) was used to define two scenarios termed “High growth” and “Low growth”. Because these two scenarios reflected rather very optimistic or very pessimistic views of the future, it was decided to construct a “**medium**” evolution path. It should be noted that this time-path involved only the evolution of total average EU GDP growth.

Figure 1: GDP per capita in the



In the baseline scenario average EU growth is assumed to increase by 2.4% in the decade 2001-2010, slowing to 1.8% in the following decade 2011-2020 and stabilising to 1.7% thereafter. The EU population is assumed to increase slightly until the first decade of the next millennium also due to immigrants. After 2010 the rate of growth falls going to 0% after 2020.

Table 2: Percent difference from EU average in per capita GDP

	2000	*2030*
Austria	9.31%	3.60%
Belgium	6.23%	3.00%
Germany	4.30%	3.70%
Denmark	35.35%	25.00%
Finland	26.19%	20.00%
France	11.85%	3.70%
Greece	-67.23%	-55.00%
Ireland	-0.22%	7.00%
Italy	11.94%	9.50%
Netherlands	3.29%	3.60%
Portugal	-57.96%	-40.00%
Spain	-28.17%	-16.00%
Sweden	28.54%	23.00%
UK	-1.71%	1.10%

The GDP projection was then elaborated by member-state following an assumption of gradual convergence of per-capita incomes within the EU. Even in 2030 this convergence is however, far from complete. Based on the projections of changes of intra-EU differences in per capita income, the general EU GDP growth and demographic assumptions, the implied GDP growth per country was obtained. The assumption of convergence implies higher growth rates for the cohesion countries (Greece, Ireland, Portugal, Spain), growth above EU average for the UK and lower growth levels for the rich Scandinavian countries (Denmark, Sweden and Finland). This trend is already present to some extent as can be seen from the high growth rate experienced by Ireland, Spain and Portugal in the period 1985-95. In these comparisons across EU member states market exchange rates have been used (relative to the ECU), rather than purchasing power parity indicators.

By keeping then constant the average EU growth as given in Figure 1, and applying the convergence process given in table 2, GDP growth rates by country are computed in a consistent manner. These are shown in table 3 and figure 2 that follow.

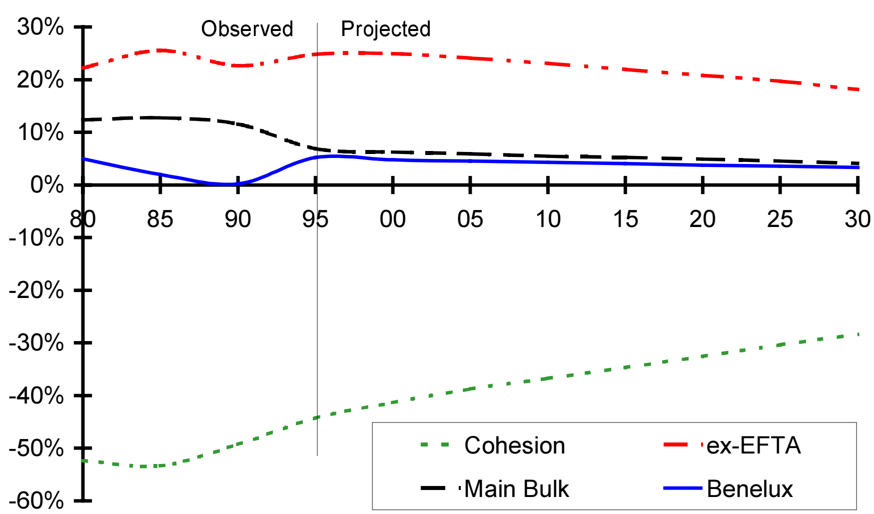


Figure 2: Evolution of growth rates in the EU 1980-2030

Table 3: Annualised percent change in GDP

	Observed			Forecast						
	1980-85	1985-90	1990-95	1995-2000	2000-05	2005-10	2010-15	2015-20	2020-25	2025-30
Austria	1.31%	3.22%	2.28%	2.22%	2.19%	2.15%	1.74%	1.59%	1.51%	1.49%
Belgium	1.02%	2.85%	1.51%	2.44%	2.29%	2.23%	1.82%	1.67%	1.59%	1.57%
Germany	1.23%	3.23%	1.84%	2.52%	2.50%	2.26%	1.80%	1.65%	1.62%	1.62%
Denmark	2.19%	1.82%	1.68%	2.81%	2.19%	2.10%	1.61%	1.44%	1.38%	1.16%
Finland	2.85%	3.39%	-0.69%	3.17%	2.40%	2.32%	1.84%	1.62%	1.56%	1.47%
France	1.42%	2.99%	0.94%	2.39%	2.30%	2.21%	1.85%	1.67%	1.58%	1.58%
Greece	1.49%	1.68%	1.40%	2.86%	3.40%	3.34%	2.99%	2.96%	2.95%	2.60%
Ireland	3.33%	5.57%	6.30%	5.63%	3.78%	2.68%	2.18%	1.97%	1.87%	1.81%
Italy	1.42%	3.00%	1.33%	2.10%	2.19%	2.08%	1.80%	1.63%	1.58%	1.53%
Netherlands	1.28%	3.06%	1.82%	2.86%	2.64%	2.55%	2.12%	1.86%	1.78%	1.75%
Portugal	0.82%	8.04%	1.72%	3.12%	3.76%	3.61%	3.09%	2.85%	2.76%	2.71%
Spain	1.46%	4.45%	1.51%	3.06%	2.91%	2.84%	2.39%	2.20%	2.16%	2.15%
Sweden	2.24%	2.80%	0.92%	2.41%	2.38%	2.24%	1.70%	1.53%	1.50%	1.50%
UK	3.47%	3.25%	1.27%	2.85%	2.59%	2.52%	2.00%	1.68%	1.63%	1.61%
EU Average	1.73%	3.22%	1.43%	2.57%	2.48%	2.35%	1.93%	1.73%	1.68%	1.66%

3.3.2 Fiscal and monetary policy

It is assumed that monetary unification around 2000-2005 will tend to eliminate fluctuations in interest and exchange rates and lead to a gradual convergence of prices. Additionally a combination of monetary policy and the high intra-EU level of competition is assumed to keep price increases and inflation below the 1995 rate.

This process further implies that growth of private consumption will be lower than average GDP, leaving more room for financing investments, in the short run. Gradually a progressive shift is projected leading after 2020 to equality of growth rates.

Tight fiscal policies are assumed to prevail in the next decade aiming to reduce public deficits. After that time a shift of the role of the government towards regulation instead of provision will result in increase of the public sector at a level lower than average GDP.

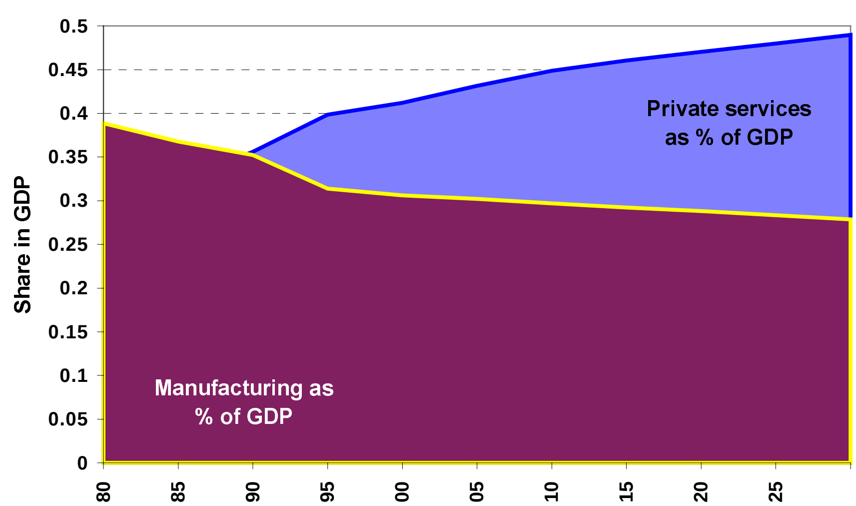
3.3.3 Long run sectoral projection

From a sectoral point of view, the baseline assumes a continuation of current trends, without entailing extreme situations. Specialisation of countries occurs but in most cases not dramatically, services increase their dominance but do not encompass the whole economy. Industrial activity is rather stabilised following a period of re-structuring. New industrial activities with high value added and lower material base are projected to emerge in most countries. Considerable differences are assumed in the evolution of the economies in the different countries. Some of the main assumptions of the scenario are as follows:

- In Germany and France industrial growth is assumed to occur mainly through engineering, chemicals and the non-ferrous sectors (at a lesser degree). Building materials, paper and pulp and non-metallic minerals will also increase but less than GDP. Production will stagnate in construction, agriculture, textiles and the iron and steel sectors. The share of services will continue to be higher than GDP.
- Similar trends are also projected in the UK. Activity in the manufacturing sector is maintained close to the 1990 levels, mainly through chemicals, equipment and paper and pulp. In Italy a general slowdown of industrial activity is projected, except in building materials, and equipment goods. Activity in textiles and food processing is preserved. Growth is balanced benefiting almost all sectors. Increase in services is assumed being higher than the EU average.

- In Belgium manufacturing in general increases more than GDP up to 2005 and keeps some of its potential thereafter. Growth comes also from specialised activities in non-ferrous and non-metallic minerals, but mainly from chemicals, engineering and construction. Services increase, but less spectacularly than in most other countries.
- Austria and the Netherlands also keep industrial activity, through engineering, metals and chemicals (in the Netherlands) or through construction and a balanced growth of most other sectors (in Austria).
- In the Scandinavian countries it is assumed that the paper and pulp sector will have a considerable increase (especially in Sweden and Finland), while engineering also increases above GDP. Building materials and construction on the other hand, will stagnate, or increase marginally (Denmark). The growth in the public sector is assumed to be very low in all these countries.
- Cohesion countries experience high growth rates. In the first years up to 2005, the main drivers of industrial growth are construction, building materials also because of the cohesion funds. After that time growth is also diverted to food, textiles and trade. Ireland is an exception, since most of the increase in industrial output is assumed to come from engineering, special activity in metals and chemicals, following an inflow of foreign investments. Similar trends are also projected to occur in Portugal. The increase in the share of market services in all these countries is assumed to be above 4% until 2010 and falls gradually thereafter.

Figure 3: Evolution of services and manufacturing in Germany



The main assumptions of the projections from a sectoral viewpoint are summarised in the following table:

Sector	*Assumptions*
Iron and Steel	Following the decreases observed between 1990-95, production continues to fall undergoing extensive restructuring, to achieve stability after 2020
Non-ferrous	Following considerable restructuring between 1990-95, the sector rebounds achieving stabilisation and growth. This effect is present in Germany, the Netherlands, Spain and the UK
Chemicals	Production of basic chemicals is projected to be maintained in some countries and especially in France, Germany and the Netherlands. The higher value-added brands of the sector (such as pharmaceuticals) are assumed to flourish benefiting from an increase both in domestic demand and in exports. Germany, France, Ireland, Italy, Netherlands and Belgium experience growth rates similar to GDP. In the southern cohesion countries, on the other hand, production is assumed to stagnate or increase only marginally
Paper and pulp	The sector is assumed to face a significant increase in demand especially from the rest of the world. The EU is assumed to continue to be a net exporter. Growth in this sector is assumed to be one of the main driving forces of economic growth in the Scandinavian countries: about 3.5% per annum for Finland and Sweden between 2000 and 2020.
Non-metallic minerals	Activity in traditional building materials is projected to increase especially in the South, benefiting from an increasing demand from the construction sector, especially in the first decade of the next millennium. In the North activity will be mostly diverted to specialised products with high value added (such as high quality ceramics etc.)
Engineering	After a decade of relative stagnation and restructuring, the sector is assumed to strongly rebound being one of the main driving engines of economic growth for the most important European economies: Growth above GDP is projected for Germany, France, UK, Ireland and Italy especially up to 2020. Significant increases are also projected for Belgium and the Netherlands.
Construction	The outlook for construction appears better in the countries of the south where it will be significantly higher than GDP, also because of the cohesion funds. In Portugal and Greece for example the increase in construction in the decade 1995-2005 is of the order of 4% and only slightly lower in Spain.
Textiles	After almost a decade of considerable restructuring that lasts up to 2000, the sector is assumed to rebound in the southern countries: Greece, Italy, Portugal and Spain all face a 1.5-2% growth per annum between 2000 and 2030. In the other countries production is assumed to stabilise in level lower than 1990.
Food and Agriculture	Some growth is expected but less than GDP. These sectors are generally assumed to undergo significant restructuring. Higher increases are projected in the south (especially in Greece and Portugal where after 2005 these sectors are expected to start growing significantly again) and to some extent in France.
Energy	The growth in the energy sector is expected to be of the order of 1-2% for most countries, growing at about half the GDP rate.
Services	The role of services is assumed to increase significantly in all countries. Their growth rate is everywhere higher than average GDP. Their share in the economy increases over time but at a decreasing speed, leading to some stabilisation after 2020. Still increase in activity in private services remains more than 2% per annum until 2030. The increase in the service sectors (especially tourism) is more pronounced in the South.

3.4 Assumptions regarding energy

The baseline scenario includes current trends and all policies in place except those that aim at reducing CO_2 emissions in the perspective of reaching the Kyoto targets. The scenario includes:

1. The dynamic trends of technology progress that improves the efficiency of the energy system,
2. The restructuring of markets effected through the liberalisation of electricity and gas market in Europe and
3. The observed sectoral pattern of economic growth that shifts away from traditional energy intensive sectors and operates through high value added activities.

Energy prices are assumed to gradually increase from their presently low-level following a smooth ascending path. Table 4 shows the main assumptions for the energy prices at the border of the EU. Oil prices are assumed to recover by 2005 at their 1995 level and then grow smoothly. Natural gas prices increase at lower rates in the first half of the period but then grow slightly faster than oil. Coal prices remain practically stable in real terms.

Energy taxation policies are assumed to remain unchanged from the current situation in the EU member-states.

Table 4: Baseline Assumptions on Energy Prices

Average Border Prices at the EU in Eur'90 per toe				
	1995	**1998**	**2005**	**2010**
Crude Oil	81.7	58.6	81.2	86.2
Natural Gas	65.7	58.6	72.7	79.7
Coal	51.7	50.9	50.4	51.1

Average % change per year			
	1998-95	**2005-98**	**2010-05**
Crude Oil	-10.5	4.8	1.2
Natural Gas	-3.8	3.1	1.9
Coal	-0.5	-0.1	0.3

Energy policies not directly related to Kyoto objectives are assumed to continue within the baseline scenario:

1. The liberalisation of electricity and gas markets starts operating in the beginning of the new century and is assumed to fully develop in the second half of the first decade.
2. The restructuring is enabled by mature gas-based power generation technologies that are efficient, involve low capital costs and are flexible regarding plant sizes, cogeneration and independent power production.
3. Energy policies that aim at promoting renewable energy (wind, small hydro, biomass and waste) are assumed to continue, involving subsidisation of capital cost and preferential electricity selling prices.
4. On-going infrastructure projects in some member-states concerning the introduction of natural gas are assumed to gain full maturity in the first half of the first decade of the projection period.
5. Finally, stringent regulation for acid rain pollutants is also assumed to continue, in particular for large combustion plants.

4. Macroeconomic assessment of environment improving actions

4.1 Overview of methodology

In this "economic priorities" study, environment-improving actions are expenditures, investments and emission targets that are deliberately undertaken by the economic agents so as to ameliorate the status of the environment in Europe. Those actions are considered to be undertaken in addition to similar actions that would have taken under baseline conditions. The aim of the macroeconomic assessment exercise is to evaluate the indirect economic implications from these actions, measured as changes from baseline levels of aggregate and sectoral macroeconomic figures, such as GDP, employment, investment, foreign trade, prices and sectoral production and consumption.

It is also assumed that the environment-improving actions are spontaneously undertaken by the economic agents and not as a response to public policy instruments, like taxes or standards. Policy instruments are always imperfect as regards their implementation efficiency, involving transaction costs and leakages. Since the study aimed at estimating the "pure" macroeconomic implications of the actions, it did not consider the policy instruments and the possible optimal mix of instruments.

Even when a global environmental target is imposed, for example as a global emission limitation, or even when an emission permit market is simulated, the modelling representation should be understood as a technical way of calculating the least-cost allocation of an effort to the economic agents, rather than as a policy instrument. Considering the latter would imply also accounting for transaction costs and policy failures.

As it is known, environment-improving actions are undertaken to avoid present or future damages to human beings caused by the degradation of the environment. If calculated in monetary terms, for example as payments to repair those damages, they are considered as external costs to the economy. Being external they are not considered playing a role within the usual economic mechanisms. Avoiding the damages because of the actions implies taking benefits as compared to baseline conditions. Comparing the monetary value of these benefits with the economic costs would help decision makers to prioritise the environment-improving actions.

The costs to compare with are the total macroeconomic implications of the actions, as measured for the economy as a whole. Given that such implications simultaneously concern all the economic agents at different degrees, it is always questionable to use a single aggregate as a measurement of economic costs. Often, the distributional impacts on markets and agents are appreciated in different ways by decision-makers. However, this study has considered GDP and its change from baseline because of the environmental actions as a measure of welfare change, hence a single aggregate to compare with benefits. The results about economic implications are rich enough to allow for using other macroeconomic figures or other cost-benefit comparisons if needed.

4.2 Feedback effects of avoiding damages

It is obvious from the above that all policy conclusions come from comparing to a baseline economic scenario. The definition of the nature of this baseline is therefore crucial. In methodological terms it matters considerably to assume whether the economy is under baseline conditions in general equilibrium or not. This study does assume that the economy is in general economic equilibrium under baseline conditions, despite the external costs or damages caused by the environmental degradation. One could make a different assumption about the baseline. For example, it may be the case that the environmental status or its progressive degradation restricts the economic growth and its potential (for example workers cannot deploy their full potential on labour productivity because they suffer from air pollution).

If this is the case in the baseline, removing the environmental damages would imply higher economic growth potential or in other terms the possibility to obtain gains from economies of scale. Under such circumstances it might be the case that the environment-improving actions do not entail costs for the economy but even gains in macroeconomic terms and GDP. In this study, however, it is assumed that the environmental problems under baseline conditions and for the limited time horizon of the study are not involving significant restrictions on economic growth. Therefore it is admitted that the baseline is in general economic equilibrium.

Therefore, almost by definition along to the theory of general equilibrium, undertaking actions to internalise external costs would lead to costs for the economy, for example losses of GDP as compared with the GDP of the baseline scenario. The actions imply deviating resources away from their optimal economic allocation under the baseline equilibrium; therefore some loss of general economic efficiency will take place. The ensuing economic costs are sacrificed by the agents in order to obtain non-economic benefits from a better environmental status.

At this point one could raise the argument that these environmental benefits are not just non-economic, in the sense of not implying economic gains within the conventional economic circuit given also that the monetisation of the benefits, as stated above, is undertaken for comparison reasons only. For example one could argue that health effects would be lower under a better environment, hence medical expenditures would be lower as well implying economic gains for the consumers.

Similar arguments can be raised about improved labour productivity enabled under a better environment, and so on. If this was true, then the net economic costs would be lower and the cost-benefit ratio would be more favourable to environmental actions.

Considering the indirect economic gains from avoiding external damages poses a methodological problem for the analysis related to the characterisation of the baseline scenario, as explained above. If such gains are large, then one should not characterise the baseline as being a general equilibrium and should incorporate these potential gains in the modelling of the microeconomic behaviour of the agents.

Quantifying these indirect economic gains is also methodologically difficult and controversial. For example, if man's health is improved by avoiding air pollution the medical expenditures may not decrease, because the man's lifetime will be higher and other diseases might prevail. Also, quantifying the effects of pollution on labour productivity has been difficult and controversial. In only some extreme cases there is general acceptance of linking the environmental status to labour productivity: examples are the centres of large cities (mainly because of congestion) and some very polluted small industrial areas.

In the literature there is use of the term "feedback effects" to describe the possible economic gains from avoiding environmental damages. Because of the mentioned difficulties, this is still a research area. Within the recent research project GEM-E3-Elite (DG Research, 1998-9) dealing with the general equilibrium model GEM-E3 that is also used in this study, there has been effort to quantify such "feedback effects". The research results also confirmed the mentioned difficulties.

The research approach in that project was to represent mortality and chronic morbidity as well-being assets in the utility function. The probability of being in a state of health is assumed to depend on actions that could improve air quality. The utility maximisation problem of the household yields that the optimum is not only to consume but also spend in environment-improving actions, which then become endogenous. Given the research status of this modelling work, it has been decided for this study to use the standard version of GEM-E3, which does not incorporate the feedback economic effects from avoiding damages.

It follows that the estimation of the economic costs according to the above mentioned methodology represents an upper bound of the costs, since it is assumed that the baseline economy is under general equilibrium and that there are no significant feedback economic effects from the avoidance of environmental damages.

4.3 Modelling methodology

Although the GEM-E3 model is very detailed and disaggregated compared to other computable general equilibrium models, it is not enough detailed to cover the complexity of linkages between environment-improving actions and the economy. The version of the model used in this study is more elaborated for air pollution issues than for other environmental problems. For air pollution, actions like investment in abatement technology, change of fuel mix, substitution between energy and non energy inputs of production and consumption are endogenously represented in the model. So for air pollution it was possible to directly set emission targets and let the model simulate the optimal allocation to agents and their best response. For example, undertaking energy efficiency improving actions is costly but spending in purchasing fuels is reduced; these effects are represented in the model.

On the contrary, other environmental areas are poorly represented. For example, actions that may improve coastal zones have a cost represented in the model, but they also may allow for benefits through the increase of tourism or other activities in the coasts. These indirect effects are not represented in the model. Similarly improving the soil and avoiding pesticides and damaging fertilisers has a cost represented in the model, but productivity of land may deteriorate, which is not taken into account. Similarly the model is poor for water availability and quality, waste management, accidents, dangerous substances and so on.

The problem is that there are no comprehensive general equilibrium models that simultaneously represent all these areas and their indirect effects, given also that the modelling methodology is not well established for these areas.

Because of these difficulties and in order to be transparent in the use of the model, it has been decided to split the environmental areas in two categories:

- First, all areas for which environment-improving actions are quantified externally from the general equilibrium model and introduced as compulsory investment-expenditure to be undertaken by the economic agents on top of their baseline conditions. Any indirect effects of these actions on factor productivity, change of production process, change of consumption pattern or indirect benefits from the improved environment are all ignored. The actions do have indirect economic implications as any other levy on production and consumption.
- Secondly, air quality areas in particular climate change for which environment-improving actions take the form of global (or regional) constraint on emissions. Depending on model parameters that mimic the establishment or not of an emission permit market, the global constraints are allocated to the sectors and countries according to the internal model mechanism.

The first category as described above applies to all environmental areas of the Technology Driven scenario and to all areas except energy-related carbon dioxide emissions of the Accelerated Policies scenario.

The preparation of the values of exogenous parameters to reflect these policy scenarios has been an intensive stage of the work and is important for the final results. The preparation stage has been carried out at a micro-scale that is far more disaggregated than the level of detail of the model. The approach consisted of starting from real-world case studies and by extrapolating their characteristics to sectors and countries. The methodology and definitions differ by environmental area and because of their complexity are only shortly described in this report.

5. Analysis for the Technology Driven (TD) Scenario

5.1 Definition of the Case Studies

The Technology Driven Scenario assumes that the economic agents undertake investments or expenditures aiming at improving the quality of the environment. It is assumed that each agent invests in the environment-improving actions because and proportionally to the influences his production or consumption exerts on the environment.

With respect to the classification of environmental areas as retained in this study, the Technology Driven Scenario involves actions in all areas except climate change, as indicated in Table 5. The last column of this table indicates whether or not the environmental area has been considered for the macroeconomic analysis. Some of the areas for which there was lack of methodology or data have been ignored in the analysis of macroeconomic implications.

Table 5: Definition of the TD scenario

Policy Scenario: Technology Driven (TD)		
Environmental Problem Areas	***Type of Action considered***	***Inclusion in extra costs for GEM-E3***
Stratosperic Ozone Depletion		No
Climate Change		No
Major Accidents	Nuclear Power Plants Upgrading	Only nuclear, not for oil spills
Biodiversity Loss		No
Acidification and Eutrophication	SO2, NOx and NH3 abatement	Yes
Chemical Risks	Dioxine & PAH abatement	Yes
Water Stress		No
Waste Management	MSW abatement	Partly
Troposhperic Ozone	VOC abatement	Yes
Coastal Zones		No
Urban Stress	PM10 Abatement	Partly (not for noise)
Soil Degradation		No

5.2 Costs of Environmental Actions under TD

The nature of the environment areas considered under the TD scenario is such that the pollution abatement investments act as a lump sum at the level of total cost of the firm or at the level of total cost of households' consumption.

The pollution is not attributed to the use of production factors or commodities, but to total production of firms or certain consumption categories of households. The agents do not get any direct benefit from investing in environmental protection. They just bear the additional costs without seeing any direct effects on their production capacity, in case of the firms, or their utility obtained from consumption in the case of households.

There is no agent (e.g. the government) that directly earns from these environmental expenditures. However, firms that may supply the commodities that are necessary to build the environment-improving constructions may indirectly take earnings from these expenditures. To implement the environment improving technologies, the expenditures involve additional demand for goods and services. The split is based on fixed technical coefficients.

The environmental expenditures are assumed to take the form of fixed annualised payments for a period of 25 to 30 years, gradually starting from 2000.

Table 6 summarises the main input data for the GEM-E3 model run for the TD Scenario. The last column is indicative of the magnitude of the environmental protection investment showing the ratio of annualised payments over sectoral costs. *Table 7* shows a similar ratio (on GDP) for each EU member state, to illustrate that the relative effort under TD Scenario differs across the countries. Also the percent contribution of firms and households differ by country. The tables show that total environmental expenditures under TD represent in average about half of one per cent of the EU GDP annually. This is a substantial effort. Looking to the sectors, the cases of agriculture, electricity and energy intensive sectors are noticeable, since the charges represent a rather high share in total production costs of these sectors. The additional charges on heating and electric appliances of households are also noticeable.

Table 6: Input Data for TD by Sector

Policy Scenario: Technology Driven (TD)									
Annuity Payments for the EU in 10^6 Euro	Major Accidents	Acidification and Eutrophication			Chemical Risks	Waste Management	Tropospheric Ozone	Urban Stress	As % of sector production cost or % of household consumption
Sectors	Nuclear	SO2	NOx	NH3	Dioxine& PAH	MSW	VOC	PM10	
Agriculture	0	181	154	13752	0	0	0	0	3.8
Coal	0	38	15	0	0	0	0	0	0.1
Crude oil and oil products	0	223	140	0	0	0	1096	45	0.4
Natural gas	0	0	117	0	0	0	0	0	0.1
Electricity	0	2078	3212	0	0	0	0	348	3.0
Ferrous, non-ferrous ore and metals	0	259	918	0	89	0	149	534	0.6
Chemical products	0	187	702	265	0	0	860	69	0.5
Other energy intensive industries	0	282	1088	0	0	0	882	673	0.5
Electrical goods	0	41	155	0	0	0	904	13	0.4
Transport equipment	0	38	127	0	0	0	912	11	0.3
Other equipment goods industries	0	57	217	0	0	0	767	18	0.2
Consumer goods industries	0	310	1113	0	0	0	245	93	0.1
Building and construction	0	33	270	0	0	0	2	11	0.1
Telecommunication services	0	7	108	0	0	0	2	0	0.1
Transports	0	25	986	0	0	0	121	0	0.3
Credit and insurance	0	8	51	0	0	0	2	0	0.0
Other market services	0	149	1007	0	0	0	105	0	0.1
Non market services	94	241	575	0	246	0	2	0	0.1
Households									
Housing	0	10	10	0	0	4712	103	0	1.3
Heating and Electric Appliances	0	764	1808	0	0	0	2467	0	14.1
Cars, Motorcycles	0	0	2896	0	0	507	166	0	3.5

Table 7: Input Data for TD per Country

Policy Scenario: Technology Driven (TD)												
Annuity Payments for the EU in 10^6 Euro	Major Accidents	Acidification and Eutrophication			Chemical Risks	Waste Management	Tropospheric Ozone	Urban Stress	TOTAL	% of GDP	Contribution % Shares of	
Countries	Nuclear	SO2	NOx	NH3	Dioxine& PAH	MSW	VOC	PM10	TD		Sectors	Household
Austria	2	28	56	300	4	117	357	32	897	0.67	60.4	39.6
Belgium	3	272	453	631	25	21	363	128	1895	1.20	84.8	15.2
Denmark	2	112	201	882	10	41	91	8	1346	1.23	86.8	13.2
Germany	22	1161	3521	2313	65	1212	1362	645	10299	1.39	42.4	57.6
Finland	2	202	271	180	2	35	168	27	885	1.18	77.0	23.0
France	16	653	2048	2648	110	412	1852	175	7915	0.83	74.8	25.2
Greece	1	344	658	283	0	182	226	78	1772	2.44	69.8	30.2
Ireland	1	92	138	580	0	87	96	17	1010	3.16	82.1	17.9
Italy	15	473	2288	856	37	875	1354	284	6182	0.78	68.0	32.0
Netherlands	4	71	901	1065	7	190	238	34	2509	1.04	79.8	20.2
Portugal	1	140	566	476	0	127	179	57	1546	3.08	70.1	29.9
Spain	7	611	1433	2568	17	507	809	177	6129	1.80	80.9	19.1
Sweden	3	31	285	254	11	57	269	22	932	0.56	73.3	26.7
UK	14	743	2850	981	48	977	1423	130	7167	0.81	71.5	28.5
EU-14	94	4932	15669	14017	336	4839	8785	1813	50484	1.00		

5.3 Overview of Macroeconomic Implications

For production sectors the direct consequences of the environment protecting investments are twofold. The unit production cost increases since firms bear additional changes. They have to spend the extra environmental obligations, without obtaining a potential for higher volume of production or higher volume of production factor input.

Higher unit production costs cause domestic prices to rise. The market equilibrium prices, nevertheless, increase less than the direct effects due to the environmental charges, because demand is readjusted as a result of rising prices and supply adapts both in volume and structure (including eventual changes in the mix of production factors).

For households, the additional charges for the environment cause a reduction of total disposable income that is allocated to the purchase of goods and services and preserve households' utility. In particular they have to spend more on certain consumption categories (like housing, heating and electric appliances and cars) without getting higher volume of consumption on these goods (just better quality with respect to the environment).

The environment-improving expenditures need goods and services so as to build the corresponding capital. These expenditures are taken as part of total investment, in other worlds the formation of gross capital. In Input-Output terms this means that total final demand increases since the environmental investments require goods and services. However the part of capital corresponding to better environmental quality does not increase the potential production capacity of the economy and in that sense it has no direct growth effects.

The additional demand for goods and services needed to build the environmental improving technologies partly compensate the drop of demand that is due to prices. They help keeping up demand, however leaving uncertain the net effect on total demand.

An upward demand shift under general equilibrium conditions provoke a rise of market prices of commodities, as long as production capacities remain unchanged, that is in the short run. Such effects on prices have to be added to the direct consequences caused by environmental charges as acting on unit production costs. Therefore domestic prices rise also as a consequence of environment protecting investments.

It follows that the relative competitiveness of domestic supply weakens implying higher imports and lower exports. The European Union having established a large single market could moderate the consequences from this loss of competitiveness, in condition that all environmental investments are uniformly undertaken in all the EU member-states. Any asymmetry in such efforts, for example when environmental protection investments are unilaterally undertaken, would entail large losses under the Single Market.

The sectors face changes of the demand for their goods. Some sectors, as for example the equipment goods industry, face a drop of demand because of loss of competitiveness but also a rise of demand because of the additional needs of environment investments. They also face changes due to the re-allocation of consumption of households, as this partly loose disposable income because of the extra environmental charges. Some other sectors see a higher decrease of the demand for their goods. The distributional effects of these changes are mostly significant. The new equilibrium leads of course to a new allocation of resources (labour and capital) to sectors and countries.

Households face higher prices for the consumption goods and see their real wage eroding. Some workers refrain form participating in the labour market provoking a downward shift of the labour supply curve, hence pushing towards higher real wages. Probably such a reaction cannot fully re-establish the real wages at their baseline levels, since the labour market exhibits a limited degree of flexibility. In any case the labour market changes and adds a further pressure on prices, aggravating the loss of competitiveness. The changes by sector also might affect the labour market. If the sectors obtaining relative gains from the new distribution are more labour intensive than the losing sectors, total demand for labour rises, so wages and prices further increase. If the contrary occurs, then employment reduces and wages might even drop in real terms.

In aggregate macroeconomic terms the above changes induce a loss in GDP at the national and EU level. The environmental expenditures cause a shift of revenues from consumption to investment. But this investment is not productive, since it is used only to improve the quality of the environment. If it was productive either directly by allowing economic benefits in some domains because of improved environment or indirectly by relaxing environment-driven restrictions on the economy's resources, then there would be economic growth effects. In the absence of such growth effects, the shift from consumption to investment entails net costs for the economy reflected in losses of GDP as compared to the baseline case.

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

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

Despite the drop of private consumption, total domestic demand for goods increases (by 0.17% for the EU), because of the goods required for the environmental protection. Firms face lower business perspectives because of loss of competitiveness, but also are optimistic as they see domestic demand rising. These effects compensate each other, resulting into a negligible decrease of total productive investments (-0.08% for the EU).

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

Ancillary benefits for the environment are worth mentioning. The lowering of domestic production in conjunction with changes in the structure of sectors (see below) and production factors lead to a substantial decrease of energy consumption, both for firms and households. Energy needs drop by 0.61% in the EU that is twice the drop of GDP. Consequently emissions are found decreasing. Emissions of carbon dioxide decrease by 0.71% from baseline, so do other atmospheric pollutants (in a range between –0.5% for NO_x and –1.1% for SO_2).

Table 8: Aggregate macroeconomic effects of the TD scenario

Technology Driven Scenario *GEM-E3*

% change from baseline	*EU*	*Austria*	*Belgium*	*Germany*	*Denmark*	*Finland*	*France*	*Greece*
Gross Domestic Product								
in 2010	-0.29	-0.09	-0.42	-0.14	-0.57	-0.72	-0.27	-1.08
long term	-0.21	-0.07	-0.24	-0.11	-0.39	-0.44	-0.21	-0.62
Employment (diff. In '000 persons)	47	0	0	27	0	-1	7	-1
Private Investment	-0.08	-0.04	-0.04	-0.04	-0.18	-0.43	-0.05	-0.46
Private Consumption	-0.50	-0.27	-0.32	-0.70	-0.59	-1.08	-0.33	-1.39
Domestic Demand	0.17	0.22	-0.01	0.30	0.09	-0.24	0.16	0.19
Exports in volume	-0.27	-0.08	-0.33	-0.19	-0.46	-0.50	-0.33	-0.97
Imports in volume	0.35	0.38	0.05	0.43	0.33	0.48	0.27	1.76
Energy consumption in volume	-0.61	-0.14	-0.42	-0.54	-0.60	-2.56	-0.64	-1.97
Consumers' price index	0.50	0.36	0.24	0.97	0.44	0.69	0.32	0.94
GDP deflator in factor prices	0.16	0.07	0.27	0.18	0.18	0.18	0.16	0.27
Nominal Wage rate	-0.73	0.09	-0.14	0.21	-0.21	-0.48	-0.08	-0.85
Real wage rate	-1.23	-0.27	-0.38	-0.76	-0.65	-1.17	-0.40	-1.79
Current account as % of GDP (diff.)	-0.13	-0.13	-0.07	-0.11	-0.16	-0.10	-0.09	-0.51
Terms of Trade	0.28	-0.02	0.08	0.07	0.16	0.26	0.08	0.37
CO2 Emissions	-0.71	-0.12	-0.47	-0.70	-0.69	-2.06	-0.71	-2.06

Technology Driven Scenario *GEM-E3*

% change from baseline	*Ireland*	*Italy*	*Netherl.*	*Portugal*	*Spain*	*Sueden*	*UK*
Gross Domestic Product							
in 2010	-0.88	-0.10	-0.36	-0.56	-1.23	-0.15	-0.25
long term	-0.43	-0.16	-0.27	-0.23	-0.89	-0.14	-0.16
Employment (diff. In '000 persons)	-2	17	2	-2	-10	0	10
Private Investment	-0.41	0.05	0.08	-0.26	-0.59	0.09	-0.09
Private Consumption	-1.07	-0.18	-0.34	-0.87	-1.26	-0.22	-0.37
Domestic Demand	-0.22	0.29	0.20	0.05	-0.06	0.10	0.12
Exports in volume	-0.51	-0.22	-0.18	-0.23	-1.07	-0.16	-0.18
Imports in volume	0.24	0.26	0.35	0.17	1.56	0.12	0.33
Energy consumption in volume	-1.26	-0.36	-0.38	-1.29	-1.23	-0.45	-0.56
Consumers' price index	0.51	0.27	0.24	0.64	0.78	0.26	0.39
GDP deflator in factor prices	0.20	0.11	0.13	0.19	0.46	0.12	0.18
Nominal Wage rate	-0.81	0.03	-0.21	-0.50	-1.04	0.02	0.04
Real wage rate	-1.31	-0.24	-0.46	-1.14	-1.82	-0.24	-0.36
Current account as % of GDP (diff.)	-0.03	-0.07	-0.12	-0.04	-0.19	-0.07	-0.07
Terms of Trade	0.22	0.04	0.09	-0.31	0.63	-0.02	0.07
CO2 Emissions	-0.93	-0.38	-0.37	-1.09	-1.46	-0.52	-0.72

Table 8[10] and *Figure 4* summarise the findings regarding the macroeconomic effects of the Technology Driven Scenario. *Figure 5* shows the indirect effects of TD in favour of reducing energy consumption and CO2 emissions. Although noticeable the effects are small in magnitude, especially if compared to the required reductions under Kyoto.

[10] It must be mentioned that % change from baseline for GDP does not reflect change in terms of growth for GDP but change of the level volume of GDP in 2010 when compared to that of baseline.

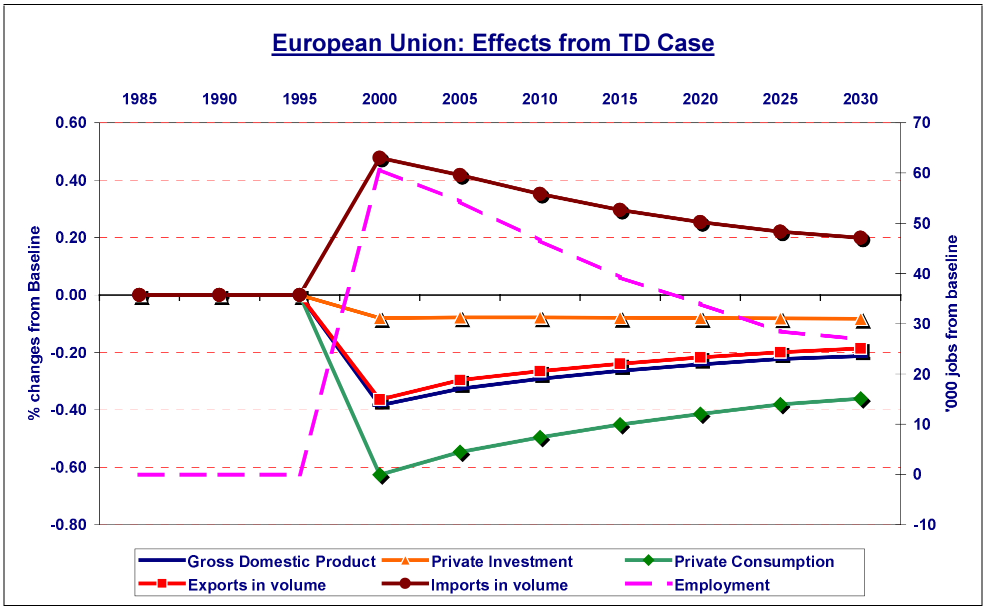


Figure 4: Macroeconomic effects of TD

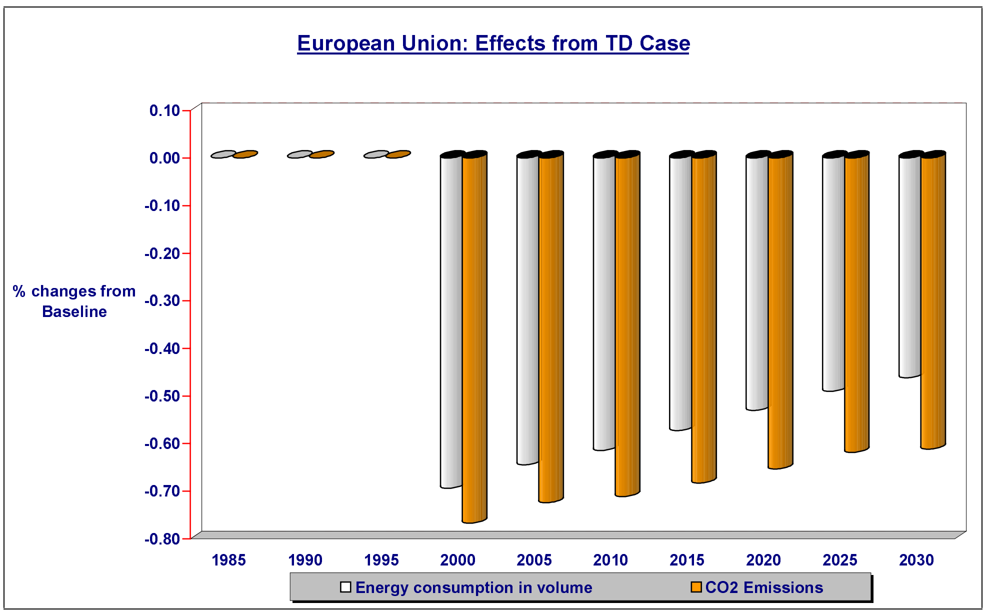


Figure 5: Side effects on energy consumption and CO_2 from TD

5.4 Sectoral and Country Effects

The effects of the Technology Driven Scenario on the sectors and countries are important and generally more interesting for policy making than the overall effects. It is complex to analyse in detail the causes of these effects. They depend of course on the allocation of environmental expenditures, but also on the structure of trade and activity of the sectors that prevails in the baseline scenario.

Regarding the effects on countries, the results show a clear correlation between the relative magnitude of the environmental expenditures, for example considered as percent ratio to GDP, and the amplitude of GDP losses. For example Greece, Ireland and Portugal facing high environmental expenditures as percentage of their GDP also bear high consequences in terms of GDP losses and price increases.

This results showing higher effects on the countries that are among the European cohesion area signify that requests for compensation policies and funding may be raised.

There are factors related to the structure of trade that also affect the country results. The trade structure combines with the sectoral changes effected by the environmental expenditures. For example, since the equipment goods industry is generally less affected because it sells equipment to build the environmental protection technologies, countries such as Germany having a strong position in trade for the goods of this sector obtain gains and partly compensate the other negative effects. On the contrary Spain bearing high environmental costs and less dominating trade in these sectors is more affected than Germany.

Regarding the sectoral effects, some sectors bear high direct environmental charges, like for example agriculture, electricity and energy intensive materials. Consequently, the price of their supply increases relatively more than in other sectors. Substitutions in favour of less affected commodities, both in intermediate consumption and in final demand, make them to lose market shares and slowdown their investment. Similarly, they also lose in foreign trade.

Other sectors gain from those substitutions, but also might be positively affected by demand for goods and services used to build the environmental technologies. This is the case of electrical goods, other equipment goods, building and construction and some service sectors. These sectors even see their market expanding. Some other sectors are heavily affected by the changes occurring at the structure of households' consumption. This is the case of transport equipment, as car prices increases needed to improve their quality lead households to invest less in purchasing cars. Table 9 summarises the results for the sector and provides information for the EU as a whole.

Table 9: Sectoral Effects of TD

Technology Driven Scenario *GEM-E3*

Results for the EU	*Domestic Production*		*Investment*		*Exports*	*Imports*
% change from baseline	2010	Long-term	2010	Long-term	2010	2010
Agriculture	-1.29	-0.91	-1.10	-0.80	-2.49	-0.36
Coal	-0.90	-0.70	-1.02	-0.88	-0.57	-0.81
Crude oil and oil products	-0.47	-0.38	-0.47	-0.37	-0.32	-0.44
Natural gas	-0.82	-0.77	-0.82	-0.80	-0.48	-0.76
Electricity	-1.11	-0.95	-1.10	-0.95	-0.82	-1.02
Ferrous, non-ferrous ore and metals	-0.77	-0.62	-0.66	-0.57	-1.14	-0.55
Chemical products	0.34	0.03	0.36	0.03	-0.22	0.77
Other energy intensive industries	-0.20	-0.17	-0.20	-0.18	-0.61	-0.10
Electrical goods	0.82	0.53	0.87	0.56	0.12	1.23
Transport equipment	-0.39	-0.25	-0.37	-0.25	-0.42	-0.33
Other equipment goods industries	2.63	1.86	2.62	1.85	1.42	3.69
Consumer goods industries	-0.34	-0.23	-0.16	-0.12	-0.97	-0.11
Building and construction	0.06	0.02	0.09	0.02	-0.04	0.08
Telecommunication services	-0.04	-0.05	-0.06	-0.07	0.03	-0.05
Transports	-0.10	-0.08	-0.09	-0.07	-0.04	-0.14
Credit and insurance	0.72	0.46	0.52	0.36	0.31	0.66
Other market services	-0.11	-0.10	-0.13	-0.11	0.02	-0.11
Non market services	-0.03	-0.02	-0.01	0.00	-0.07	-0.09

5.5 Detailed Results for each Environmental Area

Table 10 shows the macroeconomic implications when the environmental actions are considered individually. The results are obtained by running the model separately for each area. The first column in the table shows the results when actions are undertaken in all areas together.

Table 10: Effects of Environmental Expenditures for individual areas

Technology Driven Scenario - European Union ***GEM-E3***

% change from baseline	All cases together	*Macroeconomic effects when actions are on a Single Environmental area*				
		Acidification and Eutrophication	*Chemical Risks*	*Waste Management*	*Tropospheric Ozon*	*Urban Stress*
Gross Domestic Product						
in 2010	-0.292	-0.236	-0.003	0.028	-0.060	-0.019
long term	-0.212	-0.165	-0.002	0.023	-0.051	-0.016
Employment (diff. In '000 persons)	47	15	0	18	12	1
Private Investment	-0.078	-0.047	0.000	-0.001	-0.023	-0.006
Private Consumption	-0.495	-0.283	-0.001	-0.143	-0.061	-0.008
Domestic Demand	0.174	0.089	0.001	0.064	0.021	-0.002
Exports in volume	-0.266	-0.166	-0.005	0.028	-0.094	-0.028
Imports in volume	0.352	0.235	0.001	0.108	0.010	-0.004
Energy consumption in volume	-0.615	-0.393	-0.002	0.031	-0.223	-0.031
Consumers' price index	0.500	0.246	0.002	0.192	0.056	0.000
GDP deflator in factor prices	0.155	0.120	0.005	-0.018	0.037	0.008
Nominal Wage rate	-0.734	-0.714	0.000	0.092	-0.076	-0.037
Real wage rate	-1.234	-0.960	-0.002	-0.100	-0.131	-0.037
Current account as % of GDP (diff.)	-0.125	-0.087	-0.001	-0.010	-0.020	-0.006
Terms of Trade	0.277	0.169	0.004	0.003	0.078	0.021
CO_2 Emissions	-0.712	-0.467	-0.004	0.014	-0.211	-0.046

The results provide evidence that the bulk of macroeconomic implications come from the area of acidification and eutrophication. Of course this conclusion depends on the extent to which the input data to GEM-E3 cover the costs incurred in reality for those areas. The environmental expenditures considered in the application in all areas other than acidification and eutrophication have negligible macroeconomic consequences. Probably the only exception is waste management as regards the effects on private consumption and consumer price index.

6. Analysis for the Accelerated Policies Scenarios (AP)

6.1 Definition of the Case Studies

As regards the definition of environmental targets, the Accelerated Policies Scenario is substantially different from the Technology Driven Scenario. First in the latter the climate change targets are not included, while they are the driving force in the Accelerated Policies Scenario. In the Technology driven Scenario, the targets are defined according to the availability of end-of-pipe technologies for pollution abatement.

In the Accelerated Policies Scenarios the environmental targets reflect a continuation and further reinforcement of current policies or current expectations about necessary policies. Consequently, a practicability dimension is considered in addition to technology availability, leading to a different definition of targets.

As mentioned, the TD Scenario does not include the climate change area because energy-related CO_2 emissions cannot be reduced in the foreseeable future by just using end-of-pipe technologies. On the contrary, the Accelerated Policies Scenario includes climate change policies and in particular sets the target as issued from the EU commitments at Kyoto. A major finding also confirmed in the analysis undertaken in this study is that the spill-over effect from climate change actions are favourable to improving many other environmental areas. Consequently to obtain the required quality of the environment in these areas less effort is needed under the Accelerated Policies Scenario as compared to the Technology Driven Scenario. This explains why in the AP scenario the direct environmental expenditures are significantly lower than in the TD scenario.

Within the Accelerated Policies Scenarios the emission target for energy-related carbon dioxide is imposed in the model as a global constraint on the European Union or individually at each member-state. The member-states, under the EU Burden Sharing Agreement, have agreed in 1998 on allocating among themselves the global target of the European Community as undertaken in the Kyoto protocol. However they have not excluded undertaking a setting within the EU that would allow transferring some of the emission reduction obligations from one country to another or from one sector to another without changing the overall emission reduction level. The aim of such transferring is of course to approach as much as possible to a least-cost allocation of the emission reduction effort to sectors and countries.

Allowing for such flexibility implies different economic consequences on sectors and the member-states. In addition, this eventual flexibility may be generalised to include all Annex-B set of countries in this transferring of obligations, as also included in the provisions of the Kyoto protocol. One possibility for implementing such flexibility is to establish an emission permit market and define which sectors and countries are allowed to play in such a market.

The GEM-E3 model has built-in representations of a multitude of trading regimes and participations. Given that many different cases could be considered in reality, in this study two extreme situations have been analysed in detail. They form the two Accelerated Policies Scenarios, namely the so-called AP-No-Trade and the AP-Full-Trade scenarios.

The AP-No-Trade assumes that the EU member-states decide to undertake all measures that are necessary to reduce emissions in their territory according to the EU Burden Sharing Agreement without allowing any transferring of obligations between countries. However, it is assumed that within each member-state they succeed to allocate the emission reduction effort to the sectors at least cost. The AP-Full-Trade assumes that the EU member-states accept the Kyoto flexibility mechanisms and use them at the maximum possible. Therefore they consider transferring obligations between the member-states and between the EU and the other countries of Annex-B, so as to obtain a perfect least-cost allocation of the emission reduction effort.

Of course these two cases are theoretical and just serve to set the boundaries of the domain of possible real allocations of the emission reduction effort. To quantify those cases and their effects, the study uses the built-in emissions trading mechanisms of the GEM-E3 model. This choice and the ensuing economic results should not be considered as a means for assessing the permit trading system as a policy instrument. As a matter of fact, the model-based analysis does not consider transaction costs, imperfections and the impossibility for some sectors to effectively participate in such a trading system. For example this is the case of households that "theoretically" participate in the model-based trading system while in reality this would be impossible. The reader should instead consider and understand the modelled trading system as a modelling technique so as to obtain a solution that corresponds to the least-cost allocation of the emission reduction effort. In case of the AP-No-Trade this applies to the interior of each member-state, while in the AP-Full-Trade this applies to Annex-B area taken as a whole.

Reducing CO_2 emissions from the energy system implies structural changes in this domain, and in industry. Such changes involve energy efficiency gains in all sectors, substitutions in the fuel mix in favour of fuels with lower or zero carbon, higher recycling of material, etc. In addition, considering reducing the emission of non-CO_2 greenhouse gases involves changes in some sectors, as for example is the case of agriculture with respect to the reduction of emissions of methane.

Obviously, the changes driven from climate change policies indirectly improve the situation also in some environmental areas other than climate change. For example, the restructuring of power generation needed for climate change objectives greatly reduces SO_2 and NO_x emissions. Similar effects are observed in the area of urban stress.

For the computation of environmental expenditures in the non-climate-change areas, the analysis took in account the ancillary benefits coming from climate change policies. The benefits lead to a considerable reduction of environmental expenditures needed to meet the targets as defined under the AP Scenario. In some cases, the benefits lead to higher improvement than achieved under baseline conditions. These cases were interpreted as opportunities to economise some environmental expenditure from those committed under baseline. This explains why some of the environmental expenditure figures are negative.

Table 11: Definition of the AP scenario

Policy Scenario: Accelerated Policies (AP)		
Environmental Problem Areas	***Type of Action considered***	***Inclusion in extra costs for GEM-E3***
Stratosperic Ozone Depletion		No
Climate Change	Energy system changes for CO2 and abatement for non-CO2	Yes
Major Accidents	Nuclear Power Plants Upgrading	No
Biodiversity Loss		No
Acidification and Eutrophication	SO2, NOx and NH3 abatement	Yes
Chemical Risks	Dioxine & PAH abatement	No
Water Stress		No
Waste Management	MSW abatement	Partly
Troposhperic Ozone	VOC abatement	Yes
Coastal Zones		No
Urban Stress	PM10 Abatement	Partly (not for noise)
Soil Degradation		No

Table 11 shows the environmental areas that are included in the AP Scenario. Climate change is included regarding both non-CO_2 greenhouse gases and CO_2 emissions from energy combustion. Nuclear accidents and chemical risks are excluded from the evaluation of costs, whereas they were included in the TD scenario. The environmental areas included in the evaluation of costs for AP, namely acidification and eutrophication, waste management, tropospheric ozone and urban stress are all affected positively by climate change policy.

Table 12 and Table 13 summarise the input data prepared outside the model and used for the model runs.

Table 12: Input Data for the AP scenario

Policy Scenario: Accelerated Policies (AP)								
Annuity Payments for the EU in 10^6 Euro	**Climate Change**	**Acidification and Eutrophication**			**Waste Management**	**Troposhperic Ozone**	**Urban Stress**	**As % of sector production cost or % of household consumption**
Sectors	**non-CO2**	**SO2**	**NOx**	**NH3**	**MSW**	**VOC**	**PM10**	
Agriculture	-521	20	20	1370	0	0	0	0.2
Coal	-15	21	0	0	0	0	0	0.0
Crude oil and oil products	0	30	23	0	0	376	21	0.1
Natural gas	-23	0	5	0	0	0	0	0.0
Electricity	6	125	178	0	0	0	272	0.3
Ferrous, non-ferrous ore and metals	25	54	109	0	0	53	485	0.2
Chemical products	95	42	81	8	0	261	29	0.1
Other energy intensive industries	3	47	104	0	0	297	622	0.2
Electrical goods	0	10	19	0	0	342	5	0.1
Transport equipment	0	9	18	0	0	357	5	0.1
Other equipment goods industries	0	14	19	0	0	290	7	0.1
Consumer goods industries	0	72	146	0	0	140	44	0.0
Building and construction	0	7	14	0	0	0	5	0.0
Telecommunication services	0	0	1	0	0	0	0	0.0
Transports	0	0	150	0	0	-26	0	0.0
Credit and insurance	0	0	1	0	0	0	0	0.0
Other market services	0	6	18	0	0	30	0	0.0
Non market services	8	10	38	0	0	0	0	0.0
Households								
Housing	0	0	0	0	-811	0	0	-0.2
Heating and Electric Appliances	0	29	105	0	0	260	0	1.1
Cars, Motorcycles	0	0	2	0	38	-31	0	0.0

Note: The costs for CO2 in relation to Climate Change, Not included above, are indirect, coming from the changes in the energy system

Table 13: Input Data for AP scenario[11]

Policy Scenario: Accelerated Policies (AP)											
Annuity Payments for the EU in 10^6 Euro	Climate Change	Acidification and Eutrophication			Waste Management	Tropospheric Ozone	Urban Stress	TOTAL	% of GDP	Contribution % Shares of	
Countries	non-CO2	SO2	NOx	NH3	MSW	VOC	PM10	TD		Sectors	Household
Austria	-3	0	2	0	4	7	30	40	0.02	89.0	11.0
Belgium	-12	67	213	191	-103	292	103	750	0.26	94.1	5.9
Denmark	-49	0	1	0	-31	2	26	-52	-0.03	26.8	73.2
Germany	-104	74	99	405	17	931	442	1865	0.07	88.8	11.2
Finland	1	5	0	0	-20	-11	23	-2	0.00	-58.5	158.5
France	-49	100	578	0	-505	687	148	959	0.05	128.8	-28.8
Greece	3	0	22	0	46	-50	110	129	0.09	87.1	12.9
Ireland	-29	21	3	0	22	1	14	31	0.02	29.7	70.3
Italy	-89	0	98	0	-12	13	215	225	0.01	105.5	-5.5
Netherlands	-26	40	0	662	-39	130	31	798	0.17	105.3	-5.3
Portugal	-11	0	6	0	14	-1	46	54	0.04	78.7	21.3
Spain	-62	21	11	0	38	-78	163	94	0.01	99.2	0.8
Sweden	3	0	0	104	-41	7	22	95	0.03	141.8	-41.8
UK	4	168	19	16	-187	418	125	563	0.04	129.6	-29.6
EU-14	-423	496	1051	1378	-797	2348	1497	5549	0.05		

Note: The costs for CO2 in relation to Climate Change, Not included above, are indirect, coming from the changes in the energy system

Mainly because of the spillover effect from climate change targets the direct environmental expenditures under AP Scenario, as shown in

Table *12* and Table 13 are small in magnitude, even negative in some cases.

These direct charges, excluding the costs from reducing energy-related carbon dioxide emissions, represent a small fraction (0.05%) of GDP annually at the EU level. Belgium, Germany, Greece and the Netherlands bear higher charges compared to other countries.

Regarding the environmental areas, positive costs (additional to baseline) are necessary for acidification pollution, tropospheric ozone and urban stress, despite the improvement of situation effected through climate change policies. Waste management is greatly facilitated by climate change policies, also because recycling of materials is somewhat accelerated to reduce CO_2 emissions. Therefore, less effort than in baseline is necessary in AP, leading in some cases to gains rather than costs.

The reduction of emissions of non-CO_2 greenhouse gases is possible through end-of-pipe technologies. However, these also involve structural changes in the production processing of the concerned sectors. In some cases, those changes are beneficial for total production cost of the sector, because some production factors are facilitated to increase in productivity. The cases leading to gains for sectoral costs correspond to negative environmental changes, in other words gains. This holds true for methane and nitrous oxide in agriculture for which the magnitude is significant and results into a negative cost for the total of non-CO_2 greenhouse gases, overcompensating the corresponding (positive) costs for other greenhouse gases (except carbon dioxide).

However, considering all environmental areas together, agriculture does bear positive environmental costs because the costs for reducing ammonia over-compensate the gains from non-CO_2 greenhouse gases.

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[11] Notice that the direct costs for SO_2, NO_x and VOC are lower than the direct costs as mentioned the main report. The costs in table 13 above exclude the costs of legislation which was adopted in 1998 (and was *not* included in the baseline). However, this omission does not change any of the main conclusions because GDP loss is very limited in all scenarios.

In general, the sectors bear small additional charges in comparison with their total production costs. Relatively higher charges are necessary for the sectors of electricity, agriculture and the energy intensive industries. In any case, these costs are very small if compared with the costs that these sectors indirectly bear as a consequence of climate change policies.

6.2 Analysis of Macroeconomic Implications of AP Scenarios

6.2.1 Direct Environmental Expenditures

The macroeconomic effects of direct environmental expenditures, i.e. the charges corresponding to the environmental areas other than energy-related CO_2 emissions, have been extensively discussed in the section about the Technology Driven Scenario. In the Accelerated Policies Scenarios, these charges are small in magnitude mainly because of the ancillary benefits from climate change policy; the direct environmental charges (as considered for GEM-E3 application) are small and have negligible macro-economic effects.

The macroeconomic implications of the AP Scenario are dominated by the effects of the target about reducing CO_2 emissions from energy combustion. The results of the AP scenarios as regards the economic impacts through policies aiming at reducing only CO_2 emissions can be found at the end of this Annex (section 8).

6.2.2 Implications of the AP-Full-Trade Case

The AP-Full-Trade scenario assumes a theoretical emission permit trading system that encompasses all sectors and all countries in the Annex-B of the Kyoto protocol. Such a broad trading system probably would never be possible in reality. It is assumed here just for the model calculations so as to approximate as much as possible the situation of least-cost allocation of emission reduction effort and to evaluate the macroeconomic implications.

In the case of AP-full-trade, the overall CO_2 emission reduction target corresponds to stabilisation of CO_2 emissions in 2010 at the level of emissions in 1990. In addition, the provisions allowing full trade of pollution permits allow all countries and sectors to obtain the least possible compliance costs leading to equal marginal abatement costs across Europe and the trading partners.

In modelling terms, under AP-full-trade a pollution permit market is established in the European Union, starting operations just after 2000. It is assumed that the market is perfect and involves trading with the partners in Annex B of the Kyoto convention. Since Europe is small compared to the whole market of Annex-B it is admitted that the permit price of equilibrium at the level of Annex-B will also prevail as the permit price of equilibrium in the trading within the EU. It is also assumed that the agents perfectly anticipate the target for 2010 and start their actions before so as to adapt their capital turnover in a gradual way. In that sense it is assumed that they do not bear stranded costs[12], at least in an absolute way.

It is also assumed that CO_2 emission reduction continues beyond 2010. For the AP-full-trade it is assumed that the reduction beyond 2010 is defined so as to allow stabilisation of emissions at the level of 1990, continuously up to 2030. This implies that the agents cannot recover, after 2010, to their production or consumption structure as it has been in the baseline scenario. They have to continue applying changes to their structure and consequently bearing costs.

In the AP-full-trade because of least-cost allocation among the Annex-B countries, the effort of the EU corresponds to a target for reducing CO_2 emission in 2010 by –7.5% (EU) from baseline. *Table 14* shows

[12] Analysis with PRIMES has shown that standard costs might be significant if the anticipation of agents about targets was delayed.

that least-cost allocation of the emission reduction effort, where because of trading the relative reductions of emissions from baseline are rather uniformly distributed across the countries. The same table shows that the percent change of emissions from baseline increases over time because CO_2 emissions increase with economic growth, so in order to stabilise emissions relatively higher effort is necessary.

Table 14: Emission reduction in AP-full-trade

	Accelerated Policies Scenario - Full Trade						GEM-E3
	Percent change of CO2 Emissions from baseline scenario						
	2000	2005	2010	2015	2020	2025	2030
Austria	0.1	-7.4	-8.0	-11.1	-14.3	-18.3	-22.7
Belgium	-0.4	-6.6	-6.7	-8.8	-11.0	-13.6	-17.0
Germany	-0.1	-6.7	-7.2	-10.0	-12.6	-15.6	-18.4
Denmark	0.0	-6.0	-6.5	-9.1	-11.9	-15.3	-20.1
Finland	0.1	-10.2	-10.9	-14.4	-17.9	-21.2	-24.7
France	-0.2	-8.0	-8.7	-11.8	-14.7	-17.9	-21.2
Greece	-0.3	-11.1	-12.5	-15.7	-18.6	-21.6	-25.7
Ireland	0.0	-9.7	-10.5	-14.7	-18.5	-23.1	-28.4
Italy	0.0	-6.8	-7.4	-10.2	-12.8	-15.9	-20.5
Netherl.	-0.1	-8.0	-8.6	-11.6	-14.5	-18.2	-22.4
Portugal	0.0	-10.4	-11.0	-15.0	-19.0	-23.7	-28.8
Spain	0.0	-6.4	-6.7	-9.3	-12.0	-15.3	-19.6
Sueden	0.0	-4.5	-4.8	-6.6	-8.5	-10.6	-13.6
UK	0.0	-5.8	-5.6	-8.2	-10.3	-12.9	-15.5
EU-14	**-0.1**	**-7.0**	**-7.5**	**-10.4**	**-13.1**	**-16.2**	**-19.8**

A market for pollution permits is created when a limited amount of “property rights” on emission are distributed to economic agents. These rights can be traded between economic agents. The initial allocation of those rights to the agents is important for policy analysis. In the present study it is assumed that the rights are distributed according to a grand fathering principle, corresponding to the level the agents were emitting in the base year. An economic agent then has to compare the costs of reducing emissions below its endowment, to the benefit from selling his permits to the market. At the equilibrium point, the permit price will be equal to the marginal cost of abatement.

In the present study with GEM-E3 it is assumed that the establishment of the pollution permits market is not accompanied by any specific macroeconomic policy, for example policies that would aim at removing some other distortion. It is also assumed that all sectors of the EU countries, including households, participate in the pollution market in order to realise the requested reduction of total CO_2 emissions. This, as mentioned, is a modelling technique to approximate a least-cost solution.

In case of a carbon tax, all agents would observe higher costs of using fossil energy. They would then substitute in favour of non-taxed items. Since substitution cannot be perfect, the agents would face higher overall costs. In the case of permits the effects are similar despite the fact that the permit system does not exert a direct effect on relative prices of commodities or production factors. Nevertheless, the agents still understand that using fossil fuels entail high costs and consequently will prefer to substitute fossil energy. They would do so as long as their marginal cost is lower than the price of permits prevailing in the market. Of course, if an agent is endowed with permits higher than the requested reduction effort, he will sell permits.

The direct effect of the emission constraint and the permits acts in favour of substituting away from fossil energy and in general improving the productivity of energy or the marginal utility from energy. This is favourable to other production factors including labour, capital and non-energy intermediate consumption. It also acts in favour of consuming non-energy goods and services, in the case of households.

Such substitutions cannot be perfect given the technical production possibilities and the preferences of the consumer. Therefore firms face higher costs, domestic prices rise and the consumers are obliged to consume less in volume terms at given level of income.

If the market circumstances (and the initial endowment) are such that a sector can sell permits, the revenues from the sales partly compensate the direct costs from substitution. In such case, the sector obtains gains in terms of relative competitiveness (compared to other sectors) and gets a higher market share. Other sectors bearing high costs partly because of purchasing permits see their prices rising and their market shares eroding.

Consequently the permit system and especially the initial structure of endowment have significant distributional effects on sectors and countries. For example, countries that, because of high emissions in the base year, have obtained many permits and also have low cost opportunities for substituting away from fossil fuels are in a more comfortable situation than other countries.

Despite trading and restructuring within the EU, a general rise of domestic prices cannot be avoided. This undermines the commercial competitiveness of the EU with the rest of the World, at least in relation to those trade partners that do not undertake emission reduction. Consequently, imports from the rest of the World tend to increase and exports to the rest of the World diminish. It must be mentioned that it is assumed that only the Annex-B countries apply the Kyoto protocol. However the non Annex B countries represent a big share of intra-world trade, so the loss of competitiveness of Annex B countries in conjunction with possible relocation of energy-intensive industries lead to significant implications for trade and induce domestic activity losses. These results have been obtained by also using the GEM-E3 World general equilibrium model.

The general implication of the above is a drop of domestic production and GDP in all the EU members-states. The results of the model indicate that the GDP loss for the EU as a whole is 0.11 of one percent in the case of AP-full-trade. The same loss continues beyond 2010 as a consequence of continued emission reduction effort. Both domestic demand and exports drop (by 0.22%) as a consequence of competitiveness weakening. The effects on domestic demand are also due to the decrease of private consumption because real salaries fall, as workers in the labour market cannot fully recover the losses from the eroding real wages resulting from the general rise of domestic prices.

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

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

The net effect on the current account is rather positive and so are the effects on terms of trade. As imports of raw materials decrease and high value added sectors are facilitated, the average price of exports increases more than that of imports, leading to terms of trade gains.

As mentioned, the substitutions away from commodities that directly or indirectly cause carbon emissions result in a general rise of production costs and domestic prices. The resulting increase of domestic prices is far below 1% except for electricity (more than 3%) and other energy sectors. Energy intensive industries are more affected, for example the industry of metals face costs higher by 1.5% and other energy intensive industries faces increases of 0.5%. The costs of using energy increases for all sectors, ranging from 5% (manufacturing) to more than 20% in the industry of metals.

The structure of private consumption leads to an upward pressure on the consumer price index that is higher than the average GDP deflator. On the other hand the workers do not face significantly higher demand for labour. This is due to the compression of domestic production activities. Substitutions in favour of labour in the production structures, which do occur because of higher energy costs, are not enough to compensate the effects of lowered activity.

Other exercises with GEM-E3 have shown that accompanying measures such as lowering the social security costs of employers would lead to higher substitutions in favour of labour and to higher demand for labour. Under such circumstances, characterised by non-increasing demand for labour and higher consumer prices, the households receive lower income in real terms; hence they spend less in consumption. In front of dropping real wages, supply of labour readjusts downwards attempting to re-establish the level of real wages. However, it turns out that this effect is not enough to compensate the losses in real wages; this is due to imperfect flexibility of the labour market.

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

On the contrary, the purchase of durable goods by households is decreasing in volume, as a result of higher costs of using the durable goods (due to energy), the substitution effects in the structure of consumption by purpose (for example less cars as shifts occur towards public transports) and the general compression of private income.

Sectors that produce equipment and construct capital assets face higher demand for their products because of higher private investment but also face lower demand because of the reduction of demand for durable goods. As a consequence, manufacturers of car equipment see their activity shrinking, but manufacturers of professional equipment see their business expanding.

The tables and graphics below summarise the GEM-E3 results for the Accelerated Policies full trade Scenario.

The permit price of equilibrium is $€_{97}$ 17 per ton of CO_2 avoided. The loss of GDP in 2010 is about $€_{97}$ 12 billion. The emissions avoided are about 260 Mt of CO_2 in 2010.

This result is compatible with the results of the world energy system model POLES[13] which estimated in 1998-9 a permit price of $€_{97}$ 17.4 per ton of CO_2 avoided when full Annex-B emission permit trading takes place. This is also compatible with the permit price estimated with the GEM-E3 World model ($€_{97}$ 17.4 per ton of CO_2 avoided for full Annex-B trading). A similar exercise[14] recently carried out by the Energy Modelling Forum at Stanford University using a series of general equilibrium model estimated a range of permit prices from 12 to 30 $€_{97}$ per ton of CO_2 avoided under full Annex-B emission permit trading[15].

Table 15 presents the result by country, Table 16 shows the results by sector and the figures below illustrate the results for AP-Full-Trade.

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[13] Detailed results on emission trading can be found in Criqui and Viguier (2000). Other results were published in EC DG Energy's "European Union Energy Outlook to 2020" (Energy in Europe, 1999).

[14] Published in 1999 as a special issue of the review "The Energy Journal", International Association of Energy Economists.

[15] In addition, Thomas Rutherford reported at the World Environmental Economics Congress (Venice, June 1998) that the wide geenral equilibrium model Charles Rivers Associates model estimates a similar value for the permit price: 16.5 $€_{97}$ per ton of CO_2.

Table 15: Results for AP-Full-Trade

Accelerated Policies Scenario - Full Trade GEM-E3

% change from baseline	*EU*	*Austria*	*Belgium*	*Germany*	*Denmark*	*Finland*	*France*	*Greece*
Gross Domestic Product								
in 2010	-0.11	-0.07	-0.22	-0.20	0.00	-0.02	-0.12	-0.29
long term	-0.12	-0.14	0.12	-0.29	0.03	-0.07	-0.12	-0.59
Employment (diff. In '000 persons)	50	1	-1	-1	1	1	5	2
Private Investment	-0.02	-0.01	-0.08	-0.09	0.05	0.00	-0.05	-0.09
Private Consumption	-0.23	-0.10	-0.33	-0.46	-0.09	-0.08	-0.15	-0.35
Domestic Demand	-0.22	-0.22	-0.39	-0.27	-0.19	-0.25	-0.21	-0.52
Exports in volume	-0.22	-0.24	-0.41	-0.14	-0.20	-0.22	-0.29	-0.62
Imports in volume	-0.43	-0.45	-0.46	-0.36	-0.55	-0.50	-0.53	-0.73
Energy consumption in volume	-3.60	-3.89	-3.98	-4.60	-3.64	-5.13	-3.35	-4.36
Consumers' price index	0.25	0.19	0.27	0.43	0.25	0.19	0.19	0.32
GDP deflator in factor prices	0.07	0.12	0.07	0.03	0.11	0.10	0.10	0.17
Nominal Wage rate	0.08	0.13	-0.16	-0.14	0.20	0.16	0.01	-0.08
Real wage rate	-0.17	-0.07	-0.43	-0.57	-0.05	-0.03	-0.18	-0.40
Current account as % of GDP (diff.)	0.06	0.03	0.03	0.10	0.04	0.03	0.05	-0.04
Terms of Trade	0.11	0.09	0.27	0.02	0.04	0.05	0.09	0.21
CO_2 Emissions	-7.50	-7.99	-6.70	-7.21	-6.48	-10.89	-8.68	-12.53

Accelerated Policies Scenario - Full Trade GEM-E3

% change from baseline	*Ireland*	*Italy*	*Netherl.*	*Portugal*	*Spain*	*Sueden*	*UK*
Gross Domestic Product							
in 2010	-0.12	0.03	-0.30	-0.05	0.09	-0.06	-0.11
long term	-0.29	0.34	-0.31	-0.01	0.20	0.02	-0.36
Employment (diff. In '000 persons)	0	14	3	1	9	0	14
Private Investment	-0.08	0.05	-0.01	-0.22	0.06	-0.06	0.05
Private Consumption	-0.28	-0.03	-0.29	-0.21	0.05	-0.26	-0.24
Domestic Demand	-0.26	-0.15	-0.22	-0.44	-0.10	-0.21	-0.19
Exports in volume	-0.21	-0.21	-0.43	-0.13	-0.23	-0.16	-0.08
Imports in volume	-0.42	-0.71	-0.40	-0.41	-0.53	-0.40	-0.17
Energy consumption in volume	-4.10	-2.63	-3.04	-6.49	-3.70	-2.42	-2.72
Consumers' price index	0.41	0.14	0.25	0.14	0.12	0.28	0.20
GDP deflator in factor prices	0.19	0.07	0.15	-0.05	0.10	0.02	0.01
Nominal Wage rate	0.17	0.13	-0.11	-0.09	0.29	0.02	0.01
Real wage rate	-0.24	-0.01	-0.37	-0.22	0.16	-0.27	-0.19
Current account as % of GDP (diff.)	0.06	0.02	-0.01	0.03	0.04	0.05	0.07
Terms of Trade	0.12	0.08	0.15	-0.04	0.04	0.07	-0.08
CO_2 Emissions	-10.52	-7.42	-8.60	-10.98	-6.71	-4.79	-5.64

Table 16: Results for AP-Full-Trade

Accelerated Policies Scenario - Full Trade						GEM-E3
Results for the EU	**Domestic Production**		**Investment**		**Exports**	**Imports**
% change from baseline	2010	Long-term	2010	Long-term	2010	2010
Agriculture	-0.14	-0.05	-0.05	0.14	-0.37	-0.16
Coal	-13.38	-28.01	-12.81	-26.58	-8.54	-17.62
Crude oil and oil products	-2.07	-5.85	-1.87	-4.84	-0.85	-2.45
Natural gas	-2.11	-6.81	-1.52	-4.82	-0.96	-1.78
Electricity	-0.74	-2.63	0.26	-0.58	-0.23	-0.81
Ferrous, non-ferrous ore and metals	-0.24	0.11	0.33	1.46	-0.63	-0.13
Chemical products	-0.14	-0.10	0.00	0.28	-0.23	-0.07
Other energy intensive industries	-0.11	-0.05	0.01	0.27	-0.27	-0.07
Electrical goods	-0.01	-0.09	0.00	-0.02	-0.11	0.08
Transport equipment	-0.16	-0.05	-0.12	0.04	-0.18	-0.12
Other equipment goods industries	0.31	0.30	0.33	0.36	0.14	0.51
Consumer goods industries	-0.15	-0.15	-0.08	0.02	-0.22	-0.16
Building and construction	-0.01	-0.08	0.05	0.12	-0.01	-0.06
Telecommunication services	-0.04	-0.04	-0.04	0.00	-0.02	-0.06
Transports	-0.13	-0.24	0.18	0.52	-0.20	-0.07
Credit and insurance	0.00	-0.12	0.02	-0.09	0.00	0.01
Other market services	-0.07	-0.14	-0.04	-0.10	-0.02	-0.08
Non market services	-0.05	-0.18	0.00	-0.01	-0.03	-0.08

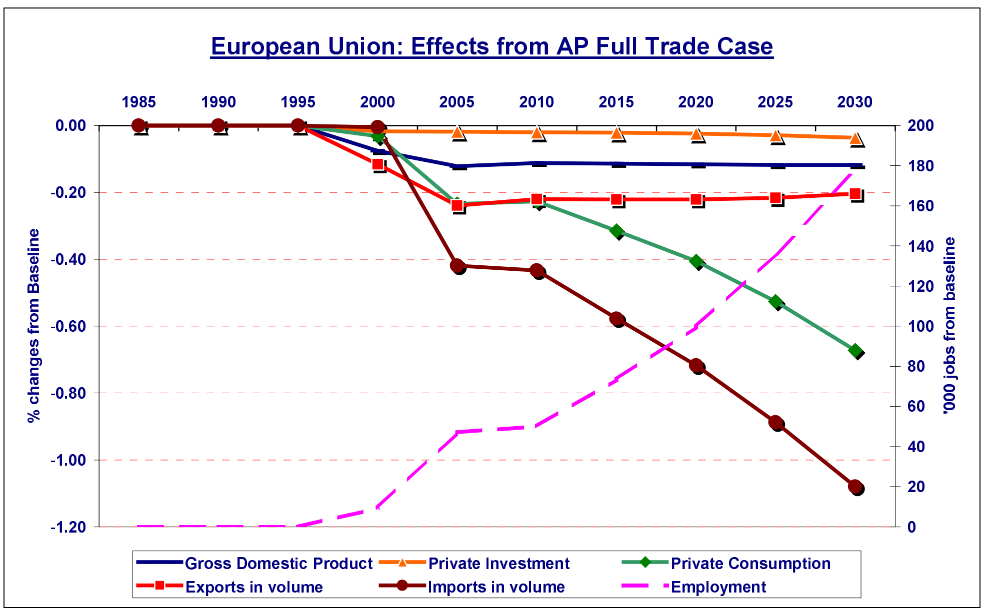

Figure 6: Macroeconomic effects of AP-Full-Trade

6.2.3 Implications of the AP-No-Trade Case

Regarding all the environmental areas, except the emissions of CO_2 from energy combustion, the AP-No-Trade Scenario is exactly the same as the AP-full-Trade one. As mentioned in the previous sections, mainly because of the ancillary benefits from climate change policy, the direct environmental charges (as considered for GEM-E3 application) are small and have negligible macro-economic effects.

The difference between AP-No-Trade and AP-Full-Trade refers to the obligatory emission reduction effort that the EU member-states have to undertake in their territories. The AP-No-Trade imposes to all member-states to meet their respective obligations under the EU Burden Sharing Agreement by reducing emissions in their territories. However it is assumed that each member-states reaches a least-cost allocation of the emission reduction effort to the sectors within the country. Theoretically, this is equivalent to establishing a system of emission permit trading for CO_2 separately in each member-state. It must be again emphasised that a real permit trading system would inevitably lead to higher costs than the least-cost because of transaction costs and other policy and market failures. In addition it would have been impossible to involve in trading sectors such as households or individual transports. If carbon taxes were for example used specifically for these sectors, further deviations from a least-cost would be inevitable. Consequently the model results for each member-state establishing a theoretical emission trading system should be also understood as a means for approaching a least-cost solution of the Burden Sharing Agreement case with strict domestic emission reductions.

Under AP-Full-Trade, the assumed flexibility allowed the EU to lower the emission reduction target to be met with measures in the EU territory, leading to setting a target for stabilisation of domestic energy related CO_2 emissions, instead of –8% reduction in 2010 from the level of 1990.

Instead, the AP-No-Trade case not allowing for trade obliges each member-state to reduce emissions exclusively from measures taking place in their territory. Therefore total emissions to be reduced within the EU must correspond to –8% reduction, instead of stabilisation. In addition, each EU member-state has to comply with the Burden Sharing Agreement, instead of searching for least-cost options in other member-states of the EU. The model-based analysis shows that marginal abatement costs are for some member-states higher than the EU average if the Burden Sharing Agreement was strictly followed. So, the AP-No-Trade Scenario, not only imposes higher targets for CO_2 emission reduction, but also introduces different targets for the EU member-states.

Regarding emission reduction targets beyond 2010, it is assumed that AP-No-Trade obliges each member-state to stabilise emissions at the level achieved in 2010. Beyond 2010, total emissions reduced within the EU are also higher than in the case of AP-Full-Trade.

Compared to baseline scenario, emissions of CO_2 have to decrease in 2010 by about -15%, instead of -7.5% in the AP-Full-Trade case (see Table 17).

Table 17: Emission Reduction under AP-No-Trade

	Accelerated Policies Scenario - No Trade						**GEM-E3**
	Percent change of CO2 Emissions from baseline scenario						
	2000	2005	2010	2015	2020	2025	2030
Austria	-0.2	-14.1	-17.4	-22.2	-24.4	-27.8	-27.5
Belgium	-0.9	-17.1	-20.9	-22.5	-24.9	-28.6	-31.6
Germany	-0.2	-11.1	-10.0	-11.9	-15.0	-18.6	-18.0
Denmark	-0.4	-23.4	-24.1	-20.8	-14.9	-16.3	-16.2
Finland	-0.2	-25.5	-28.8	-33.3	-35.8	-42.9	-41.0
France	-0.1	-11.2	-9.9	-14.6	-17.1	-18.2	-30.5
Greece	-0.3	-15.2	-18.8	-22.2	-26.4	-26.0	-27.7
Ireland	-0.4	-20.2	-20.8	-22.4	-24.4	-25.5	-30.2
Italy	-0.2	-15.9	-15.5	-16.4	-18.8	-19.5	-21.6
Netherl.	-2.2	-25.1	-30.4	-32.7	-34.7	-36.8	-41.1
Portugal	-0.3	-22.5	-23.0	-33.1	-39.1	-41.0	-44.9
Spain	-0.1	-14.7	-15.5	-17.3	-17.4	-20.4	-27.5
Sueden	-0.8	-17.4	-22.9	-25.6	-27.2	-35.8	-30.7
UK	-0.1	-9.9	-13.1	-16.0	-19.1	-24.2	-27.7
EU-14	**-0.3**	**-14.2**	**-15.4**	**-18.2**	**-20.8**	**-23.7**	**-27.2**

Under AP-No-Trade, each member-state faces an individual emission reduction constraint. General equilibrium allows for fulfilling the constraint at least cost within each country. Therefore the allocation of total effort to the sectors within a country operates as if a pollution permit market was established within each country (without any communication with other markets).

Therefore, the sectors perceive the country constraint as driving higher costs associated to the use of fossil fuels. They undertake substitutions away from fossil fuels but total costs do increase, as substitutions are imperfect.

The effects and macroeconomic mechanisms are similar as in the case of full trading. The amplitude of the effects differs because AP-No-Trade involves higher targets, as explained before. The country-level effects also differ, because AP-No-Trade involves a different allocation of total EU emission reduction to the countries.

The model results indicate that the additional costs induced by substitution away from carbon intensive fuels lead to a general rise of prices (0.11% for GDP deflator and 0.62% for consumer price index). The cost of domestic production increases by about 0.4% in the non-energy intensive sectors, by 1 to 3% in energy intensive sectors and by 8 to 10% in power generation. Nominal wage rates increase less than the consumer price index, leading to a fall (by 0.40%) of the real wage rates, also because labour demand growth is too small to re-establish higher wages.

Households face a reduction of their real income so they consume less, as shown by private consumption falling in volume terms by -0.6%. As also domestic production drops, final and intermediate domestic demand is found lowered by -0.55%.

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

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

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

The analysis shows significant differentiation of impacts when comparing the countries (see *Table 18*). Mostly this is due to the allocation decided at the Burden Sharing Agreement. The assessment is based on how the model estimates both the baseline developments and the marginal abatement cost curves. These estimates do not necessarily coincide with the perceptions the member-states had when concluding the Burden Sharing Agreement.

Table 18: Results of the AP-No-Trade Scenario

Accelerated Policies Scenario - No Trade — *GEM-E3*

% change from baseline	EU	Austria	Belgium	Germany	Denmark	Finland	France	Greece
Gross Domestic Product								
in 2010	-0.23	-0.14	-0.24	-0.27	-0.46	-0.30	-0.10	-0.32
long term	-0.23	-0.09	0.12	-0.18	0.32	-0.47	-0.20	-0.30
Employment (diff. In '000 persons)	140	3	1	0	5	2	10	10
Private Investment	-0.04	0.06	-0.13	-0.12	0.06	-0.14	-0.02	0.14
Private Consumption	-0.58	-0.16	-1.00	-0.68	-1.08	-0.76	-0.15	-0.31
Domestic Demand	-0.55	-0.47	-1.25	-0.42	-0.97	-0.96	-0.22	-0.66
Exports in volume	-0.48	-0.54	-0.79	-0.20	-1.24	-0.82	-0.29	-1.00
Imports in volume	-1.11	-0.99	-1.47	-0.60	-2.32	-1.47	-0.63	-1.21
Energy consumption in volume	-7.89	-9.24	-13.56	-6.66	-16.31	-15.72	-3.91	-7.05
Consumers' price index	0.62	0.49	1.05	0.58	1.69	0.95	0.17	0.56
GDP deflator in factor prices	0.11	0.35	0.05	-0.04	0.64	0.34	0.06	0.49
Nominal Wage rate	0.22	0.44	-0.14	-0.25	0.72	0.28	0.01	0.45
Real wage rate	-0.40	-0.05	-1.19	-0.83	-0.97	-0.67	-0.16	-0.11
Current account as % of GDP (diff.)	0.17	0.12	0.29	0.15	0.25	0.10	0.07	0.02
Terms of Trade	0.18	0.24	0.56	-0.02	0.42	0.26	0.06	0.33
CO2 Emissions	-15.42	-17.45	-20.88	-10.05	-24.05	-28.84	-9.85	-18.84

Accelerated Policies Scenario - No Trade — *GEM-E3*

% change from baseline	Ireland	Italy	Netherl.	Portugal	Spain	Sueden	UK
Gross Domestic Product							
in 2010	-0.28	0.11	-1.14	-0.10	0.14	-0.41	-0.38
long term	-0.04	0.40	-1.45	-0.20	0.28	-0.23	-0.88
Employment (diff. In '000 persons)	2	40	22	4	20	0	20
Private Investment	-0.05	0.21	-0.09	-0.39	0.08	-0.44	-0.10
Private Consumption	-0.55	-0.05	-1.54	-0.40	0.00	-1.93	-0.93
Domestic Demand	-0.50	-0.31	-1.19	-0.89	-0.35	-1.34	-0.73
Exports in volume	-0.50	-0.43	-1.58	-0.29	-0.59	-0.76	-0.16
Imports in volume	-0.91	-1.58	-1.71	-0.82	-1.40	-2.30	-0.65
Energy consumption in volume	-9.52	-6.40	-14.47	-14.18	-8.95	-14.75	-7.02
Consumers' price index	1.01	0.33	1.73	0.36	0.29	2.24	0.57
GDP deflator in factor prices	0.59	0.16	0.70	0.01	0.15	0.19	-0.19
Nominal Wage rate	0.59	0.39	-0.18	-0.02	0.49	0.22	-0.34
Real wage rate	-0.42	0.06	-1.91	-0.38	0.20	-2.02	-0.91
Current account as % of GDP (diff.)	0.22	0.09	0.28	0.11	0.07	0.52	0.12
Terms of Trade	0.33	0.20	0.69	0.00	0.20	0.56	-0.27
CO2 Emissions	-20.77	-15.46	-30.36	-22.99	-15.49	-22.89	-13.08

The analysis with GEM-E3 shows that mainly the Netherlands (-1.14% loss of GDP) and secondarily Denmark, Sweden and UK bear losses that are higher than the EU average. The other countries are better off, in particular Spain, Italy and France. The mechanism is complex and the country results should not be attributed only to the Burden Sharing Agreement but also to the pre-existing structure of intra-EU trade and sectoral specialisation of the countries. The indirect effects of sectoral changes through intra-EU trade are significant. This explains why, despite bearing higher domestic costs, some countries like Italy and Spain even reach gains in terms of GDP. The sectoral and trade changes are such that these countries reinforce their market position in the sectors of consumer goods, market services and agriculture. Through the expansion in these sectors they overcompensate the losses in other sectors.

The sectoral analysis for all countries provides clear evidence that the equipment goods industry of the EU can obtain market expansion under climate change policy. The only exception is car manufacturing. See *Table 19*.

Table 19: Results of AP-No-Trade Scenario

Accelerated Policies Scenario - No Trade						***GEM-E3***
Results for the EU	***Domestic Production***		***Investment***		***Exports***	***Imports***
% change from baseline	2010	Long-term	2010	Long-term	2010	2010
Agriculture	-0.13	0.01	0.08	0.31	-0.35	-0.16
Coal	-21.57	-34.40	-20.83	-34.68	-14.90	-33.58
Crude oil and oil products	-5.24	-8.93	-4.76	-7.13	-2.53	-6.62
Natural gas	-5.57	-12.27	-3.88	-8.23	-2.58	-3.57
Electricity	-1.85	-4.49	0.56	-1.41	-0.61	-1.80
Ferrous, non-ferrous ore and metals	-0.40	-0.20	0.80	1.92	-1.07	-0.13
Chemical products	-0.24	-0.12	0.18	0.54	-0.39	-0.14
Other energy intensive industries	-0.13	-0.02	0.17	0.47	-0.38	-0.07
Electrical goods	-0.10	-0.11	-0.05	0.02	-0.15	-0.09
Transport equipment	-0.20	0.05	-0.11	0.23	-0.22	-0.19
Other equipment goods industries	0.26	0.41	0.32	0.51	0.12	0.44
Consumer goods industries	-0.23	-0.13	-0.08	0.11	-0.32	-0.27
Building and construction	-0.05	-0.17	0.11	0.10	-0.02	-0.15
Telecommunication services	-0.10	-0.09	-0.05	0.01	0.02	-0.20
Transports	-0.68	-0.77	0.38	0.77	-1.08	-0.45
Credit and insurance	-0.11	-0.17	-0.18	-0.35	0.02	-0.08
Other market services	-0.17	-0.24	-0.09	-0.15	-0.03	-0.27
Non market services	-0.13	-0.28	-0.01	-0.04	-0.04	-0.22

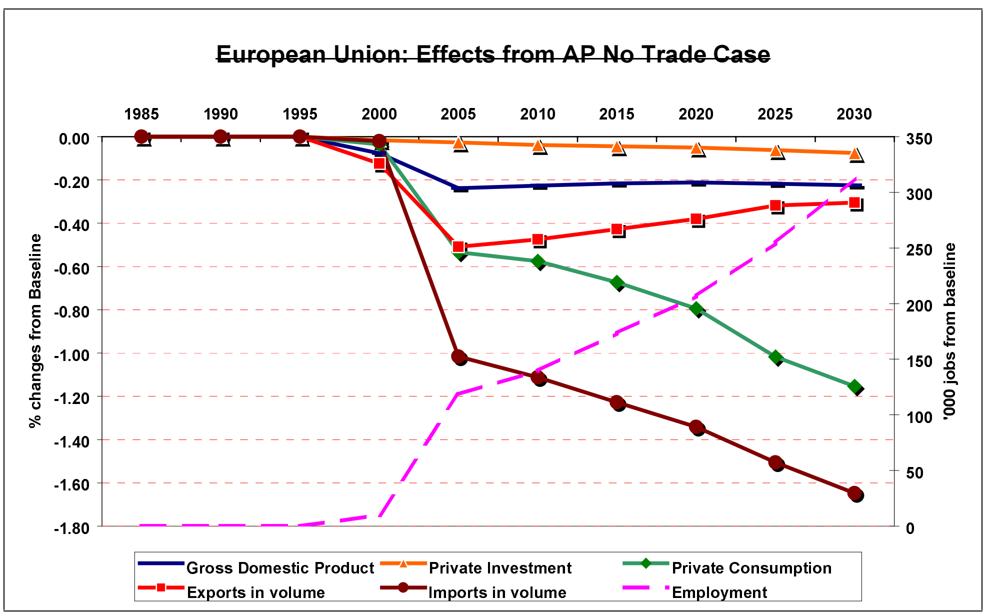

Figure7: Macroeconomic effects of AP-No-Trade

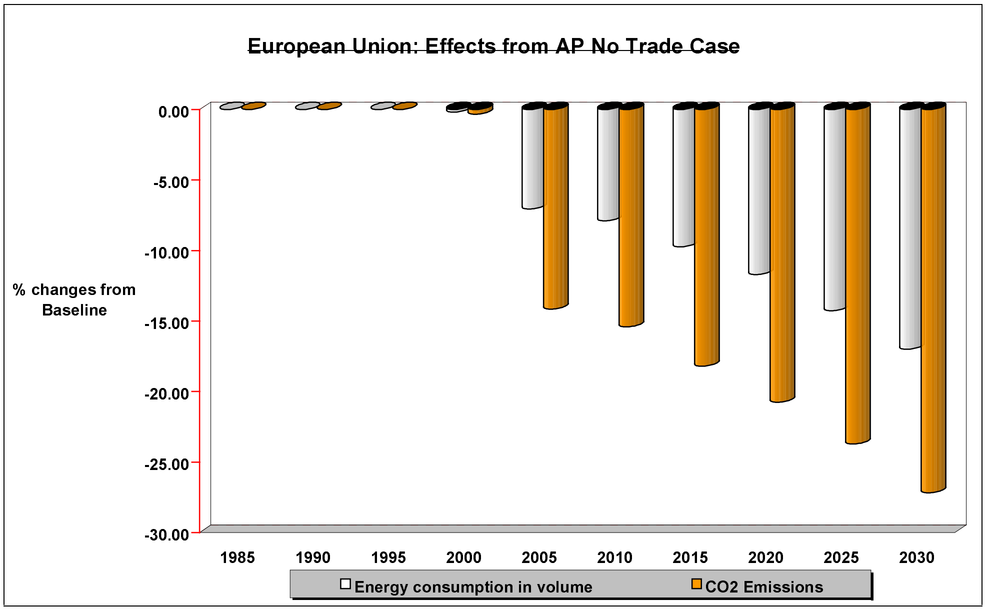

Figure 8: Effects of AP-No-Trade on Energy and CO2

The shadow values associated to the emission constraints imposed to the countries are equivalent to the marginal abatement costs. They are of course indicative of the difficulty of the emission reduction effort. They are also equivalent to the price of pollution permits if hypothetically such a market was established separately within each member state. Marginal abatement costs are estimated by GEM-E3 as a result of general economic equilibrium. A partial equilibrium model, like PRIMES, also computes marginal abatement costs but this estimation of course does not take into account the complete economic mechanisms. Therefore, the cost estimates from the two models are not directly comparable.

Table 20: Prices of pollution permits

Permit Price of Equilibrium - GEM-E3 model
Accelerated Policies Scenario
in Euro'97 per ton of CO_2

	Full Trade Scenario	No Trade Scenario
Austria	17.1	48.4
Belgium	17.1	82.0
Germany	17.1	25.8
Denmark	17.1	108.2
Finland	17.1	74.6
France	17.1	20.3
Greece	17.1	34.3
Ireland	17.1	48.7
Italy	17.1	48.8
Netherl.	17.1	134.3
Portugal	17.1	47.6
Spain	17.1	47.8
Sueden	17.1	152.7
UK	17.1	47.7
EU-14	**17.1**	**49.2**
Change of CO2 Emissions in 2010 from Baseline		
	-7.5	-15.4

Table 20 shows the value of these permits and compares with the full trade case. Generally, no trading induces significantly higher marginal abatement costs, signifying that trading is more cost-effective. In addition, according to the model estimates, no trading leads to unequally distributed marginal abatement costs. It must be emphasized that the information from the marginal abatement costs (see table above) should not be considered as equivalent to GDP losses. For example, UK has a marginal abatement cost below EU average, while it bears GDP losses significantly higher than EU average. Evidently the mechanism affecting GDP is more complex.

7. Limitations and Uncertainties

There are several types of limitations. There are limitations related to the way the model applications were designed, limitations related to the model itself and limitations related to the nature of the general approach.

As regards the environmental areas other than climate change, the design of the model applications is rather simplistic. This is of course due to complexity of the problems and the lack of data. It has been considered that the agents only bear direct environment-improving costs (in annualised payments terms). In reality, they would face a variety of situations and probably would consider that partly some of the commodities used in intermediate and final consumption would be more responsible than others for pollution. Therefore, the substitution effects could be higher than those estimated by the model applications. Similarly benefits may be obtained in some sectors because of the improvement of the environment. A similar remark for the climate change issue is not true, because GEM-E3 has been designed to cover these complex mechanisms as much as possible.

A major uncertainty regards the definition of the baseline scenario. It is assumed that under baseline conditions the economy is in general equilibrium despite the environmental problems. Therefore the improvement of the environment has no direct feedback effects on the economy and only presents costs. If it was admitted that the environmental status under baseline conditions induces limitations to the potential of economic growth (for example because of restrictions of factor productivity or because growth opportunities cannot be exploited as being excluded by the status of the environment) then lower costs and higher growth would be possible as a result of environment0improving expenditures.

Also the environment cost data prepared for GEM-E3 applications did not cover the whole area of environmental problems. This of course was due to lack of data and methodological uncertainties. There has been no estimation whether the non-covered areas would represent high costs for the EU, in which case the conclusions qualifying the macroeconomic implications could be different.

The main limitation regarding the nature of the model refers to the issues of limited aggregation and the lack of engineering detail. Despite the relatively high level of detail, GEM-E3 is a macroeconomic model and uses monetary units for all items. It also follows standard economic formulations for production, trade and consumption functions, in which elasticity parameters mask a far higher complexity of technical possibilities and constraints. The merits of GEM-E3 lie on the comprehensiveness of economic mechanisms.

The general approach is weak in two different senses.

First it is generally weak because it does not consider the effects that the environmental policies will have on the progress and structure of technology change over time. The model does involve dynamic technology progress but its pace and structure is invariant across the policy scenarios. On the contrary, in reality, environmental policies would incite innovators to re-orient and accelerate technology improvement. The new technologies that will be dynamically available, under an environment-constrained world, will allow for benefits and will facilitating reaching environmental targets in the future by lowering the compliance costs. This mechanism is completely ignored in the model as used in this study. This is also the case of all operational CGE models. On going research work on GEM-E3 (under EC-Joule programme[16]) develops a new generation of CGE modelling in which technology progress is endogenous. Therefore the results of the current study should be qualified as over-estimating the costs of complying with environmental targets.

The general approach is also weak regarding the timeliness of policy and the short-term effects. GEM-E3 being a general equilibrium model is not able to encounter for business cycles, temporary pressures and fluctuations. Also GEM-E3 cannot fully account for the eventual stranded costs induced by short-term environmental constraints. A detailed vintage model would be necessary for that purpose. So in the present analysis all these effects are ignored, although mattering for policy making.

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[16] This is the GEM-E3-Elite research project that has been completed in December 1999.

The highest uncertainty in the results concerns the consequences of competitiveness losses of the EU vis-à-vis trade with the rest of the World. If the relative price elasticity in foreign trade with the rest of the World were high, then the consequences on the EU domestic activity would be considerable. In that case the consequences of bearing high costs in favour of the environment at a unilateral basis for the EU could be important, probably leading to a conclusion that international co-operation has to be a condition for such a policy. Previous exercises with GEM-E3 have shown that the results are significantly sensitive on assumptions about foreign trade.

8. Conclusions on Macroeconomic Implications

The Technology Driven Scenario conveys significant environmental charges to the economic sectors. These lead to higher prices and the ensuing loss of competitiveness implies a fall of domestic activities, hence a GDP loss. The substitution effects are rather small; however there are some gains for some sectors, as for example the equipment good industries.

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

The analysis has shown clear benefits from trading pollution permits of CO_2 in the case of Accelerated Policies Scenario. The macro economic consequences are considerably moderated and the GDP losses are rather small.

The Technology Driven Scenario leads to a GDP loss that is of the same order of magnitude as in the case of Accelerated Policies No-Trade Scenario. By trading (in AP-Full-Trade) the losses reduce to less than half, while obtaining almost the same environmental benefits. In addition, the consequences on sectors and countries are highly more uniformly distributed across the EU than when the system is not allowed to trade. There are however effects that might be of concern, regarding sectors using energy intensively, like heavy industry and power generation.

Within the limitations of the study, there is clear evidence that AP-Full-Trade case is manageable in macroeconomic terms.

9. Analysis of Macroeconomic Implications of AP Scenarios for CO_2 emissions

The following tables summarise the results obtain from the GEM-E3 model for the Accelerated Policies scenarios in the case that these policies are implemented only as regards CO_2 emissions. It must be stressed that the costs of non-CO_2 greenhouse gases are not included in system costs.

Table 21: Emission reduction in AP-full-trade for CO_2

	CO_2 scenario - Full Trade						GEM-E3
	Percent change of CO2 Emissions from baseline scenario						
	2000	2005	2010	2015	2020	2025	2030
Austria	-0.1	-7.6	-8.1	-11.2	-14.4	-18.4	-22.8
Belgium	-0.1	-6.4	-6.6	-8.7	-10.9	-13.5	-16.9
Germany	-0.1	-6.6	-7.2	-9.9	-12.6	-15.6	-18.3
Denmark	-0.1	-6.1	-6.6	-9.2	-12.0	-15.3	-20.1
Finland	-0.2	-10.4	-11.1	-14.6	-18.1	-21.3	-24.8
France	-0.1	-7.9	-8.6	-11.7	-14.6	-17.8	-21.1
Greece	-0.2	-10.9	-12.4	-15.6	-18.5	-21.5	-25.7
Ireland	-0.1	-9.8	-10.6	-14.8	-18.6	-23.2	-28.4
Italy	-0.1	-6.9	-7.5	-10.3	-12.9	-15.9	-20.5
Netherl.	-0.1	-8.0	-8.6	-11.6	-14.5	-18.2	-22.4
Portugal	-0.1	-10.5	-11.1	-15.1	-19.1	-23.8	-28.9
Spain	-0.1	-6.4	-6.8	-9.4	-12.0	-15.3	-19.6
Sueden	-0.1	-4.5	-4.8	-6.6	-8.5	-10.6	-13.6
UK	-0.1	-5.8	-5.7	-8.2	-10.3	-12.9	-15.5
EU-14	**-0.1**	**-7.0**	**-7.5**	**-10.4**	**-13.1**	**-16.2**	**-19.8**

Table 22: Results for AP-Full-Trade for CO_2

CO_2 scenario - Full Trade GEM-E3

% change from baseline	EU	Austria	Belgium	Germany	Denmark	Finland	France	Greece
Gross Domestic Product								
in 2010	-0.05	-0.07	0.03	-0.12	-0.04	-0.02	-0.03	-0.18
long term	-0.07	-0.14	0.26	-0.22	0.02	-0.07	-0.05	-0.52
Employment (diff. In '000 persons)	47	1	0	-2	1	1	6	3
Private Investment	0.00	-0.01	-0.03	-0.06	0.03	-0.01	-0.02	-0.02
Private Consumption	-0.20	-0.09	-0.22	-0.41	-0.17	-0.15	-0.13	-0.26
Domestic Demand	-0.23	-0.24	-0.35	-0.27	-0.20	-0.26	-0.21	-0.52
Exports in volume	-0.13	-0.23	-0.15	-0.04	-0.24	-0.20	-0.15	-0.50
Imports in volume	-0.43	-0.47	-0.42	-0.35	-0.54	-0.47	-0.49	-0.85
Energy consumption in volume	-3.56	-3.94	-3.82	-4.55	-3.69	-5.20	-3.19	-4.17
Consumers' price index	0.25	0.19	0.22	0.39	0.31	0.27	0.20	0.31
GDP deflator in factor prices	0.04	0.12	-0.07	-0.02	0.11	0.10	0.05	0.17
Nominal Wage rate	0.16	0.12	-0.05	-0.12	0.17	0.15	0.06	0.06
Real wage rate	-0.10	-0.07	-0.27	-0.51	-0.15	-0.12	-0.15	-0.25
Current account as % of GDP (diff.)	0.07	0.04	0.06	0.12	0.04	0.03	0.06	0.00
Terms of Trade	0.05	0.11	0.11	0.00	0.08	0.08	0.06	0.19
CO2 Emissions	-7.50	-8.10	-6.55	-7.19	-6.55	-11.05	-8.58	-12.41

CO_2 scenario - Full Trade GEM-E3

% change from baseline	Ireland	Italy	Netherl.	Portugal	Spain	Sueden	UK
Gross Domestic Product							
in 2010	-0.13	0.03	-0.07	-0.03	0.11	-0.03	-0.07
long term	-0.28	0.36	-0.14	0.00	0.22	0.05	-0.33
Employment (diff. In '000 persons)	0	12	4	1	8	0	12
Private Investment	-0.07	0.05	0.03	-0.20	0.07	-0.06	0.05
Private Consumption	-0.24	-0.04	-0.17	-0.19	0.06	-0.24	-0.23
Domestic Demand	-0.27	-0.17	-0.21	-0.44	-0.10	-0.21	-0.21
Exports in volume	-0.24	-0.20	-0.24	-0.11	-0.18	-0.13	-0.03
Imports in volume	-0.46	-0.71	-0.41	-0.38	-0.54	-0.41	-0.18
Energy consumption in volume	-4.07	-2.67	-2.97	-6.54	-3.74	-2.43	-2.69
Consumers' price index	0.38	0.15	0.25	0.14	0.14	0.29	0.20
GDP deflator in factor prices	0.21	0.07	0.08	-0.04	0.10	0.01	-0.02
Nominal Wage rate	0.17	0.12	0.08	-0.06	0.30	0.04	0.01
Real wage rate	-0.21	-0.03	-0.18	-0.20	0.16	-0.25	-0.20
Current account as % of GDP (diff.)	0.06	0.02	0.04	0.03	0.04	0.06	0.08
Terms of Trade	0.15	0.11	0.09	0.03	0.05	0.09	-0.09
CO2 Emissions	-10.59	-7.49	-8.61	-11.09	-6.76	-4.83	-5.67

Table 23: Results for AP-Full-Trade for CO_2

CO_2 scenario - Full Trade						***GEM-E3***
Results for the EU	***Domestic Production***		***Investment***		***Exports***	***Imports***
% change from baseline	2010	Long-term	2010	Long-term	2010	2010
Agriculture	-0.01	0.06	0.06	0.23	-0.02	-0.02
Coal	-13.40	-28.00	-12.83	-26.56	-8.50	-17.67
Crude oil and oil products	-2.01	-5.81	-1.85	-4.82	-0.78	-2.41
Natural gas	-2.03	-6.75	-1.43	-4.75	-0.80	-1.67
Electricity	-0.63	-2.54	0.39	-0.48	-0.11	-0.66
Ferrous, non-ferrous ore and metals	0.11	0.37	0.68	1.73	-0.19	0.17
Chemical products	-0.07	-0.05	0.08	0.34	-0.11	-0.03
Other energy intensive industries	-0.01	0.03	0.11	0.36	-0.07	0.00
Electrical goods	-0.05	-0.10	-0.03	-0.03	-0.05	-0.06
Transport equipment	-0.05	0.03	-0.02	0.12	-0.06	-0.04
Other equipment goods industries	-0.05	0.06	-0.02	0.13	-0.04	-0.04
Consumer goods industries	-0.07	-0.09	-0.02	0.08	-0.10	-0.06
Building and construction	-0.03	-0.09	0.03	0.11	-0.03	-0.08
Telecommunication services	-0.04	-0.03	-0.02	0.02	-0.03	-0.05
Transports	-0.12	-0.23	0.19	0.54	-0.22	-0.05
Credit and insurance	-0.07	-0.16	-0.05	-0.14	-0.03	-0.05
Other market services	-0.07	-0.13	-0.04	-0.09	-0.04	-0.07
Non market services	-0.05	-0.18	0.00	-0.01	-0.02	-0.08

Table 24: Emission Reduction under AP-No-Trade for CO_2

	CO_2 scenario - No Trade						**GEM-E3**
	Percent change of CO2 Emissions from baseline scenario						
	2000	2005	2010	2015	2020	2025	2030
Austria	-0.2	-14.1	-17.4	-22.2	-24.4	-27.8	-27.5
Belgium	-0.9	-17.1	-20.9	-22.5	-24.9	-28.6	-31.6
Germany	-0.2	-11.1	-10.0	-11.9	-15.0	-18.6	-18.0
Denmark	-0.4	-23.4	-24.1	-20.8	-14.9	-16.3	-16.2
Finland	-0.2	-25.5	-28.8	-33.3	-35.8	-42.9	-41.0
France	-0.1	-11.2	-9.9	-14.6	-17.1	-18.2	-30.5
Greece	-0.3	-15.2	-18.8	-22.2	-26.4	-26.0	-27.7
Ireland	-0.4	-20.2	-20.8	-22.4	-24.4	-25.5	-30.2
Italy	-0.2	-15.9	-15.5	-16.4	-18.8	-19.5	-21.6
Netherl.	-2.2	-25.1	-30.4	-32.7	-34.7	-36.8	-41.1
Portugal	-0.3	-22.5	-23.0	-33.1	-39.1	-41.0	-44.9
Spain	-0.1	-14.7	-15.5	-17.3	-17.4	-20.4	-27.5
Sueden	-0.8	-17.4	-22.9	-25.6	-27.2	-35.8	-30.7
UK	-0.1	-9.9	-13.1	-16.0	-19.1	-24.2	-27.7
EU-14	**-0.3**	**-14.2**	**-15.4**	**-18.2**	**-20.8**	**-23.7**	**-27.2**

Table 25: Results of the AP-No-Trade Scenario for CO_2

CO_2 scenario - No Trade GEM-E3

% change from baseline	EU	Austria	Belgium	Germany	Denmark	Finland	France	Greece
Gross Domestic Product								
in 2010	-0.16	-0.14	0.00	-0.19	-0.50	-0.30	-0.01	-0.21
long term	-0.17	-0.08	0.25	-0.12	0.31	-0.47	-0.13	-0.24
Employment (diff. In '000 persons)	137	3	1	-1	5	2	11	11
Private Investment	-0.02	0.06	-0.08	-0.09	0.04	-0.15	0.01	0.21
Private Consumption	-0.55	-0.16	-0.89	-0.63	-1.15	-0.83	-0.13	-0.23
Domestic Demand	-0.56	-0.49	-1.22	-0.42	-0.98	-0.96	-0.22	-0.66
Exports in volume	-0.39	-0.52	-0.54	-0.09	-1.27	-0.80	-0.16	-0.89
Imports in volume	-1.11	-1.01	-1.44	-0.60	-2.30	-1.43	-0.60	-1.35
Energy consumption in volume	-7.85	-9.24	-13.51	-6.63	-16.31	-15.70	-3.79	-6.93
Consumers' price index	0.62	0.48	1.02	0.54	1.76	1.02	0.19	0.57
GDP deflator in factor prices	0.08	0.35	-0.09	-0.09	0.65	0.33	0.02	0.50
Nominal Wage rate	0.29	0.43	-0.03	-0.23	0.69	0.27	0.06	0.60
Real wage rate	-0.33	-0.05	-1.05	-0.78	-1.07	-0.76	-0.13	0.04
Current account as % of GDP (diff.)	0.19	0.13	0.33	0.17	0.25	0.10	0.08	0.07
Terms of Trade	0.12	0.26	0.40	-0.04	0.46	0.29	0.03	0.32
CO2 Emissions	-15.42	-17.45	-20.88	-10.05	-24.05	-28.84	-9.85	-18.84

CO_2 scenario - No Trade GEM-E3

% change from baseline	Ireland	Italy	Netherl.	Portugal	Spain	Sueden	UK
Gross Domestic Product							
in 2010	-0.29	0.11	-0.91	-0.07	0.16	-0.38	-0.34
long term	-0.03	0.43	-1.28	-0.18	0.31	-0.20	-0.85
Employment (diff. In '000 persons)	2	38	23	4	20	0	18
Private Investment	-0.04	0.20	-0.05	-0.37	0.09	-0.44	-0.09
Private Consumption	-0.51	-0.06	-1.43	-0.38	0.00	-1.92	-0.93
Domestic Demand	-0.50	-0.32	-1.18	-0.88	-0.35	-1.34	-0.74
Exports in volume	-0.52	-0.41	-1.39	-0.27	-0.53	-0.73	-0.10
Imports in volume	-0.94	-1.57	-1.73	-0.80	-1.41	-2.30	-0.66
Energy consumption in volume	-9.47	-6.40	-14.42	-14.16	-8.97	-14.75	-6.98
Consumers' price index	0.98	0.34	1.73	0.36	0.31	2.24	0.57
GDP deflator in factor prices	0.60	0.16	0.63	0.02	0.15	0.18	-0.22
Nominal Wage rate	0.60	0.38	0.00	0.01	0.50	0.24	-0.35
Real wage rate	-0.38	0.04	-1.73	-0.35	0.19	-2.00	-0.92
Current account as % of GDP (diff.)	0.23	0.09	0.32	0.12	0.07	0.53	0.13
Terms of Trade	0.36	0.23	0.62	0.07	0.21	0.59	-0.29
CO2 Emissions	-20.77	-15.46	-30.36	-22.99	-15.49	-22.89	-13.08

Table 26: Results of the AP-No-Trade Scenario for CO_2

CO_2 scenario - No Trade *GEM-E3*

Results for the EU	Domestic Production		Investment		Exports	Imports
% change from baseline	2010	Long-term	2010	Long-term	2010	2010
Agriculture	0.01	0.12	0.20	0.40	0.00	-0.02
Coal	-21.61	-34.40	-20.86	-34.68	-14.90	-33.60
Crude oil and oil products	-5.18	-8.89	-4.73	-7.10	-2.46	-6.59
Natural gas	-5.50	-12.23	-3.80	-8.18	-2.44	-3.48
Electricity	-1.74	-4.41	0.69	-1.32	-0.48	-1.66
Ferrous, non-ferrous ore and metals	-0.05	0.07	1.15	2.20	-0.63	0.17
Chemical products	-0.17	-0.07	0.25	0.60	-0.28	-0.10
Other energy intensive industries	-0.03	0.07	0.27	0.56	-0.17	0.00
Electrical goods	-0.14	-0.13	-0.09	0.01	-0.09	-0.24
Transport equipment	-0.10	0.13	-0.01	0.31	-0.10	-0.12
Other equipment goods industries	-0.09	0.17	-0.02	0.28	-0.06	-0.11
Consumer goods industries	-0.15	-0.07	-0.02	0.17	-0.19	-0.18
Building and construction	-0.07	-0.17	0.10	0.10	-0.04	-0.18
Telecommunication services	-0.10	-0.08	-0.03	0.03	0.01	-0.19
Transports	-0.68	-0.75	0.39	0.78	-1.10	-0.43
Credit and insurance	-0.17	-0.21	-0.25	-0.39	-0.02	-0.13
Other market services	-0.17	-0.23	-0.09	-0.14	-0.04	-0.26
Non market services	-0.13	-0.28	-0.01	-0.03	-0.03	-0.21

Table 27: Prices of pollution permits

Permit Price of Equilibrium - GEM-E3 model
Accelerated Policies Scenario for CO_2
in Euro'97 per ton of CO_2

	CO_2 - Full Trade	CO_2 - No Trade
Austria	17.4	48.4
Belgium	17.4	83.2
Germany	17.4	26.2
Denmark	17.4	108.3
Finland	17.4	74.5
France	17.4	20.9
Greece	17.4	35.1
Ireland	17.4	49.0
Italy	17.4	48.9
Netherl.	17.4	135.0
Portugal	17.4	47.7
Spain	17.4	47.9
Sueden	17.4	152.9
UK	17.4	48.0
EU-14	**17.4**	**49.6**
Change of CO_2 Emissions in 2010 from Baseline		
	-7.5	-15.4

10. Environmental expenditure inputs to GEM-E3

For the two scenario's Technology Driven (TD) and Accelerated Policy, No Trade (AP-NT) TME has prepared the input for GEM-E3 based on cost data provided by AEA Technology (Climate Change, CH_4), ECOFYS (Climate Change, N_2O and HFC, PFC and SF_6), TME (Nuclear Accidents, Nuclear Power Plants; Waste Management, Municipal Solid Waste), IIASA (Acidification and Eutrophication, SO_2, NO_x and NH_3; Tropospheric Ozone, VOC) and TNO (Chemical Risks, Dioxine and PAHs; Urban Stress, PM_{10}). In the next two sections the specific input preparation steps are presented for the TD- and AP-NT scenario respectively. These preparation steps are described in more detail in the TME documents:

- *Assumptions in the determinations of abatement costs, TME's assumptions for Environmental issues 2, 3, 7, 8 and 11*, [TME, November 1999];
- *Application of distribution keys in the interface, distribution keys for Environmental issues 2, 3, 5, 6, 8, 9 and 11*, [TME, November 1999]

10.1 GEM-E3 input preparation for TD-scenario

As can be seen in table 5 (*Definition of the TD scenario*, [Capros, November 1999]), extra costs for GEM-E3 have been included for the following Environmental Problem Areas:

- Nuclear Accidents: upgrading of Nuclear Power Plants (NPP) in Central and Eastern Europe;
- Acidification and Eutrophication: abatement of SO_2, NO_x and NH_3 emissions;
- Chemical Risks: abatement of Dioxine and PAH emissions;
- Waste Management: disposal of MSW;
- Tropospheric Ozone: abatement of VOC emissions;
- Urban Stress: abatement of PM_{10} emissions.

For each Environmental Problem Area, the steps to come to GEM-E3 inputs are described. The required steps, undertaken by TME, are the following:

- Generation of cost data: upgrading of NPP, disposal of MSW;
- Conversion of costs to prices $€_{97}$;
- Translation of costs to GEM-E3 format.

10.1.1 Nuclear Accidents

Attention has been paid to upgrading of Nuclear Power Plants (NPP) in Central and Eastern Europe. Limited to NPP's constructed after 1975 (NPP's younger than 35 years in 2010), with an accident probability of 10^{-3} and still to be upgraded (to an accident probability of 10^{-4}) in the period 2000-2010. In total 15 NPP's are involved.

Generation of cost data

Based on *Annex 1, Major Conclusions, The Panel's Summary on the "In-Depth Assessment of INPP"* [EBRD, September 1998] and in co-operation with RIVM, the unit upgrading costs are estimated to be 60 million € per NPP (prices 1995). These unit upgrading costs consist of two parts, namely:

- Composition of a Probabilistic Safety Assessment (PSA), 5 million €/NPP;
- Implementation of the PSA, 55 million €/NPP. Especially these implementation costs show a large variation and are predominantly based on implementation costs prognosticated for the NPP of Ignalina, Lithuania.

Conversion of costs to prices €₉₇

The unit upgrading costs (prices $€_{95}$) are converted to prices $€_{97}$ by using the Consumer Price Index (CPI). This results in a conversion factor of 1,042.

Translation of costs to GEM-E3 format

Combination of unit upgrading costs and number of NPP's to be upgraded results in total upgrading costs. To come to annual sectoral upgrading costs per EU-15 country three distribution steps are taken, namely:

1. Upgrading takes place in 10 years, in the period 2000-2010;
2. Distribution of total EU-15 upgrading costs over the individual Member States. As distribution key, the total Gross Domestic Products (GDP) of the EU-15 countries in 2010 have been used;
3. The upgrading costs made by the governments are in the GEM-E3 model coupled to the sector *Non-market services*.

10.1.2 Acidification and Eutrophication

Attention has been paid to the abatement of three different emissions: sulphur dioxide (SO_2), nitrogen oxide (NO_x) and ammonia (NH_3). All abatement costs related to the different scenario's (BL, TD and AP-NT) have been prepared by IIASA. Based on IIASA's input data TME has derived additional abatement costs (TD/AP-NT costs subtracted with BL costs) per GEM-E3 sector.

Conversion of costs to prices $€_{97}$

All abatement costs presented by IIASA are in prices $€_{90}$. These costs are converted to prices $€_{97}$ by using the Consumer Price Index (CPI). This results in a conversion factor of 1,274.

Translation of costs to GEM-E3 format

In translating IIASA's SO_2 and NO_x-abatement costs to the GEM-E3 sectors, three types of distribution keys have been used, namely:

- Transport. Keys to distribute road transport (TRA_RD) costs over the GEM-E3 sectors Building and construction, Telecommunication services, Transports, Services of credit and insurance, Market services, Non-market services and Consumers. Keys to distribute other transport (TRA_OT and TRA_OTS) costs over the GEM-E3 sectors Agriculture and Transports;
- Industry. Keys to distribute industrial abatement costs (IN_BO, IN_OC and IN_PROC) over the GEM-E3 sectors Ferrous and non-ferrous metals, Chemical industry, Other energy intensive industry, Electrical goods, Transport equipment, Other equipment goods, Consumer goods, and Building and construction. The distribution keys are based on the sectoral energy demands presented in [NTUA 1998];
- Domestic. Keys to distribute the abatement costs related to the domestic sector (DOM) over the GEM-E3 sectors Agriculture, Telecommunication services, Service of credit and insurance institutions, Market services, Non-market services and Consumers. The distribution keys are based on the sectoral energy demands presented in [NTUA 1998].

In translating IIASA's NH_3-abatement costs to the GEM-E3 sectors, the approach is quite straightforward, namely:

- Costs in Agriculture to the GEM-E3 sector Agriculture;

- Costs in Industry to the GEM-E3 sector Chemical industry. In IIASA's sector Industry, the emissions of ammonia and therefore the abatement costs are limited to the ammonia producing plants, belonging to the base chemical sector.

10.1.3 Chemical Risks

Attention has been paid to the abatement of two emissions: dioxine and poly-aromatic hydrocarbons (PAHs). All additional (on top of BL) abatement costs related to the TD scenario have been prepared by TNO and are expressed in €$_{97}$. TME has only carried out the translation to GEM-E3 sectors.

Translation of costs to GEM-E3 format

Costs for dioxine and PAH-abatement are presented together and aggregated by RIVM to CORINAIR SNAP-codes. Therefore only three SNAP-codes have abatement costs related to dioxine and PAHs, namely:

- SNAP-04, Iron and Steel;
- SNAP-04, Non-ferrous metals;
- SNAP-09, Waste incineration.

The translation of costs to GEM-E3 sectors is straightforward:

- Iron and Steel to the GEM-E3 sector Ferrous and non-ferrous metals;
- Non-ferrous metals to the GEM-E3 sector Ferrous and non-ferrous metals;
- Waste incineration to the GEM-E3 sector Non-market services

10.1.4 Waste Management

Attention is only focused on Municipal Solid Waste (MSW). The generated MSW will be disposed by Composting, Recycling, Incineration with energy recovery, Incineration or Landfill. For each Member State the amount of generated MSW and the distribution over the five disposal methods is known/determined and the resulting MSW disposal costs are derived. TME has carried out all process steps in close co-operation with RIVM and the results are presented in the Annex on Waste Management.

Translation of costs to GEM-E3 format

The resulting total MSW disposal costs have been coupled straightforwardly to the GEM-E3 sector Consumers.

10.1.5 Tropospheric Ozone

Attention has been paid to the abatement of Volatile Organic Compounds (VOC). All abatement costs related to the different scenario's (BL, TD and AP-NT) have been prepared by IIASA. Based on IIASA's input data TME has derived additional abatement costs (TD/AP-NT costs subtracted with BL costs) per GEM-E3 sector.

Conversion of costs to prices €$_{97}$

All abatement costs presented by IIASA are in prices €$_{90}$. These costs are converted to prices €$_{97}$ by using the Consumer Price Index (CPI). This results in a conversion factor of 1,274.

Translation of costs to GEM-E3 format

In translating IIASA's VOC-abatement costs to the GEM-E3 sectors, four types of distribution keys have been used, namely:

- Degreasing. Keys to distribute abatement costs from IIASA's emission category Degreasing over the GEM-E3 sectors Ferrous and non-ferrous metals, Other energy intensive industries, Electrical goods, Transport equipment and Other equipment goods. Data on added values [CE 1995] for these sectors have been used;
- Industrial solvent use. Keys to distribute abatement costs from IIASA's emission category Industrial solvent use over the GEM-E3 sectors Ferrous and non-ferrous metals, Chemical industries, Other energy intensive industries, Electrical goods, Transport equipment, Other equipment goods and Consumer goods. Again data on added values [CE 1995] for these sectors have been used;
- Industrial paint use. Keys to distribute abatement costs from IIASA's emission category Industrial paint use over the GEM-E3 sectors Other energy intensive industries, Electrical goods, Transport equipment, Other equipment goods and Consumer goods. Again data on added values [CE 1995] for these sectors have been used;
- Transport. See the Environmental Problem Area Acidification and Eutrophication (SO_2 and NO_x).

10.1.6 Urban Stress

Attention has been paid to the abatement of particulate matter with a diameter smaller than 10 micrometer (PM_{10}) emissions. All additional (on top of BL) abatement costs related to the TD scenario have been prepared by TNO and are expressed in $€_{97}$. TME has only carried out the translation to GEM-E3 sectors.

Translation of costs to GEM-E3 format

Costs for PM_{10} abatement are have been aggregated by RIVM to CORINAIR SNAP-codes. For the following SNAP-codes PM_{10}-abatement costs are available:

- SNAP-01, Fuel oils;
- SNAP-01, Hard/brown coal;
- SNAP-01, Other fuels;
- SNAP-03, Fuel oils;
- SNAP-03, Hard/brown coal;
- SNAP-04, Iron and Steel;
- SNAP-04, Non-ferrous metals;
- SNAP-04, Non-metallic minerals;
- SNAP-04, Other processes.

The translation to the GEM-E3 sectors was as follows:

- SNAP-01 to the GEM-E3 sector Electricity;
- SNAP-03. Application of the distribution key Industry (see Acidification and Eutrophication, SO_2 and NO_x abatement) to the GEM-E3 sectors Ferrous and non-ferrous metals, Chemical industry, Other energy intensive industry, Electrical goods, Transport equipment, Other equipment goods, Consumer goods, and Building and construction;
- SNAP-04, Iron and Steel/Non-ferrous metals to the GEM-E3 sector Ferrous and non-ferrous metals;
- SNAP-04, Non-metallic minerals to the GEM-E3 sector Other energy intensive industries;
- SNAP-04, Other processes to the GEM-E3 sector Liquid fuels.

10.2 GEM-E3 input preparation for AP-NT scenario

As can be seen in table 11 (*Definition of AP scenario*, [Capros, November 1999]), extra costs for GEM-E3 have been included for the following Environmental Problem Areas:

- Climate Change: abatement of CH_4, N_2O and HFC, PFC and SF_6 emissions;
- Acidification and Eutrophication: abatement of SO_2, NO_x and NH_3 emissions;
- Waste Management: disposal of MSW;
- Tropospheric Ozone: abatement of VOC emissions;
- Urban Stress: abatement of PM_{10} emissions.

All Environmental Problem Areas in the TD-scenario, except for Climate Change, return in the AP-NT scenario. The required steps (generation of cost data, conversion to prices €$_{97}$ and translation to GEM-E3 sector) are for these Environmental Problem Areas the same as in the TD-scenario. The only differences occur in the distribution keys related to the sectoral energy demands because the applied TD and AP-NT energy scenario's differ. This has no consequences for the methodology, only for the resulting distribution percentages for the involved GEM-E3 sectors. Therefore only the Environmental Problem Area Climate Change is described in this section.

10.2.1 Climate Change

Attention has been paid to the abatement of three different emissions: methane (CH_4), nitrous oxide (N_2O) and HFC/PFC/SF_6. All additional (on top of BL) abatement costs have been derived by TME in close co-operation with RIVM. Underlying basic cost/emission data come from AEA Technology (CH_4) and ECOFYS (N_2O and HFC/PFC/SF_6).

Conversion of costs to prices €$_{97}$

All abatement costs presented by AEA Technology and ECOFYS are in prices €$_{95}$. These costs are converted to prices €$_{97}$ by using the Industrial Producer Price Index (IPPI). This results in a conversion factor of 1,016.

Translation of costs to GEM-E3 format

In translating AEA Technology's CH_4 abatement costs to the GEM-E3 sectors, the approach was straightforward, namely:

- Enteric Fermentation and Animal Manure management to the GEM-E3 sector Agriculture;
- Waste, Landfill to the GEM-E3 sector Non-market services;
- Coal Mining to the GEM-E3 sector Solid fuels;
- Oil & Gas to the GEM-E3 sector Natural gas.

In translating ECOFYS' N_2O abatement costs to the GEM-E3 sectors, the approach was straightforward, namely:

- Agriculture to the GEM-E3 sector Agriculture;
- Industrial Processes (production of nitric and adipic acid) to the GEM-E3 sector Chemical industry;
- Waste to the GEM-E3 sector Non-market services.

In translating ECOFYS' HFC/PFC/SF_6 abatement costs to the GEM-E3 sectors, the approach consisted of more steps because costs were presented at EU-15 level. The distribution steps are the following:

HFC, PFC and SF_6 emissions and abatement costs have been based on [ECOFYS, April 1999]. In the study of ECOFYS the abatement costs are presented per reduction measure for the whole EU-15. In order to get abatement costs per specific GEM-E3 sector and per country, the following distribution steps have to be taken:

- Allocation to economic sectors. HFC, PFC and SF_6 emission sources as described in [ECOFYS, April 1999] where reduction measures take place, have been connected to economic sectors. Most of these economic sectors were already described in [ECOFYS, April 1999]. Others have been assumed by TME;
- Distribution of the total EU-15 costs over the 15 individual countries. Total EU-15 costs per economic sector are distributed over the 15 Member States by applying added value data presented in [CE 1995];
- Translation of the economic sectors to the GEM-E3 sectors Electricity, Ferrous and non-ferrous metals, Chemical industry, Other energy intensive industries, Electrical goods, Consumer goods, Transport, Service of credit and insurance institutions, Market services, Non-market services and Consumers.

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