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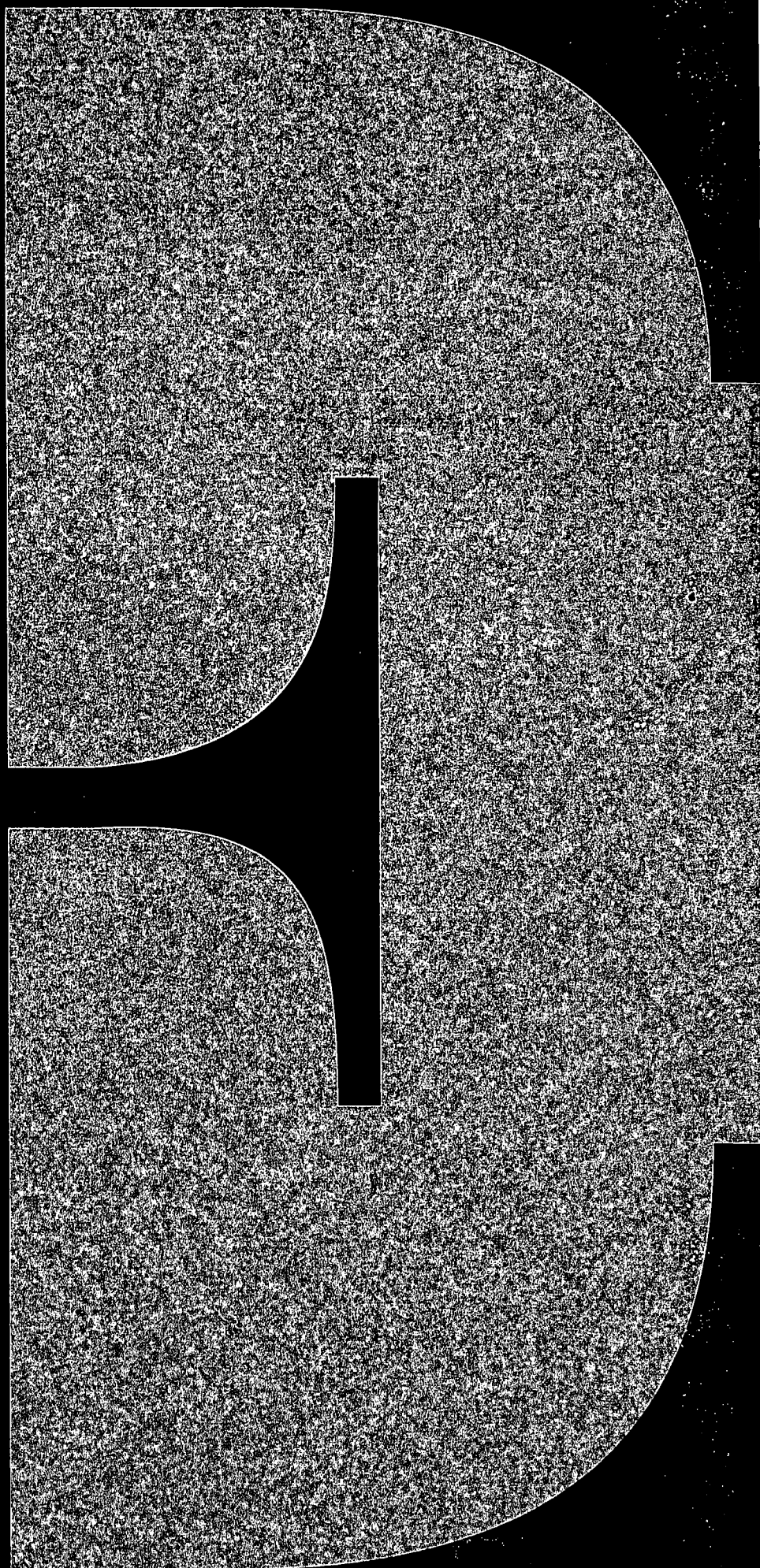
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CUTTING CARBON EMISSIONS WHILE MAKING MONEY:

Climate Saving Energy
Strategies for the
European Union

IPSEP

International Project for
Sustainable Energy Paths



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POST-KYOTO

Effects on the Climate Policy of the European Union

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Economic and energy system implications of European CO₂ mitigation strategy: Synthesis of results from model based analysis

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Abstract: Since the decision of the Council of Ministers of the EU member states (3.3.1997) specifying a decrease of green house gas emissions by 15% in 2010 compared to the 1990, there has been a wide-spread study of the appropriate policy instruments and the costs associated with this goal. The task of meeting the emission reduction targets should not be underestimated. Reducing CO₂ emissions for the EU as a whole over the next 15 years would amount to no less than breaking the historical link between economic growth and energy use. Especially in the short term the problem of stranded costs is important. The paper attempts a synthesis of results coming from several new generation models developed recently and examines the economic and energy system implications of both short-term policies and measures for emission reduction as well as long-term technology options.

Keywords: climate technology strategy, competitive energy markets, pollution permits, general equilibrium, partial equilibrium, GEM-E3, PRIMES, POLES.

1. Introduction

The paper attempts a synthesis of results coming from a number of new generation models that were developed under the auspices of DG XII of the European Commission. The views however expressed in this paper do not engage the European Commission. The models are the result of collaborative research projects involving a large number of participants, mentioned in the acknowledgements. The analysis presented in this paper was mainly derived from work done within the JOULE-III project "Climate Technology Strategy within Competitive Energy Markets" (see Capros et. al., 1997).

All the models addressed, from different perspectives, the issue of defining and evaluating a policy mix that would simultaneously:

- Lead to a reduction of CO₂ emissions for the EU.
- Meet sustainability targets for the economy.
- Consider technological development and the long-term prospects of the energy system.
- Ensure consistency with global economic and energy system trends.

The sets of policy measures discussed are those for which the costs of curbing emissions are compensated (partly or fully) by external (environmental) benefits. Additionally, policy instruments were designed to operate towards meeting non-environmental goals, such as for example RTD prioritisation, employment or economic cohesion of countries. The analysis was detailed enough to lead to concrete policy recommendations, that contributed to the preparatory **analysis for the Kyoto negotiations** and for the **5th Framework Programme of the European Commission for Research and Development**.

All projections and assessment activities have been empirical and numerical. All were based on large-scale models for the energy system and the economy. The coverage was detailed for all

EU countries, but the international perspective was also satisfied. The model assumptions were uniformly used in all modelling work to ensure compatibility of the results.

Three models were mainly used:

- The **GEM-E3** computable general equilibrium model for the EU-14. The model integrates the energy system with the rest of the economy, including several policy instruments for the environment such as taxes and pollution permits. Benefits from better atmospheric quality are also quantified. The model was used for macro-economic projections and the analysis of combined energy and economic policies for CO₂ mitigation. A description of the GEM-E3 model is given in Capros et. al. (1997).
- The **PRIMES** partial equilibrium model for the European energy system. The PRIMES model provides simulation of the energy system, the decisions of the agents and the markets, covering in detail several sectors, uses and technologies. The model was used for the evaluation of the European energy system policies and measures, regarding their potential and costs (see Capros et. al., 1996).
- The **POLES** world energy system model. This ensured the consistency between the projections for Europe carried out with the two previous models and served for them as input for world prices and demand. The POLES model provided international comparisons of CO₂ abatement marginal costs and conducted analyses of world-level implications from the development of energy technologies. The authors of the model and the results presented in this analysis are Patrick Criqui (IEPE) and Niko Kouvaritakis (ECOSIM). A description of POLES is given in P. Criqui et. al. (1996).

The model-based analysis dealt with technology and policy options to tackle the problem of rising emissions in the period to 2010. As the model-based energy and economic outlook that was constructed within the project showed, under "business as usual" assumptions CO₂ emissions are likely to grow substantially in the period to 2010. For Europe, emissions were projected to increase by almost 8.8% above their level of 1990, while for the whole world the rise was projected to be considerable: 53.8%.

Yet over the past couple of years there has been a great deal of debate on how to reduce emissions even in the medium term. This debate reached a turning point as approaching the Kyoto Conference of the Parties (December 1997). The European Union, through a decision of the Council on 3.3.1997, agreed to decrease the CO₂ emissions in 2010 by 15% compared to the level of emissions in 1990. The Council agreed also upon a scheme distributing the emission reduction effort among the member-states and envisaged a set of policies and measures in all sectors.

The task of meeting the Kyoto targets should not be underestimated. It is taken for granted, of course, that the reduction in emissions should be designed so as to minimise the effects on economic growth. For most developed economies, while there is a tendency for energy demand to grow with economic growth, there is a very strong tendency for any sizeable economic expansion to be associated with an increase in energy demand of about 1% less than GDP. Furthermore, as the baseline scenario indicates, energy patterns are almost certain to continue to be dominated by CO₂ emitting fossil fuels in the period to 2010, as a result of saturation in the progress towards lower carbon intensity of the energy system. Even if renewable fuel technologies were more competitive than they are currently, it would take much longer than 15 years for their massive introduction. Hence, reducing CO₂ emissions for the EU as a whole over the next 15 years would amount to no less than breaking the historical link between economic growth and energy use. This link has been very strong in most countries throughout the post war period and it has survived even the upward energy price shocks of the 1970s.

However, the main factor that makes the Kyoto targets difficult to reach is related to the fact that 2010 is short-term for the energy system, implying limited scope of contribution by new

technologies. New technologies can either break the link between energy and growth, through equipment that is much more energy efficient, or make energy much less carbon intensive, through energy from renewable sources or through much more efficient generation of final energy. However, even if these new technologies were fully available at present, there is simply not enough time to replace the bulk of energy using capital stock and equipment by 2010 without causing substantial economic damage as a result of stranded costs. A number of analyses have been carried out on this subject. See for example Grubb, M., Edmonds J. (1993) and Wigley, T. M. L., Richels, R., Edmonds, J.A. (1996)

The difficulties mentioned above are not insurmountable in the longer run. Even by 2010, the analysis showed that there is a great deal that could be done to limit emissions and, perhaps, meet the Kyoto targets. However, there is associated a net economic cost at the macroeconomic level. Moreover, using carefully designed accompanying policies, it may even be possible that environmental protection is compatible with economic objectives such as employment or competitiveness.

Technology plays a key role in these scenarios. However, most of its contribution will be in the form of integrating faster existing energy efficient technologies or accelerating the introduction of known advanced technologies. As it is shown in the analysis, much of the reduction in emissions by 2010 can only be reached through means that improve energy efficiency.

It is very important to examine the likely economic costs of CO₂ mitigation. The research showed that, both for the EU and for the rest of the world, there are large differences between the average and marginal costs of meeting any target. Furthermore these differences increase as the emissions target gets more severe. Indeed, one of the key messages of the results is that the more severe the target and the shorter the time horizon over which it must be reached, the greater the likely economic costs.

The CO₂ reduction policy, whether through a tax or through a permit system, is likely to invoke important changes for the whole of the economy of all the EU member states. The impact on sectors, countries and consumer's is likely to be, at least on a first approximation negative. If however, economic inefficiencies are currently present in the economy, then the environmental policy, properly accompanied by a re-structuring that reduces the inefficiencies may lead to a situation where multiple benefits may be effected. One often cited example of such inefficiency concerns the labour market. It is argued that by using the environmental revenues from a carbon tax to reduce the employer's social security contribution employment gains may result, giving an example of the so-called "double dividend" hypothesis. These issues were studied in detail within the project. A discussion of different approaches on this subject is given in Carraro, C. and D. Siniscalco (1996), while Bovenberg, L. and L. Goulder (1993) give a theoretical presentation of the double dividend issue.

Another important aspect of the likely costs of policy on emissions is the differential impact on different countries and regions. This impact clearly depends on the level of development of a country, its economic and industrial structure, and on its natural resource endowment and the carbon intensity of its energy system. The results for the EU member states indicate that, even when the degree of the severity of the target is similar, mitigation costs are likely to diverge a great deal between countries. This issue has been also studied in detail with the GEM-E3 model (see for example Conrad, K. and T.F.N. Schmidt, 1996).

The international dimensions of emissions target for 2010 are also important. The environmental threat is perceived with different degrees of concern by governments, decision-makers and the general public in different world regions. Amongst the developed nations, the European Union has taken a leading role in recognising the problem as an important issue to be solved, and in proposing co-ordinated efforts to achieve a cost-efficient solution. As the POLES world energy scenario shows, most of the emissions over the next 15 years are likely to originate from non-OECD regions. Consequently, any uncoordinated action by the EU, or even

the OECD, is likely to have a very small impact on long term carbon concentrations. Large, rapidly growing countries, such as China, India and some other in the Asian continent give priority to economic development, often accompanied by massive increase in energy consumption. Joint implementation may provide the opportunity to reduce the CO₂ emissions in developing countries, possibly the most important emitters in the future. The results indicate that there is even more of a difference in the likely costs of emission reductions among world regions than there are among European countries. Thus, there is plenty of scope for an international market approach to the issue, if important practical problems can be resolved, complemented with joint implementation for the shorter term.

The work presented here was concluded before the Kyoto summit. Indeed, the major motivation of the analysis was to assist the debate within the EU by providing quantitative estimates of the impact and cost of a number of policies and measures.

The analysis was extended beyond 2010 and emphasised on the longer run up to 2030. The analysis was technology-oriented aiming at providing strategic analytical information to assist in the formulation of the Community 5th Framework program for research and technological development.

It is clearly over a long time horizon that the impact of technological improvements can really be important for climate change policy. The role of policy regarding technology is also different between the medium and long term. In the medium term, policy measures cannot lead to the development of new technologies but they can encourage the faster introduction and the more intensive utilisation of existing technologies. On the other hand, government and industry objectives through spending on RTD can influence the nature of technological progress in the longer term.

Several technology development pathways for the power generation sector are examined in this research in relation to their energy system implications and the global CO₂ emission problem. Important though the power generation sector may be, it still accounts for about 40% of the projected world CO₂ emissions by 2030.

The long-term technology development may provide opportunities for economic growth. The accelerated capital turnover that is necessary for the short term to meet the CO₂ targets, resulting in net economic costs because of stranded investments, also involves acceleration of technology evolution further leading to net economic benefits in the longer term.

2. Energy and economic outlook

2.1 World energy outlook

The world energy outlook is based on POLES' simulations and aims at providing a consistent and detailed description of the world energy situation until the year 2030.

Table 1: CO₂ emissions by world region (source: P. Criqui and N. Kouvaritakis, POLES model)

MtC	1990	Increment		Increase Ratio for 2010
		2010-1990	2030-2010	
World	5986	3178	4710	1.53
OECD	2949	774	419	1.26
Trans. Econ.	1290	-283	295	0.78
Dvg Asia	1069	2055	2448	2.92
Dvg Oth	679	632	1548	1.93

The simulations project a rapid increase in the weight of developing regions in the world economy and energy system, so that most part of the energy consumption in the next forty years will originate from them. By 2010, they will contribute to half the world GDP and almost half the world energy consumption.

International energy markets will be affected by this shift, as oil demand will largely grow along the development of transport and car equipment in these regions. Although oil resources are large and might be extended by technological progress, non-conventional fuels will need to be used after 2010. Oil prices are projected to increase in order both to satisfy the growing demand and to encourage the development of non-conventional resources. Natural gas prices may also increase, as gas demand will be especially strong in every region of the world.

Consequent on the growth in world energy demand, world CO₂ emissions will be on an upward trend. While "flat rate" reductions provide ambitious but reasonable targets for industrialised countries and the economies in transition, they are fully inadequate for CO₂ policies in the developing world. The expected increase in developing country emissions is very large and stems directly from the strong dynamics in energy demand, particularly for transport and electricity. For the latter, coal use in power generation in Asia, and especially in China and India, is projected to be one of the main sources of incremental emissions in the medium term as well as in the period to 2030.

The world of energy will probably be very different after 2010 of what it is today. This is already the case in this baseline projection, the main characteristics of which are a higher level of demand, international prices and CO₂ emissions. Mitigation policies, particularly if they are also addressed in the developing regions will, no doubt, introduce further changes to this picture.

2.2 European economic and energy outlook

The baseline scenario for the whole analysis is based on the pre-Kyoto business as usual scenario constructed by NTUA in 1997. This scenario has co-ordinated macro-economic and sectoral growth assumptions, world energy price trajectories and energy system technical progress assumptions. The GEM-E3 model provided the macro-economic framework, while the energy system implications were derived from the PRIMES energy system model for 8 EU member states. The evolution projected by the two models follow similar trends concerning energy and CO₂ emissions.

The pre-Kyoto business as usual scenario includes policies that are in the pipeline and trends in technology progress and industrial restructuring. For example, technology progress, industrial reorganisation towards higher value-added products (and less material and energy intensive products) and the on-going energy conservation programmes are included. In addition, the on-going liberalisation in the electricity and gas markets are assumed in the scenario to allow for more gas-based competitive power generation plants and acceleration of the use of cogeneration of heat and power.

The implementation of these policies, implies that overall energy intensity will decrease significantly in the baseline (about 1.5% per year, see Table 2), which is higher than the historical average. Consequently, CO₂ emissions and primary energy consumption will increase only moderately. In the power generation sector, the scenario also projects a spectacular growth of the use of gas and a substantial increase of cogeneration and (to a lesser degree) renewables.

The scenario follows a rather optimistic path for the GDP of the EU, which remains above 2% for the first to decades of the next millennium. The main proponents of this increase are market services and high quality manufacturing (e.g. in chemicals), specialised in particular countries.

Government consumption and basic processing on the other hand, is projected at best to remain to its present levels.

Table 2: pre-Kyoto scenario indicators

pre-Kyoto scenario			
EU-14	2000/ 1990	2020/ 2000	2020/ 1995
	% change / year		
Population (Million)	0.8	0.1	0.2
GDP (bil. ECU1985)	2.1	2.1	2.2
Gross Inland Consumption	1.1	0.6	0.7
Gross Inl Cons./GDP (toe/1985 MECU)	-1.0	-1.5	-1.5
Gross Inl Cons./Capita (kgoe/inhab.)	0.2	0.4	0.5
Electricity Generated/Capita (kWh/inhab.)	0.9	0.9	1.0
CO2 Emission Index (1990=100)	0.2	0.6	0.6
CO2 Emissions/Capita (t of CO2/inhab.)	-0.6	0.5	0.4
CO2 / Gross Inl. Cons. (t of CO2/toe)	-0.8	0.1	-0.1

GDP per capita is projected to converge, implying higher growth rates for cohesion countries.

The differences across countries both in terms of rate of growth and structure of growth have significant implications on projected CO₂ emissions. Generally, cohesion countries exhibit strong upward tendencies, while mature industrial economies show only moderate emissions increases. In the extremes are Germany where re-structuring after unification leads to a reduction in CO₂ emissions (in 2010 compared to 1990) and Sweden where the phase-out of nuclear stations will augment emissions. Table 3 shows the evolution of emissions in the EU-14 and the distribution of effort as agreed in the pre-Kyoto period at the Council (last column).

The target set for the EU before the Kyoto conference, that is -15% of emission reduction in 2010 (for the whole basket of greenhouse gases), leads to a need to avoid the emission of about 675 Mtn of CO₂ in 2010, which represents a significant reduction from the emissions in 2010 according to the baseline scenario. The fuel mix in primary energy changes smoothly, mainly allowing for substitution of solid fuels by natural gas. Nuclear and liquids preserve there shares, while the penetration of renewables is noticeable but limited (5.5% of primary energy demand in 2010, being 3.9% in 1990). The changes in fuel mix imply a moderate decrease of the carbon intensity (-0.4% per year), contributing to the decoupling of CO₂ from energy demand growth. This effect is however significantly smaller in size than the energy intensity effect.

Table 3 : CO₂ Emissions per Country

	pre-Kyoto scenario				pre-Kyoto target
	1990	1995	2010	% change from 1990	
AU	58	59	60	4.5%	-25.0%
BE	112	116	133	18.8%	-10.0%
DN	53	61	59	9.6%	-25.0%
FI	54	71	74	36.9%	0.0%
FR	367	365	389	5.9%	0.0%
GE	997	892	909	-8.8%	-25.0%
GR	72	86	103	43.7%	30.0%
IR	31	33	39	24.9%	15.0%
IT	401	413	475	18.3%	-7.0%
NL	158	172	195	23.5%	-10.0%
PO	40	49	62	55.9%	43.0%
SP	209	242	289	38.0%	17.0%
SV	52	56	68	31.2%	5.0%
UK	584	551	592	1.4%	-10.0%
EU-14	3187	3166	3446	8.1%	-10.0%

In final energy demand, transports (1.69% per year) and tertiary (1.30% per year) continue to grow significantly, while stagnation of energy demand is projected for industry (0.70% per year) and households (1.42% per year). Regarding the fuel mix in final demand, the projection shows a penetration of distributed heat (mainly produced by cogeneration), a decline of solid fuels and a continued, even though moderated, penetration of gas and electricity. The part of liquids is maintained, because of their use in transports.

Power generation is projected to increase in EU-8 by 1.3% per year. The sectoral evolution involves mainly a relatively high growth of independent generation (it represents 12.5% of total power capacity in 2010, to be compared to 5.4% in 1990), and an important shift in favour of natural gas used in combined cycle power plants (more than 2/3 of all new power capacities). The progress in gas turbine technology allows also a significant increase of cogeneration (12.5 GW more capacity in 2010).

3. The costs of emission abatement in 2010

3.1 Introduction

In view of the Kyoto Conference on climate change held in December 1997, the European Union agreed to decrease the basket of greenhouse gas emissions in 2010 by 15% compared to the level of emissions in 1990.

The evaluation of the costs and benefits from reducing CO₂ emissions have been based on model simulations with the same models which were used for the baseline scenario: **GEM-E3**, **PRIMES** and **POLES**.

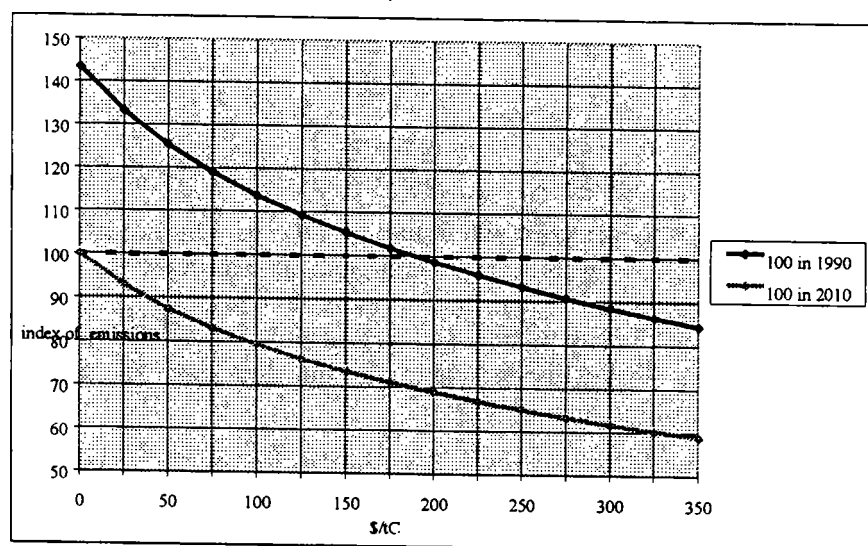
3.2 International dimension

The **POLES** model was used in order to examine the comparative costs of emission reduction in countries and regions outside the EU. The methodology selected was to determine the marginal and total costs incurred in achieving the reduction targets by introducing a "shadow carbon-tax" in the various countries and regions identified in the model. The model is used to construct

marginal cost curves for emission reduction and then to clarify the position of the various parties in the negotiations.

By introducing a shadow carbon tax into the POLES model, it is possible to calculate changes in emissions in relation to the reference case. This is illustrated, at world level, in Figure 1 on the basis of an emission index of 145 in 2010, the emission level decreases with the introduction of a shadow tax of from 25 \$/tC up to 350 \$/tC. If it is read vertically, this figure also represents the curve for sectoral marginal costs of emission reduction. It can thus be seen that stabilisation of emissions at the 1990 level would correspond to a shadow tax of 180 \$/tC, or, in other words, that the equivalent objective of a 30% reduction in emissions in relation to the 2010 reference would be achieved at a marginal reduction cost (MRC) of 180 \$/tC.

Figure 1 : World Marginal Abatement Costs as computed with POLES (source: P. Criqui and N. Kouvaritakis, POLES model)



The amount of the shadow carbon tax for a given reduction target reflects in fact all the changes imposed on the energy sector, as simulated by the model: cost of improved energy efficiency, of greater development of non-fossil energy, and of stronger penetration of fossil sources with low carbon intensity. From one region of the world to the next, the MRC will therefore depend essentially on the reference situation in each of these fields. In a seemingly paradoxical way, the more unfavourable this initial situation, the easier it will be to reduce emissions, while the more virtuous a country is with respect to CO₂ emissions, the greater will be the cost for that country of making further reductions.

There are considerable differences between the major regions of the world:

- for the OECD regions, reduction costs with respect to the 2010 reference would be higher than the world average in Europe and Pacific Asia, but lower in North America;
- the diversity of costs would be even more marked for developing regions, with reduction costs much lower than the average in China, Southern Asia and sub-Saharan Africa (all regions with high coal potential), but higher in South-East Asia, North Africa and the Middle East, and Latin America.

Thus, the analysis whereby reduction costs would be systematically higher in the industrialised countries than in developing countries is not confirmed in every case by a sectoral analysis taking into account the structural characteristics of the energy systems. This conclusion is important in that proposed permit trading systems and joint implementation schemes are based on an *a priori* vision and, as will be seen, will therefore have to be considered on a case by case

basis. In fact, low cost reduction potentials exist in every country, opening up the way for "emission trading".

The results of the exercise on the introduction of a shadow carbon tax can also be examined for a single country or a group of countries. These results can thus help shed light on some of the issues at stake in the international negotiations, in particular the costs associated with quantitative objectives in the form of a flat-rate reduction compared with a base year. Thus, the marginal cost of achieving the objective proposed by the European Union before the Kyoto COP-3 can be analysed for the major Annex I partners: a 15% cut in emissions by 2010 compared with the 1990 level.

A non-differentiated reduction rate of 15% would unquestionably impose extremely different marginal costs on the various parties: 125 \$/tC in the United States, 175 \$/tC in Australia-New Zealand, 200 \$/tC in the European Union and as much as 350 \$/tC in Japan. On the other hand, equalisation of marginal costs among the various parties should result in differentiation of reduction objectives. Thus, for 200 \$/tC, the reduction targets would be 25% in the United States and Australia-New Zealand, 15% in Europe, and 5% in Japan. It is important to note that projected trends up to 2010 are of crucial importance in determining the marginal cost.

The position of each country with respect to one of the objectives proposed prior to the Kyoto conference, namely to reduce emissions by a flat rate of 15% compared with 1990 levels, varies:

- for the United States and the European Union, the total costs might be comparable (less than 0.3% of estimated GDP in 2010), although the corresponding marginal costs differ considerably, with the EU level almost twice that of the United States;
- in Canada and Japan, on the other hand, the same objective could be achieved only with higher marginal costs and a total cost of about 0.45% of GDP;
- finally, Australia appears destined to bear by far the highest total cost, almost 0.6% of GDP, even though its marginal cost is lower than that of the Community.

The simulation of reduction programmes through the introduction of a shadow carbon-tax thus provides coherent information on the relative costs for the various countries. These results can then be re-examined with reference to the various plans proposed for the international negotiation, in order to assess the respective limits and advantages, in terms both of efficiency and acceptability by the various parties.

Figure 2: Marginal reduction cost curves for the major partners of annex I (in relation to reference year 2010, source: P. Criqui and N. Kouvaritakis, POLES model).

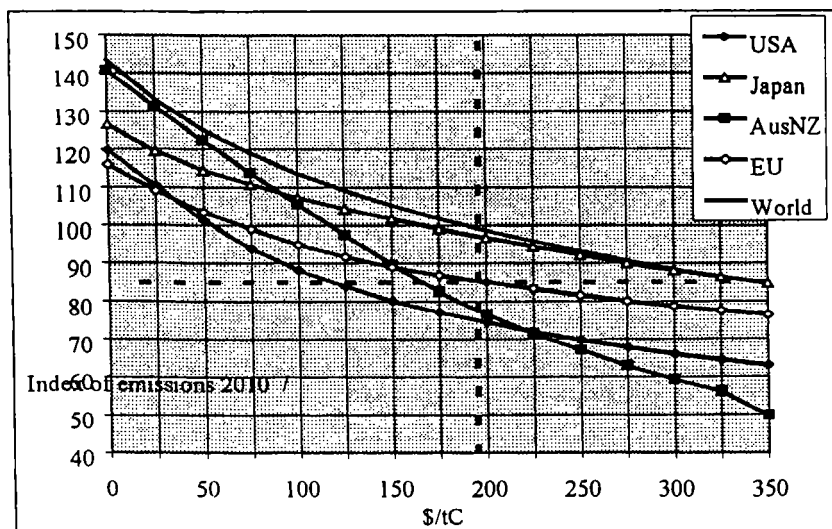
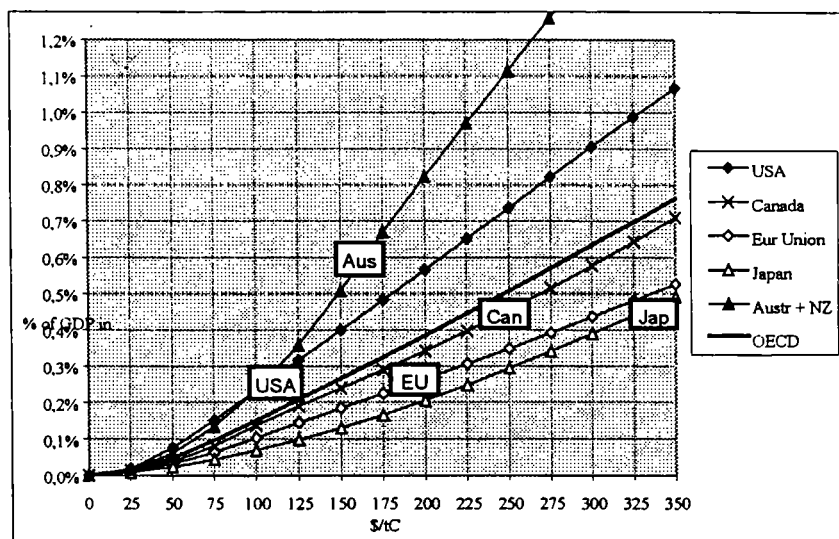


Figure 3: Total cost of reduction as a function of the marginal cost level. (source: P. Criqui and N. Kouvaritakis, POLES model)



Four hypotheses have been analysed:

A "Flat-Rate" Reduction In Emissions of 15% Compared with the 1990 Level in OECD Countries

Here, it is assumed that all the OECD countries - the EU being regarded as a "bubble" - must reduce their emissions to 15% below 1990 levels, with no possibility of emission trading outside their territory. The differences in marginal costs obtained in POLES for such a reduction per country are then significant, ranging from 125 \$/tC for the United States to 200 \$/tC in the European Union and as high as 350 \$/tC in Japan. The figure is even higher in the non-Union region of Europe, which includes Turkey, a country where there is high potential for increased emissions. The total effort in relation GDP in 2010 depends both on the marginal reduction cost in 2010 and emission dynamics in the reference projection. Thus, the corresponding cost would represent slightly less than 0.3% of GDP for the United States, due to a low marginal cost, as in the case of Europe, in this case because of the moderate increase in emissions envisaged in the reference situation. On the other hand, this cost would be one and half times higher in Japan and Canada and up to twice as high in Australia - New Zealand. It thus appears that without the possibility of emission trading; non-differentiation of objectives is likely to create substantial disparities in the charges imposed on the various parties.

The Same Reduction, but at World Level, through a Joint Implementation System or a Generalised Emission Permit Trading System

Another theoretical hypothesis is to assume that the same reduction target as before is imposed on OECD countries, but that this is obtained through a broad joint implementation scheme, or the purchase of emission reduction certificates in other regions of the world. If such an emission trading system could be generalised to all the countries and all the sectors, marginal costs would be equalised at the world level. This would imply optimal allocation of effort and lower costs than before. A world reduction of 12% in relation to the reference could, in theory, be obtained at a marginal cost slightly below 50 \$/tC. With the above scheme the emission reduction in OECD territories would be 460 MtC (about half the total objective), while the rest, would be financed by these countries (directly or through the purchase of emission rights) but correspond to emission reduction in other world regions.

Equalisation of Marginal Costs within the OECD Countries, through a Tax or Permit Trading Systems

This hypothesis is probably more operational than the previous one since it could be implemented in two quite radically different -but possibly realistic- ways: through the introduction of a common carbon-tax in the different countries or permit trading between countries that have agreed to restrictive quantitative reductions. The results of the model show that emissions could be reduced to 15% below 1990 levels at a marginal cost of about 170 \$/tC for the OECD countries as a whole. The total cost of this reduction would represent approximately 0.3% of the GDP of the OECD in 2010.

When it comes to the burden sharing issue between the OECD countries, it is crucial to know whether this should be achieved through equalisation of marginal costs by means of a common tax or through permit trading. Under equalisation of marginal costs, the countries with the highest reduction potential at low or moderate cost would contribute more, so that paradoxically their total cost in relation to GDP would be higher than that of the other countries. Thus, total potential at a cost of less than 170 \$/tC would represent a reduction of 23% compared with 1990 in the United States, for a total cost of almost 0.45% of GDP. For the EU, the reduction would be 13% for a cost of 0.22% of GDP and for Japan only 1% for 0.16% of GDP. Although the rejection of a carbon tax by the United States is probably based on other reasons, there are clearly limits to an international approach based on a single tax, but this does preclude "local" implementation of such a system.

Under a permit trading system, it is assumed that each country is required to contribute to a 15% reduction compared with its situation in 1990, but can buy or sell the reductions corresponding to the difference between the national marginal cost and the equalised marginal cost. The situation will then differ in each country, depending on whether their marginal cost for a 15% reduction is lower or higher than 170 US dollars per ton of carbon (\$/tC).

Differentiation of Quantified Objectives to Equalise Effort

As an alternative to the solutions of a single tax or permit trading systems there is the possibility of differentiation of agreements to take into account, in a global manner, the present and future characteristics of each country. Various equity criteria can be used to formulate a system of differentiated objectives. The criterion adopted was the equalisation of the ratio of the total reduction cost expressed in terms of estimated GDP in 2010.

Equalisation of marginal costs within the OECD countries would make it possible to achieve the objective of a flat-rate reduction of 15 % for a total cost of approximately 0.3% of the 2010 GDP for the region. It is then possible to calculate the emission reduction level on the basis of each OECD country devoting 0.3% of its 2010 GDP to the reduction effort. (This figure could be compared to the objective -declared but seldom attained- of industrialised countries to contribute 0.7% of their GDP in the form of aid to developing countries).

The results of the model show that emission objectives corresponding to this kind of reduction effort can, in certain cases, reduce the disparities between the solution of equalised marginal costs and the flat-rate solution:

- for the United States, the reduction would be 15%, the same as in the flat-rate solution;
- for the EU, it would be slightly higher, about 17%;
- in the Pacific OECD region, it would be lower, reaching -10% in Japan and only stabilisation in Australia - New Zealand.

3.3 Analysis for the European Union

3.3.1 Energy System Implications

3.3.1.1 Policies and measures

The objective of the analysis with PRIMES has been mainly to re-quantify the economic potential of the “**Policies and Measures**” (PAM) package, following the agenda of the ad hoc expert group of the Council, and consider the energy markets and their interactions. Consistency analysis and quantified re-evaluation were the aims of the model-based analysis

The agenda of the PAM package includes the following:

- Energy Efficiency in Heavy Industry
- Equipment (domestic appliances, motors, air compressors, heat pumps, etc.)
- Cogeneration, district heating
- Renewables
- Transports (cars, modal shifts)
- Buildings, thermal integrity
- Taxation (minimum excise taxes on energy)
- Removal of subsidies
- No other Measures for Power Generation

A scenario constructed with PRIMES, named “**Kyoto Advanced Technologies and Renewables**” (KATREN), considered the set of Policies and Measures defined by the EU ad hoc climate group and assumed the imposition of targets by sector as regulation constraints. The PAM sectoral targets take the form of sectoral efficiency gains (for example in % of energy use) or obligations for inputs in the output of power and/or steam. These regulatory targets are imposed at the level of a sector, following a bottom-up engineering approach, represented in the model as constraints on the economic agent's optimisation behaviour.

The KATREN scenario, as constructed with PRIMES, reaches -10.6% of CO₂ emissions in 2010 compared to the 1990 level. This does not mean that it is impossible to obtain more emission reduction. It would be sufficient to impose a more severe regulation. As the marginal efficiency of the regulation in reducing emissions increases with the severity of the regulation, it would be needed proportionally higher regulation to reach a more ambitious reduction target.

Compared to the baseline, the KATREN scenario abates in 2010 about 450 Mtn of CO₂ for EU-8 (or 120 Mtn of carbon that is about 150 Mtoe of primary energy or -11.4% of primary energy demand of EU-8). The emissions are reduced by -15.4% in 2010 from the baseline scenario.

By referring to primary energy demand (gross inland consumption), as GDP growth remains unchanged from the baseline, the KATREN scenario achieves the reduction of emissions mainly by improving dramatically the energy intensity. In all demand sectors, and also through cogeneration and renewables, substantial gains in energy efficiency are obtained. This concerns all energy forms, including electricity, the use of which is highly rationalised. As natural gas penetration already was substantial in the baseline, the possibilities for further substitution in favour of natural gas are limited.

The fuel mix in power generation does not change significantly (as no policy was imposed in this respect). The only difference is derived from the non-fossil fuel obligation that was

imposed. However, due to the shrinking of the electricity sector, as a consequence of demand side savings, the development of renewables is significantly lower than projected both in the work of the ad hoc group on climate change and TERES II (both engineering-types approaches). Favourable regulations lead to an impressive increase in the demand for co-generated heat and power, although this is partly balanced from direct measures implying efficiency gains in steam uses.

Additional (compared to baseline) investment in renewables for power generation amounts to 34 GW in EU-8, representing an increase of 72% from baseline. Similarly, the increase of investment in cogeneration corresponds to a doubling of capacities from baseline (25 GW additional capacities).

The structural shift in favour of independent generation is also more pronounced in KATREN than in the baseline scenario. Electricity generation from independent power producers (IPP) increases by 20% while centralised generation decreases by -13% in 2010. Investments in gas turbine technologies (mainly equipped with steam injection) in industrial and tertiary application are accompanied by premature scrapping of older plants (compared to the baseline). This of course induces higher electricity production costs.

The changes in the tertiary sector differ, despite the similarity related to the substantial energy efficiency gains obtained in this sector, as well. In this sector, it seems more preferable to give priority to electricity demand savings than to rely on distributed heat. Final energy demand in the tertiary sector decreases by -11.5% from baseline, leading to a compensation of the high energy growth of the sector as projected in the baseline.

The households act mainly through accelerating preference to advanced technology appliances, resulting in significant savings in the specific electricity uses. Savings in the heat uses are rather limited, confirming the difficulties faced by households in seeking for energy efficiency gains.

High uncertainty prevails in the analysis for the transportation sector and road transports in particular. The bottom-up engineering studies specified that there is technically possible to commercialise a new type of car (with internal combustion engine) that would be controlled by a computer to reach a specific consumption of 5 lt. per 100 km in average. Such a car, if its production were generalised, would induce a moderate increase of car purchase price (15%) and would achieve as much as 40% savings in the energy bill for the consumer. In the presence of such regulation (new cars only available for new purchases after 2002), the model projects a substantial decrease of final energy demand in transports (-17.5% in 2010 from baseline) and in road transports in particular (its share decreases in energy terms). The average car efficiency improves by 20% in 2010. Small changes occur in the other transport means and there are little effects from inter-modal transport combinations (this related also to the fact that PRIMES has ran separately by country), as these are not regulated.

As mentioned, the reduction of CO₂ emissions in KATREN is a result of the combined effect of energy efficiency gains, mainly in final demand and through cogeneration (these are the main causes of emission reduction), substitutions in favour of renewables and some limited substitutions in favour of natural gas. This can be summarised in the following table.

Table 4: Main trends in KATREN (annualised growth terms)

KATREN - Annual rates of change	1995-2010
Overall Energy Intensity	-2.30
Fossil Fuel Intensity of GIC	-0.16
Carbon Intensity of Fossil Fuels	-0.53
CO ₂ emissions per unit of GDP	-2.97

Table 5: Impact of PAM on CO₂ emissions

in 2010 for EU-8					% Diff. from baseline
CO ₂ Emissions in Mtn	Baseline	Shares	KATREN	Shares	
Industry	466.6	15.5%	372.8	14.7%	-20.1%
Tertiary	194.8	6.5%	177.0	7.0%	-9.1%
Residential	396.9	13.2%	365.3	14.4%	-8.0%
Transports	899.4	29.9%	738.4	29.0%	-17.9%
Central Power	716.2	23.8%	545.5	21.5%	-23.8%
Independent CHP	192.8	6.4%	221.1	8.7%	14.7%
Other	139.1	4.6%	121.9	4.8%	-12.4%
TOTAL Emissions	3005.8		2542		-15.4%

The table below shows a decomposition of CO₂ emission reduction by type of PAM (policies and measures) classified according to the agenda of the ad hoc group on climate change of the Council. This decomposition needs a complex calculation on the numerical results of the model and involves certain assumptions.

The table shows a high contribution of transports. The uncertainty in the analysis for transportation sector emphasises the importance of conducting additional in depth studies. It is evident that if the corresponding potential is smaller than that of the above table, then there will be important difficulties in reaching the CO₂ emission reduction target.

The contribution of CHP and renewables is also impressive, ranking second after transports. The rest of emission reduction is attributed to direct energy efficiency gains in the end-use of energy, equally distributed between industrial processes and domestic appliances.

The KATREN scenario shows an economically and technically feasible package of standards and regulation that serves to approach the emission reduction target. Of course, additional sensitivity analysis is required to refine the regulation assumptions and their allocation to sectors and energy uses. The scenario also revealed important side effects, regarding CHP and renewables in particular, that cannot be neglected when considering the energy markets and their interactions.

3.3.1.2 Carbon tax scenario

PRIMES has been used also to construct a set of Carbon-Tax-Equivalent scenarios (starting from the baseline) to compute the shadow-marginal cost of the emission reduction target by country.

In each scenario of this type, several runs are made to determine the value of a carbon tax that is necessary to operate throughout the energy system so as to reaches a predetermined level of CO₂ emission reduction. Given that PRIMES is a market equilibrium model, the required level of carbon tax is exactly the measurement of the system's marginal abatement cost associated to a reduction level. Therefore, the so-called CO₂Tax scenario is not a taxation scenario, in policy terms, but simply serves to the evaluation of the marginal abatement cost.

Table 6 : PRIMES version 1 results in % of CO₂ reduction in 2010 from 1990

PRIMESv1: Marginal Cost of CO₂ reduction in 2010, in ECU'90/ton of Carbon							
	0	50	100	150	200	300	350
BE	18.8%	-5.3%	-7.0%	-8.1%	-8.8%	-9.3%	-9.8%
FR	5.9%	-0.7%	-2.0%	-2.9%	-3.4%	-3.9%	-4.2%
GE	-8.8%	-21.8%	-23.3%	-24.2%	-24.8%	-25.3%	-25.7%
IT	18.3%	-1.9%	-4.0%	-5.2%	-6.1%	-6.8%	-7.3%
NL	23.5%	7.4%	2.4%	-0.7%	-2.9%	-4.6%	-6.1%
SP	38.0%	19.8%	17.1%	15.5%	14.4%	13.5%	12.8%
SV	31.2%	23.9%	17.4%	12.5%	8.5%	5.2%	2.3%
UK	1.4%	-8.0%	-10.1%	-11.4%	-12.4%	-13.1%	-13.7%
EU-8	5.9%	-7.4%	-9.5%	-10.8%	-11.7%	-12.4%	-13.0%

It must be also emphasised that the CO₂Tax scenario leads by construction to an optimal allocation of the CO₂ reduction effort. On the contrary, the KATREN scenario, as being a regulation scenario, is sub-optimal. This optimality rule theoretically applies to allocation for both the countries and the sectors. However, in the present CO₂Tax runs, the analysis limited the optimality only among the sectors of each country, considering the allocation by country as given following the decision of the Council on 3.3.1997. Of course, the country allocation needs not to be optimal. Therefore, the CO₂Tax scenario overestimates the optimal marginal abatement cost, compared to the case that the CO₂ effort would be allowed to be flexible among the countries, as well. The inefficiency of the allocation (regarding the countries) has been estimated to be around 36% in marginal abatement cost terms.

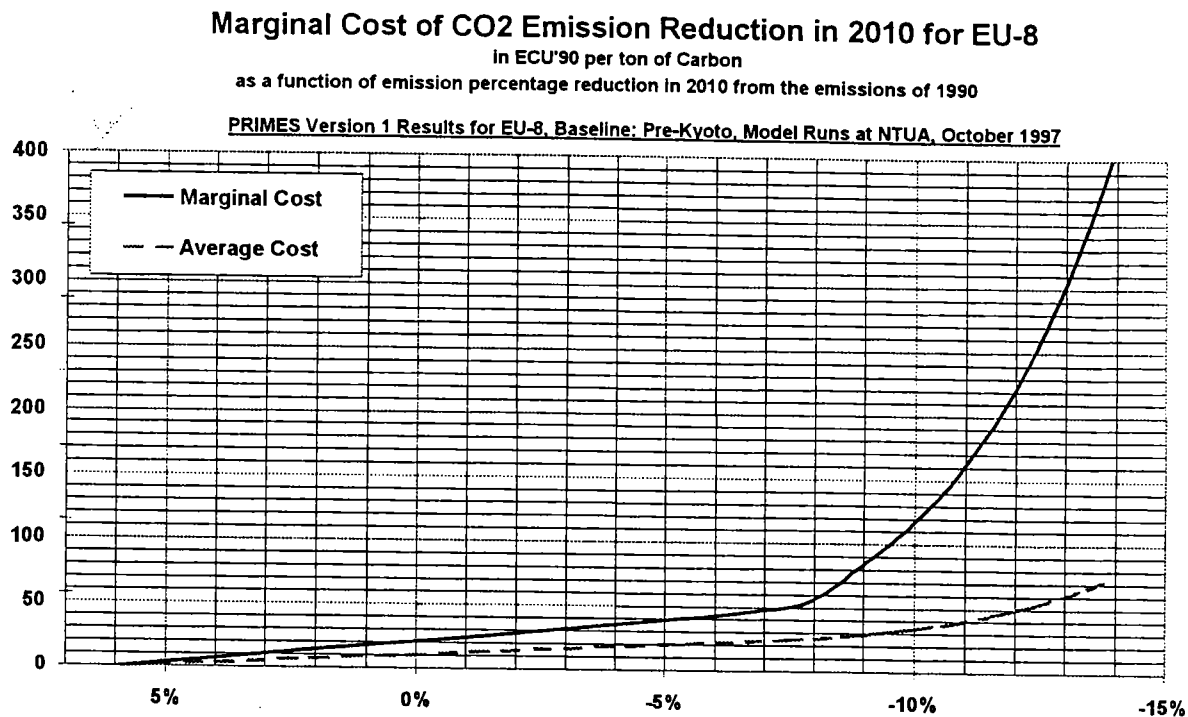
The CO₂Tax scenario showed how important is the power generation sector for least cost actions in the short run. Fuel shifts in power generation are possible and cheap leading to an important (about 20%) contribution of the sector to reach the target. Less emission reduction effort is required in the demand-side, mainly in the residential and services sectors, leading to cost savings.

The CO₂Tax scenario showed how market competition plays an important role in the allocation of effort among the sectors. It has shown for example that the CO₂Tax scenario induces higher operation costs for power generation, but the centralised generators have the advantage of exploiting economies of scale and the possibility to rely more on carbon free resources. In these circumstances, the increase in the fuel bill partly compensates the gains from the production of steam by decentralised generators, an effect that undermines their competitiveness. In such a case it seems that there is more opportunity to invest in direct savings in heat uses (as it is shown in the results for industry) than to save through the CHP, as decentralised power generation is less competitive (because of costs and economies of scale).

Regarding the magnitude of the energy system costs for the EU, the results show the following:

- The marginal abatement costs are significantly higher than the average costs. In case of optimal allocation by sector that is for the CO₂Tax scenario marginal costs are 297 ECU'90/tn Carbon (-11.3% of CO₂ in EU-8), compared to average cost of 38 ECU'90/tn Carbon.
- The distribution of marginal costs per country differs substantially. This is of course related to the pre-defined allocation of the emission reduction effort, as it follows the decision of 3.3.97 which is a result of negotiation involving consideration of several factors on top of cost-engineering. In case of optimal allocation of effort by country, as in a different CO₂Tax, the marginal abatement cost is reduced to 190 ECU'90/tn of Carbon (36% more efficient).

Figure 4: Marginal abatement cost curve with PRIMES



As it can be seen from the figure above, the marginal abatement cost curve is steeply increasing, especially beyond -8 to -9% of CO₂ emissions in 2010 (compared to 1990). The average cost curve is increasing smoothly.

3.3.2 Macro-economic results

The results in this paragraph are a short summary from a very large number of simulations conducted with the GEM-E3 model over a span of several years.

3.3.2.1 Abatement cost curves

One way to depict the effort needed to achieve particular CO₂ targets, is through marginal and average cost abatement curves. Although these are not necessarily indicators of the economic consequences or costs of the target, they show the degree of difficulty of adjustment of the system to achieve the target.

To construct the cost abatement curve, alternative emission reduction targets were defined for the EU as a whole and the model was allowed to evaluate the optimal allocation of the effort needed across countries, firms and households. The emission constraints define the marginal cost of emission reduction. This is then linked to the rest of the model in a way to reflect explicitly the type of policy instrument used to achieve the target. The analysis with GEM-E3 included pollution permits as well as taxes.

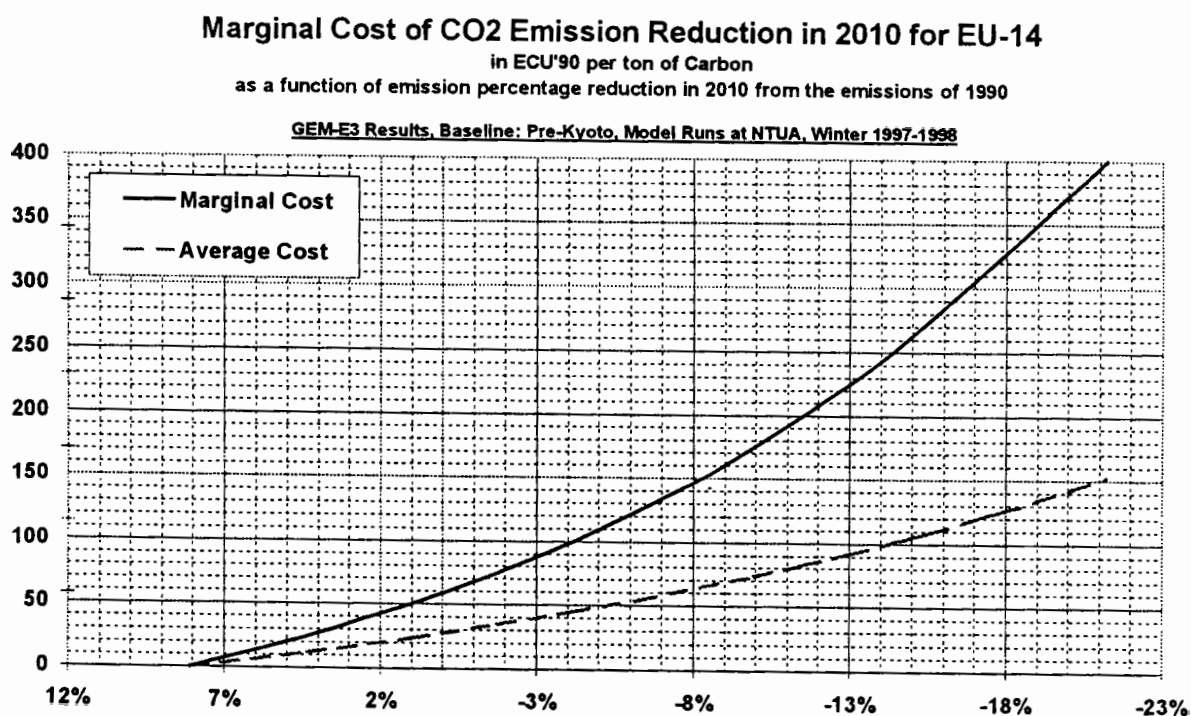
Table 7 presents the results of GEM-E3 and shows the optimal emission reduction targets for 2010 per EU member-state and for different levels of the marginal abatement cost of CO₂ reduction. If considered by column, this table provides the optimal allocation of effort and the corresponding marginal abatement cost for a given EU-wide emission reduction target.

Table 7: GEM-E3 results in % of CO₂ reduction in 2010 from 1990

GEM-E3: Marginal Cost of CO₂ reduction in 2010, in ECU'90/ton of Carbon							
	0	50	100	150	200	300	350
AU	4.5%	-2.7%	-8.0%	-12.1%	-15.3%	-20.6%	-22.9%
BE	18.8%	7.7%	0.2%	-5.3%	-9.3%	-15.6%	-18.3%
DK	9.6%	1.9%	-3.5%	-7.7%	-10.9%	-16.1%	-18.3%
FI	36.8%	26.1%	18.7%	12.9%	8.5%	1.3%	-1.7%
FR	5.9%	-0.3%	-4.7%	-8.2%	-10.9%	-15.4%	-17.4%
GE	-8.8%	-13.9%	-17.9%	-21.3%	-24.0%	-28.4%	-30.3%
GR	43.6%	30.6%	21.7%	15.1%	10.1%	2.2%	-1.2%
IR	25.0%	13.4%	6.2%	1.0%	-2.9%	-9.2%	-11.8%
IT	18.3%	10.4%	5.0%	0.8%	-2.4%	-7.8%	-10.1%
NL	23.5%	17.2%	12.7%	9.1%	5.9%	0.4%	-2.2%
PO	56.1%	46.9%	39.9%	34.2%	29.6%	22.0%	18.6%
SP	38.0%	28.6%	21.3%	15.5%	11.1%	4.0%	0.9%
SV	31.2%	23.3%	17.9%	13.7%	10.4%	4.9%	2.5%
UK	1.4%	-6.1%	-11.6%	-16.0%	-19.3%	-24.8%	-27.1%
EU-14	8.1%	1.0%	-4.2%	-8.3%	-11.5%	-16.7%	-19.0%

The following figure presents the marginal and average cost curves as a function of the EU-wide emission reduction target (for 2010).

Figure 5: Marginal abatement cost curve with GEM-E3



The average costs as evaluated from the GEM-E3 results include all direct, indirect and system equilibrium effects resulting from the additional environmental constraint. They are defined as the ratio of additional charges per sector (for an activity equal to that of baseline) divided by the number of tons of carbon avoided in 2010 per sector.

3.3.2.2 Macro-economic impact

As already mentioned, GEM-E3 includes the feedback from the energy system to the whole economy and therefore allows the evaluation of the economic impact of the policy on sectors, countries and households. The marginal cost curve presents insufficient information for evaluating the policy as the impacts on GDP, employment or competitiveness are not considered.

GEM-E3 by directly reflecting economic theory provides a unique criterion for policy evaluation. Under reasonable assumptions, observable quantities (such as consumption and employment) lead to a quantification of an unobservable quantity, i.e. the consumer's welfare, whose changes are used for policy evaluation.

Two problems exist in this respect: although the welfare function in GEM-E3 is derived in a standard way found in the economic literature, there remains the problem of valuation of unemployment or leisure. On one hand, for a person that is currently employed, working more can be seen as, *ceteris paribus*, a reduction in welfare while for an unemployed person finding a job is certainly welfare-increasing. This problem is still not resolved in the theory of welfare economics and no single satisfactory answer exists. A second problem comes for the fact that changes in environmental quality should result in welfare gains. Such a valuation is inherent in all GEM-E3 model versions, derived from EXTERNE⁶ data. This leads to the computation of the "**total welfare**" index of the model, i.e. inclusive of the benefit from enhanced environment.

Two separate sets of scenarios were simulated with the model:

Pollution Permits, in which economic agents are endowed with an initial amount of property rights to the environment that are tradable across firms, households and countries. The main mechanism for the initial allocation of permits used was "grandfathering" (i.e. pollution permits allocated in proportion to base year emissions). Other initial allocations (e.g. equal per capita burden or equal per GDP burden) were also simulated as sensitivity tests. A discussion of pollution permits in general can be found in Tietenberg, T.H. (1995).

Taxes. In these policy cases, a carbon tax is imposed on all economic agents according to CO₂ emissions. The government collects the tax revenues. This is the "Constrained case, no recycling" in the figure below. In the other cases, the tax revenues are re-distributed, defining two alternative policy scenarios. The first, called "double dividend for labour", involved subsidising employers' social security contributions. In this case labour becomes more competitive as a production factor and substitutes energy in some sectors. The outcome, under a wide range of initial conditions, is favourable for employment. Structural shifts away from equipment and towards consumer goods may have negative long-term implications not covered in the model simulations. In the second, called "reduction in investment costs", environmental policy revenues were used to subsidise investments. The rationale behind this scenario is to induce higher investments in the hope of achieving long-term economic growth.

All model simulations involved reaching the "Kyoto" target in 2010 and did not consider the impacts beyond that year.

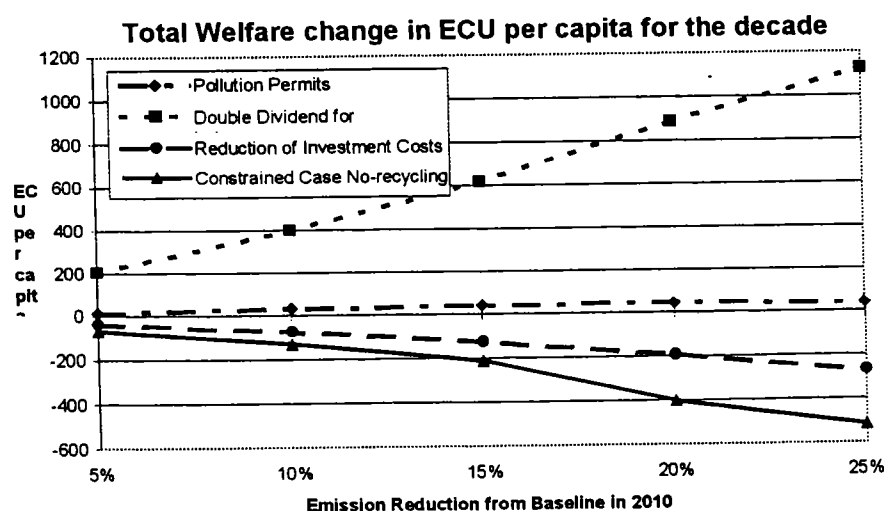
Table 8: Macro-economic effects of reaching the "Kyoto" target by 2010.

Macroeconomic Aggregates for EU-14 (all scenarios)

	PP	DD	CR	NR
Gross Domestic Product	-0.34%	-0.38%	-0.40%	-0.70%
Employment*	175	1023	-60	-362
Private Investment	0.01%	-0.35%	1.65%	-0.93%
Private Consumption	-1.20%	0.80%	-1.70%	-1.89%
Domestic Demand	-0.83%	-0.94%	-1.31%	-1.85%
Exports in volume	-0.31%	-3.39%	-0.97%	0.06%
Imports in volume	-2.95%	-1.57%	-3.37%	-4.30%
Intra trade in the EU	-0.29%	-3.46%	-0.87%	0.23%
Energy consumption in volume	-8.77%	-10.35%	-10.05%	-10.18%
Consumers' price index	1.20%	3.51%	0.42%	-0.32%
GDP deflator in factor prices	-0.19%	0.15%	-2.51%	-3.38%
Real wage rate	-1.19%	0.61%	-1.06%	-1.11%
Tax revenues as % of GDP	0.89%	2.70%	2.56%	2.50%
Current account as % of GDP	0.34%	-0.15%	0.35%	0.56%
Marginal abatement cost (ECU'85/tn C)	176.2	153.3	140.7	135.8
Total atmospheric emissions				
CO2	-14.7%	-15.0%	-15.0%	-15.0%
NOX	-11.8%	-11.7%	-11.8%	-12.0%
SO2	-21.9%	-22.7%	-22.4%	-22.3%
VOC	-7.3%	-6.7%	-7.2%	-7.4%
PM	-24.5%	-25.0%	-24.7%	-24.6%

Note: PP is the grandfathered pollution permits scenario, DD is the labour recycling scenario, CR is the capital recycling scenario and NR is the no recycling case.

Figure 6: Welfare change in ECU per capita, for the period 2001-10 for different emission reduction targets.



The quantitative nature of the results is confirmed in the sensitivity tests performed, but the exact figures vary significantly depending on the accompanying policy and the assumption about the possibility of adjustment of the economic agents. For example under the assumption

that energy intensive industries are already on the limit of their possibilities for energy conservation or that they operate in an international environment which is very competitive, the results would be more negative. Under extreme assumptions concerning labour market regimes and international competition, even the employment dividend may disappear.

If, on the other hand, there exists in the economy the potential to achieve significant efficiency gains in energy use at a moderate cost, then the negative impact of environmental constraints on the economy may be lower. In this case additional benefits from terms-of-trade effects may further reduce the cost of the policy. In this case, it is possible that there is no net economic cost for the policy, supporting the "strong" double dividend hypothesis. But this requires rather extreme assumptions (very low exposure to foreign competition, high potential for cheap energy-saving investments, high flexibility of the labour market).

The relative efficiency between pollution permits and taxes cannot be addressed with GEM-E3. Since the economic agents operate under perfect information and total resources are allocated so as to reduce total costs, there is no theoretical distinction between taxes and permits. More importantly the costs of setting up the necessary infrastructure needed for operating the pollution permits market were not included in the model.

The environmental target was always set at the EU-14 level, and the allocation of effort was distributed across the countries so as to minimise total costs. The tax burden (or equivalent permit allocation) by economic agent and country is however arbitrary. In the main model applications simplifying assumptions were made on both issues: on the permits simulations the initial endowment follows the "grandfathering" principle, i.e. permits proportional to the base year emission by agent; on the tax case the revenues were recycled within the country given to labour or investments. The chapter on burden sharing modifies this assumption and shows its importance. Under different permit allocation schemes, the results vary significantly with some countries gaining and some countries losing. There of course no single criterion exists and the question of equity is raised. To what extent some countries may take more burdens than others?

Sensitivity tests were also done on a similar issue, namely whether it is worth to exempt some sectors or derogate action in some countries for some years. Exemptions were studied for the energy intensive industries and it was found that indeed these sectors suffer much less. As a matter of fact, it may even be possible that, in a first approximation, these sectors might also benefit (e.g. from lower labour costs, from subsidised investments or from selling permits). However the additional burden facing the other sectors (because the CO₂ target is given) has negative implications for the economy as a whole, so that indirectly energy intensive industries suffer as well. The final outcome of the simulations is that the overall effectiveness of the policy when energy intensive industries are exempted gets lower.

3.4 Long-term technology options.

A case study on the power generation sector was carried out to examine the issue of long-term technological developments in power generation.

3.4.1 A global perspective

The technology scenarios have been defined in terms of clusters of technological breakthroughs affecting mainly power generation. These include:

- A "**Nuclear**" scenario which assumes the advent of cheap and relatively risk-free nuclear power generation.

- A "**Clean Coal**" scenario involving rapid technical progress and price decreases in clean coal technology.
- Two "**Gas**" scenarios, both starting from the assumption that the gas resources are higher than predicted today and that the price of gas will be low. The second additionally assumes rapid technical evolution on fuel cells.
- A scenario on "**Renewables**", which assumes major breakthroughs on renewable technologies.

The technology scenarios for the power generation sector that are examined in this research do not offer panaceas for the global CO₂ emission problem. Important though the power generation sector may be, it still accounts for about 40% of the projected world CO₂ emissions by 2030. Also, scenarios involving major technical-economic improvements in fossil fuel technologies produce weakened impacts on CO₂ emissions because at the same time as they reduce specific emissions they make these technologies economically attractive, not only vis-à-vis more polluting technologies but also more polluting ones. It is important to note that all supply side technological improvements, result one way or another in a reduction in the cost of consuming energy and hence potentially cause consumption to increase.

Scenarios involving increased gas availability produce surprisingly weak results as far as CO₂ emissions are concerned. This is due partly to the uneven geographical distribution of the enhanced resources resulting in the gas not being available at sufficiently cheap prices where it could have made the biggest impact, i.e. in China and India, but also due to the resulting lower prices for gas and electricity

There is a clear need for energy saving technology breakthroughs, as these are likely to suffer less from the ambiguities and secondary effects associated with supply technologies. It is hard to see how clusters of energy technologies could by themselves make a major impact on the global CO₂ problem unaccompanied by major policy initiatives albeit market related ones. Combining technology breakthroughs with internalisation of external costs through taxation or tradable permits would magnify the impact and tend to neutralise some of the more ambiguous side effects quite apart from the fact that these policy instruments can by definition act on a much wider front.

Table 9: summary table of the impact of technology scenarios, World in 2030, Comparison with Reference Case

Scenario	Coal	Oil	Gas	Nuclear	Hydro	CO ₂ Emissions
Nuclear	-94%	-0.8%	-4.0%	142%	-0.7%	-5.3%
Clean Coal	4.5%	-1.0%	-3.9%	-13.1%	-1.1%	1.0%
Gas Technology	-17.5%	-8.1%	49.7%	-19.6%	-2.2%	-2.1%
Gas and Fuel Cells	-18.6%	-8.2%	50.1%	-22.5%	-2.6%	-2.5%
Renewables	-5.4%	0.1%	-2.3%	-4.5%	-0.3%	-3.3%

A cursory glance at the table above is sufficient to realise that the technology scenarios as defined in the current work do not offer a solution for the global CO₂ emission problem. The reasons for this are inherent in the way the scenarios were constructed as well as energy market structures and the way their functioning is represented in the POLES model.

3.4.2 Long term technology options for the EU

Throughout the period to 2030 and beyond, developments in power and steam generation technologies are likely to play a significant role in the trends in the energy consumption and emissions of the EU. However, the overall growth in the EU electricity and steam demand is likely to be very modest, due to the maturity of the European economies and their energy systems. Given also the longevity of the generating equipment, the speed with which new technologies can be introduced will be limited, at least in the medium term.

The scenarios analysed in this research are quite revealing for the likely future of the European Union's power generation system. The EU energy system seems to be very sensitive in the period after 2020 when the massive decommissioning of old plants will necessitate the selection of new technologies for replacement generation equipment. The differential progress of different technologies is likely to influence directly a number of strategic decisions of the EU, which could lead to highly varying profiles of the future power and steam system.

The scenarios reveal the strategic importance of natural gas and gas related technologies for limiting CO₂ emissions and for reaching objectives on the development of cogeneration and the decentralisation of the generation market. Under all sets of energy prices examined, the gas and fuel cells scenarios result in the lowest amount of emissions by 2030. These two scenarios also have the lowest generation costs although this is partly because of the lower gas prices assumed in these scenarios. Somewhat surprisingly, the gas scenario does not have dramatic implications the degree of decentralisation by 2030. The projected generation system even in the reference case is already much more decentralised in 2030 than in 1995 and this is largely due to the penetration of gas. The additional gas generation in the gas scenario is mostly to the detriment of base load nuclear and coal plants. Of course, under the gas based fuel cell scenario, the degree of decentralisation reaches its peak.

The long term outlook of coal and nuclear is highly dependent on the technological developments in these fuels. Only under the assumptions of their corresponding scenarios do these fuels play a role significantly more important than the one assumed in the baseline scenario. Of course, EU based clean coal technological developments, could prove very beneficial to the exports of power equipment. However, the clean coal scenario indicated that technological developments in this sector could have adverse effects for the emissions within the EU. The development of nuclear energy seem to be limited in scope and gains, as restricted from load constraints and the interaction with decentralised steam generation. The incremental improvement of renewable technologies is not enough to alter the profile of the system in terms of emissions and costs.

4. Acknowledgements

The development of the models and the results presented in this paper are the outcome of collaborative efforts carried out in successive JOULE projects. The GEM-E3 model was developed by a core modelling group involving the P. Capros, T. Georgakopoulos and L. Mantzos from the National Technical University of Athens, D. Van Regemorter and S. Proost from the Centre for Economic Studies of the University of Leuven, T.S.M. Schmidt from the Centre for European Economic Studies in Mannheim and K. Conrad from the University of Mannheim. The PRIMES energy system model in the form used for the analysis presented in this paper was developed by NTUA. Finally the POLES model was developed by P. Criqui (IEPE) and N. Kouvaritakis (ECOSIM).

Most of the analysis in this paper summarises contributions made within the context of the JOULE-III project "Climate Technology Strategy within Competitive Markets", supervised by Mr. P. Valette, head of division, DG XII, European Commission.

The views expressed in this paper are those of the authors and do not engage the European Commission.

5. References

- Bovenberg, L. and L. Goulder (1993), "Integrating Environmental and Distortionary Taxes: General Equilibrium Analysis", paper presented at the Conference on "Market Approaches to Environmental Protection", Stanford University, December 3-4, 1993.
- Capros P. et. al. (1998): "*Climate Technology Strategy within Competitive Energy Markets*", final report to the European Commission, JOULE project, DG XII, July.
- Capros P., T. Georgakopoulos, D. Van Regemorter, S. Proost, T. Schmidt and K. Conrad (1997): "*The GEM-E3 model for the European Union*", Journal of Economic & Financial Modelling, Volume 4, no 2&3, special double issue, pp. 51-160.
- Capros P., E. Kokkolakis (1996) "*Energy Efficiency and Conversion Decentralisation: Evidence from the PRIMES Model*", International Workshop jointly organised by the European Commission, the International Energy Agency and the OECD on "Instruments for Environmental Improvement with Structural and Technological Change in the Electricity Sector", 9-10 September, Brussels, Belgium.
- Capros P., P. Georgakopoulos et al. (1995) "Coordinated versus uncoordinated European carbon tax solutions analysed with GEM-E3 linking the EU-12 countries", in S. Proost (editor) "*Economic Aspects of Environmental Policy*", Kluwer Academic Publishers, forthcoming.
- Carraro, C. and D. Siniscalco eds. (1996), "*Environmental Fiscal Reform and Unemployment*", Dordrecht: Kluwer Academic Pub.
- Criqui, P. et al., (1996): *POLES 2.2*, European Commission, DG XII, EUR 17538 EN, 99p
- Conrad, K. and T.F.N. Schmidt (1996): 'Economic Impacts of a Non-Coordinated vs. a Coordinated CO₂ Policy in the EU - An Applied General Equilibrium Analysis', Economic Systems Research, Special Issue, forthcoming 1998.
- Grubb, M., Edmonds J. (1993): "*The Cost of Limiting Fossil-Fuel CO₂ Emissions, A Survey and Analysis*", in Annual Review of Energy and Environment, Vol. 18, p. 397-478.
- Wigley, T. M. L., Richels, R., Edmonds, J.A. (1996): "*Economic and environmental choices in the stabilisation of atmospheric CO₂ concentrations*", Nature, 379, 240-243.
- Tietenberg, T.H. (1995) "*Tradeable Permits for Pollution Control when Emission Location Matters: What have We Learned?*" In: Environmental and Resource Economics 5, pp. 95-113.

Quindi C. Franco
10/21/98 11:14:42 AM

Record Type: Record

To: Joseph E. Aldy/CEA/EOP

cc:

Subject: German Nukes

Joe,

Here is some information on german nukes and implications of taking them out in 2010. Were you putting this into a memo or something for Jeff? Let me know if we need anything else for this...

* The government is discussing introducing legislation in 12 months which would set a timetable for the shutdown of all of Germany's nuclear generators. There are no details of what that timetable would look like. The following assumes all nukes would be shutdown for the 2008-2010 timeperiod, and takes 2010 as indicative.

* **CURRENT & FORECASTED STATUS:** Nuclear energy currently supplies 30% of Germany's electricity, and . Nuclear capacity is 22.3 GW, supplying 153.5 billion kwhrs in '96. Interestingly, nuclear power utilization has been increasing of late, 1996 and 1997 were both record breaking years. EIA predicts that Germany would have 16 GW of nuclear capacity in 2010.

* **COMPOSITION OF NEW CAPACITY:** Germany is expected to add nearly 5.5 GW of capacity by 2002. This will be 58% lignite (dirty coal), 11% natural gas, 14% "pumped storage", and 7% other [note this doesn't add up to 100 -- aren't EIA folks great?]

* **IMPLICATIONS:** Assuming 60% of power would be supplied by coal, 40% by natural gas, eliminating the nuclear industry would add 20 mmtc to 2010 emissions (this assumes German power plants operate at similar efficiencies to US plants, and that German fuels have similar carbon content as US fuels). * This is approximately 7.8% of Germany's commitment, and ___ % of its estimated required reductions. [do you have a baseline forecast for Germany in 2010?]

* Note that Germany's nuclear industry is quoted in FT as saying the closure of all nuclear plants would add 44 mmtc. The difference is probably because 1) they are looking at immediate closure and not in 2010, when some nuke plants would have been closed anyway, and 2) they assume all new capacity would be coal.

LEVEL 1 - 1 OF 1 STORY

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The Economist

June 27, 1998, U.S. Edition

SECTION: World Politics and Current Affairs; **BRITAIN**; Pg. 56

LENGTH: 1143 words

HEADLINE: Climate change. A taxing issue

BODY:

Exactly how is the government going to meet its targets for cutting **emissions of greenhouse gases**?

PROMISES are easier to make in opposition than to keep in government, as the lengthy queues for health care prove. Reducing hospital waiting lists, however, is child's play compared with honouring Labour's manifesto pledge "to lead the fight against global warming."

That fight has been made harder by the government's "energy review", the conclusions of which were announced on June 25th, as The Economist went to press. The purpose of the six-month review was, in effect, to shore up what remains of **Britain's** dying coal industry, which in the past few years has seen its last big market, electricity generation, lost to new gas-fired power stations. The government has bought time for coal by delaying approvals for further gas-fired plant; it also wants coal producers to cut their prices. As industrial policy, this is suspect; measured against the government's environmental boasts, it is incomprehensible. The trouble is, the switch to gas has cut **Britain's emissions** of carbon dioxide (CO2), the main **greenhouse gas**. By slowing down this change, the government is discouraging further progress.

Under the Kyoto agreement on climate change, **Britain** is legally committed to reducing its production of six **greenhouse gases** by 12.5% of 1990 **emission** levels by 2010. Labour's election manifesto went much further than this, promising to cut CO2 **emissions** by 20%. If this target is to be met, it will inevitably require much higher energy prices as well as radical action to restrain car traffic. The ground is ill-prepared for such politically sensitive decisions. But later this summer ministers are due to publish a consultation document on their plans. This will be followed by a white paper next year.

The size of the task is shown by a warning last year from the government's own advisory panel on energy. It said that, if reliance were placed solely on higher energy taxes to meet the 20% target, domestic gas prices might have to double and electricity prices increase by nearly half. Last year the Royal Commission on Environmental Pollution proposed broader-based but equally eye-popping measures. These included raising transport fuel duties by 9% a year in real terms--50% faster than the government's current policy--thus doubling petrol and diesel prices over the next decade. In addition, the commission said,



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the growth in urban traffic would have to be cut by half and the average fuel efficiency of new cars improved by 40%.

Some business leaders support the idea of a tax--as long as revenues are recycled through cuts in other corporate taxes, such as employers' national-insurance contributions. Earlier this year the Advisory Committee on Business and the Environment, a business group, urged the government to consider a levy on CO2 **emissions**. In response, Gordon Brown, the chancellor of the exchequer, set up a task-force chaired by Sir Colin Marshall, chairman of British Airways. Its report is due to be delivered in November; and an energy tax levied on businesses is a possibility in next year's budget.

The Marshall task-force, aided by civil servants from the Treasury, the Department of Trade and Industry, and Customs and Excise, is examining two main options. One is an energy tax on businesses. The other is a system of **emissions** trading in which companies would buy and sell permits allowing them to emit a specified amount of **greenhouse gases** over a given time period.

In some respects, the two ideas would have similar effects. Both would give companies an incentive to cut **emissions** (clean up, or else pay the tax or buy a permit). Both, in theory, should encourage those who can afford it to cut **emissions** the most. The net effect of either on the exchequer could be nil if the chancellor chose: he could hand back tax revenues to business, or auction permits and hand back the proceeds. But both would create big winners and losers: some energy-intensive companies would pay far more in tax, or for permits, than they received in rebates.

There are important differences, too. A general energy tax would be far simpler to administer and less of a burden for smaller companies than a permit-trading system. Against that, control of the number of permits should allow the government to limit, and cut, **emissions** with more precision than it could by using a tax. And the effect of permit trading on different industries would depend on how the permits were allocated in the first place. Energy-intensive firms, not surprisingly, would like permits to be handed out in proportion to past **emissions**. That would soften the blow for them--but would also hurt new entrants and growing companies, which would have to buy permits to expand.

The task-force may dodge this last issue but it is expected to recommend a hybrid system: a general energy tax for smaller firms combined with **emissions** trading for larger companies. Both will require legislation which will not be passed speedily.

Other questions remain. For instance, who should pay the tax? Taxing firms' consumption of energy is a blunt instrument: there is no way of telling whether a specific kilowatt-hour was generated from coal- or gas-fired power stations. Taxing electricity generators is also unsatisfactory if the tax is not to fall on domestic as well as corporate electricity consumers. And whatever method is chosen, such is the short-run unresponsiveness of energy demand to prices, that a tax or permit system will probably take several years to have an effect.

Time, however, is running out for the government if it is to fulfil its election pledge. To meet its target of a 20% reduction on the 1990 level of 158m tonnes of carbon, **emissions** will have to be cut by 35m tonnes from the levels projected for 2010 (see chart). Industry may be able to contribute a quarter of

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that amount if taxed heavily. But what of the rest?

The fastest growing source of CO2 **emissions** is traffic. As the Royal Commission on Environmental Pollution points out, transport accounts for the whole of the projected increase in CO2 **emissions** between 1970 and 2020, an increase of 39m tonnes of carbon. Two-thirds of the rise is accounted for by private cars.

Supposedly, the white paper on transport to be published next month will seek to restrict such growth. But Tony Blair was reported once again this week to be watering down the politically unpalatable measures that would be needed. This, plus the cut in VAT on domestic fuel and this week's deal to help the coal industry suggest that ministers do not have the stomach for a fight, even one of their own choosing.

GRAPHIC: chart

LANGUAGE: ENGLISH

LOAD-DATE: July 2, 1998



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APPENDIX I

MEMBER STATES	COMMITMENTS IN ACCORDANCE WITH ARTICLE 4 OF THE KYOTO PROTOCOL	PREVIOUS 3 ^{gas} ALLOCATION
BELGIUM	- 7.5%	-10%
DENMARK	-21%	-25%
GERMANY	-21%	-25%
GREECE	+25%	+30%
SPAIN	+15%	+17%
FRANCE	0%	0%
IRELAND	+13%	+15%
ITALY	- 6.5%	-7%
LUXEMBOURG	-28%	-30%
NETHERLANDS	- 6%	-10%
AUSTRIA	-13%	-25%
PORTUGAL	+27%	+40%
FINLAND	0%	0%
SWEDEN	+ 4%	+5%
UNITED KINGDOM	-12.5%	-10%

MEMORANDUM

DATE: 9/30/97

RE: The effects of aggressive targets and timetables on the U.S. and Western Europe

Aggressive reductions in carbon emissions have substantial economic costs to both the U.S. and Western Europe, and the costs appear to be greater for the Europeans. Western Europe uses less energy per capita and per GDP than the U.S., and has fewer opportunities to make substantial cuts in carbon emissions. Under aggressive emissions paths, GDP losses would be greater in Europe, and both the U.S. and Europe would experience welfare losses in excess of a trillion dollars over the next half century. The U.S. would bear permit prices between \$100 and \$200, while Western Europe would bear permit prices nearly double those. These economic losses for Europe presume an EU bubble -- without a bubble and EU trading, they would be greater. Full Annex I trading does lower the costs for both, as they purchase carbon permits from Russia, with transfers from the U.S. ranging between \$8 and \$16 billion in 2010 and increasing thereafter.

U.S. and European Energy Use

The United States uses nearly double the energy per capita and generates more than twice the carbon emissions per capita than Western Europe. This is largely the result of Western Europe's long history with substantially higher energy prices, which are presently about double the U.S. energy prices. Western Europe requires less energy in part because of its higher population density (yielding lower total transportation costs) and long-run adaptations to high energy prices. In spite of its natural advantages and its long history of high energy prices, energy per dollar of GDP is only 44% lower in Europe than in the United States. Since the Europeans already use less energy, and are more reliant on non-carbon energy (e.g., nuclear) than the U.S., opportunities for reducing carbon emissions are more limited for Western Europe than for the U.S.

Descriptions of Aggressive Paths

To assess the relative impacts to the U.S. and Western Europe of aggressive climate policies, we analyzed the results of SGM model runs on two targets and timetables:

- 1) 1990 in 2010, and
- 2) -10% of 1990 in 2010.

For both, we review runs with and without Annex I trading. Note that all runs assume that Eastern Europe and the Former Soviet Union can sell paper tons in Annex I trading. Further, SGM models Western Europe as one region, essentially analogous to the EU bubble proposal (although this region includes four non-EU bubble participants). The SGM model projects that both U.S. and Western Europe will experience emissions growth such that, in business as usual, they are 28% above their 1990 emissions levels in 2010. However, more recent projections by the Energy Information Administration indicate that the U.S. will still be about 28% above 1990 levels in 2010, but Western Europe will likely be only about 18% above.

GDP and Consumption Losses Under Aggressive Paths

An aggressive path would lead to a substantial departure from business as usual emissions growth. This constraint on the energy use in the economy can lead to negative economic impacts. The following chart indicates that the GDP losses in 2010 to both the U.S. and Western Europe are significant, but are larger in Europe. These are absolute differences from their BAU GDP level -- as a percentage of their GDP, the losses in Europe are even greater than the U.S. losses.

1. 2010 GDP Losses Relative to BAU for U.S. and Western Europe

	BAU GDP	1990 in 2010, No Trading	1990 in 2010, Annex I Trading	-10% in 2010, No Trading	10% in 2010, Annex I Trading
Western Europe	\$6,942 billion	\$81 billion	\$24 billion	\$151 billion	\$52 billion
U.S.	\$9,185 billion	\$20 billion	\$13 billion	\$36 billion	\$30 billion

The present discounted value of foregone consumption provides a welfare measure for the impact of climate policy on both the U.S. and Western Europe.¹ In the 1990 in 2010 scenarios, Western Europe bears consumption losses 25% greater than the U.S. without trade and 30% more with trade. However, Western Europe bears substantially more consumption losses under the -10% case without trade -- summing to more than \$7 trillion, Western Europe's losses are 560% greater than the losses borne by the U.S. With trade, Western Europe's losses are much lower, but still 12% greater than those in the U.S.

Permit Prices Under Aggressive Paths

The large losses in GDP and consumption reflect a significant premature turning over of the capital stock stimulated by high carbon permit prices. The following table illustrates that Western Europe has higher marginal costs of abatement reflected in the permit prices. Also note that both Western Europe and the U.S. would face lower permit prices under Annex I trading and would thus be net buyers of permits.

2. Permit Prices in 2010

	1990 in 2010, No Trading	1990 in 2010, Annex I Trading	-10% in 2010, No Trading	-10% in 2010, Annex I Trading
Western Europe	\$160/ton	\$42/ton	\$354/ton	\$91/ton
U.S.	\$110/ton	\$42/ton	\$175/ton	\$91/ton

¹ These calculations of the present discounted value of foregone consumption assume a time horizon of 2000-2050 and a 5% discount rate.

International Trading of Permits Under Aggressive Paths

Under Annex I trading, the U.S. and Western Europe would buy a substantial number of permits from Eastern Europe and the Former Soviet Union.

3. International Trade of Permits in 2010

	1990 in 2010, Annex I Trading	1990 in 2010, Annex I Trading	10% in 2010, Annex I Trading	10% in 2010, Annex I Trading
	MMTCE	Value of Trades	MMTCE	Value of Trades
Western Europe	-156	\$6.6 billion	-166	\$15.1 billion
U.S.	-202	\$8.5 billion	-180	\$16.4 billion

For
Ray Arnaudo

Labour's
Env. Think To K.

"It will not be easy. Vigorous measures are required in electricity supply, homes, businesses and transport."

TAKING A COOL LOOK

- policies to reduce UK carbon dioxide emissions by 20%.

Executive Summary

The Labour Government made an important commitment in its manifesto, to: "lead the fight against global warming, through ... a 20 per cent reduction in carbon dioxide emissions by the year 2010". This is significantly tougher than the previous Government target of a 10% reduction in all greenhouse gases.

This paper seeks to begin the debate about how the target should be achieved. It sets out how it is possible to cut CO₂ emissions by a fifth by the year 2010, using policies and measures which either already form part of Government policy, or which are clearly consistent with its aims.

It will not be easy. Vigorous measures are required in electricity supply, homes, businesses and trans-

port. In order to meet the target, the Government will have to deliver:

- a major programme of home energy efficiency funded by a levy on the monopoly energy distributors,
- priority for renewable energy and CHP in electricity planning,
- a shift in corporate taxation towards energy,
- tough standards for vehicle and appliance efficiency, and
- a package of transport measures to stabilise and reverse road traffic growth.

As well as helping to tackle the major challenge posed by climate change, these policies will have other positive effects - sustainable jobs in green industries, increased industrial competitiveness, reduced road congestion, warmer homes, less respiratory illness and improvements to the urban environment.

transportation - 97%

GA
JF
Jy

"The new Labour Government to provide international leadership on this issue. Its credibility depends upon having ambitious targets for emissions reduction and realistic policies to achieve them."

TAKING A COOL LOOK

INTRODUCTION

There is a scientific consensus that human activities are causing climate change and that the effects are potentially serious. This is now widely accepted as the major environmental challenge facing the international community. Developed countries have accepted that current plans to stabilise emissions at 1990 levels are inadequate. Proposals for more stringent targets will be on the table at the re-negotiation of the Framework Convention on Climate Change in Kyoto in December.

The new Labour Government seeks to provide international leadership on this issue. Its credibility depends upon having ambitious targets for emissions reduction and realistic policies to achieve them. The Government has a commitment to reducing United Kingdom emissions of the main greenhouse gas, carbon dioxide (CO₂) by 20% by the year 2010¹. This is significantly tougher than the previous Government's target of a 10% reduction over all greenhouse gases. Although the Labour manifesto and earlier policy documents contain policies which will clearly contribute to the target, there is no comprehensive strategy. This paper seeks to initiate a debate about that strategy, and to make a preliminary assessment of how what is now a Government target might be met.

THE BACKGROUND TO EMISSIONS ASSESSMENT

Energy supply and use is critical to carbon dioxide - contributing 92% to current emissions². Attention is therefore confined here to energy supply and use. Under the conventions of climate change negotiation, the baseline for the emissions is 1990.

Energy related CO₂ emissions in that year were 158.3 million tonnes of carbon (MtC), and therefore the target for 2010 is 126.6 MtC.

One of the most difficult questions in setting future CO₂ targets is to define the likely trend in emissions if the Government were to take no action. Government projections of CO₂ emissions are based on projections of energy use in Energy Paper 65 (EP65)³. Modelling energy futures is notoriously difficult. The energy model of the Department of Trade and Industry (DTI), which underpins the energy projections uses econometric projections based on past relationships between energy use, prices and economic growth. There is limited social or technological input to the projections. In the past this approach has yielded energy projections well above what have subsequently been observed, and therefore the method is controversial for long term emissions. EP65 addressed these problems to some extent by incorporating saturation of demand for some goods, but the projections for industry and transport are still higher than many commentators believe is warranted.

EP65 contains six projections with different assumptions about future energy prices and economic growth, but all assuming no further policy initiatives to reduce emissions. A common convention is to take the CL scenario (central economic growth of 2.35% and low energy prices) as the central assumption. Higher world prices currently look unlikely and would lead to lower energy use. For this reason, and because of the methodological problems outlined above, the CL projection emissions tend towards the high end of a plausible 'business as usual' range. The projection is therefore a conservative basis against which to test policies to achieve the 20% reduction target.

CO₂ emissions are projected to rise to 161.8 MtC in 2010 (see Table 1). The Government target for 2010 is therefore a 35.2 MtC (21.9%) reduction from projected 2010 levels.

These projections include policies in the previous Government's climate change programme in 1994. It is important in addressing the scope for emissions reduction

"The government is committed on environmental and economic grounds to phasing out nuclear power."

to avoid including these measures again, as this would be double counting. Notable areas in which the projections already assume significant action are:

- electricity supply, where there is a major shift to gas-fired generation and some increases in CHP and renewables, and
- transport fuel pricing, where the fuel excise tax escalator (5% real annually) is included.

TARGETS AND MEASURES FOR UK POLICY

From Table 1, it is clear that electricity supply, household, business and road transport energy use are all important sources of CO₂ emissions. The following analysis concentrates on policies in these sectors which could reduce emissions and contribute to the overall goal.

A. Electricity Supply

The government is committed on environmental and economic grounds to phasing out nuclear power¹. There is prima facie a risk that this will increase emissions. However, the baseline projection assumes nuclear capacity falls from the current 13 GW to 7 GW by 2010. This implies the closure of all Magnox reactors and two Advanced Gas-Cooled Reactors (AGRs). As this is consistent with policy, no emissions changes due to nuclear policy are included.

There is no new coal-fired capacity in the baseline projection and coal burn falls to 17 Mt in 2010. Oil burn remains broadly steady at 6 Mt. Most new capacity is gas-fired and the carbon intensity of electricity falls significantly (from 200 gC/kWh in 1990 to 110 gC/kWh in 2010). The scope for further displacement of coal and oil is

Table 1

UK Energy Related Carbon Dioxide Emissions Projections (EP65 CL)

End Use Sector	Emissions (in MtC) in year				
	1990	1995	2000	2005	2010
Domestic	41.7	40.2	36.6	38.4	36.5
Public and Commercial	23.0	21.3	20.2	22.9	22.5
Industry	48.0	42.9	44.2	48.9	47.6
Agriculture	1.6	1.4	1.2	1.3	1.2
Road transport	33.2	35.2	37.8	40.5	43.5
Other transport	5.0	4.9	5.0	5.3	5.5
Exports	1.0	1.1	1.1	1.1	1.2
Other	4.4	3.7	3.6	3.7	4.0
Total	158.3	150.7	149.7	162.1	161.8
of which...					
Electricity use	54.3	41.3	44.1	44.1	40.3

Existing Government guidance to local authorities implies that cost effective efficiency improvements of 30% are generally available in the UK housing stock⁹. This is corroborated by calculations from other agencies. To achieve this by 2010 will require a very large programme, but the corresponding social and economic benefits are also large¹⁰. Current programmes - the Home Energy Efficiency Scheme (HEES) and those of the Energy Saving Trust (EST) - are useful but far too small. Energy market liberalisation will not produce the necessary activity; market stimulation and intervention are required.

In new buildings, higher efficiency standards are needed. But, the longevity of the housing stock means that most savings will have to come from existing buildings. The scale of the investment required to achieve a 30% improvement is large. A variety of sources will be needed, including government, local authorities, the housing finance sector and householders. This will not occur spontaneously - a programme of incentives will be needed. These can only realistically be funded by the energy companies. One approach would be a small levy on monopoly distributors to finance programmes of a specialist agency such as the EST¹¹.

Not all efficiency benefits will be taken as energy use reductions. Some, especially in poorer households, will be taken as improved warmth. A 30% efficiency improvement will probably produce about a 20% energy saving¹². The reduction in CO₂ in 2010 is 5.8 MtC.

Priority policies are:

- expanded public programmes funded by a levy on gas and electricity distribution,
 - equalisation of VAT on energy saving materials, and
 - improved building efficiency standards.
- Other potentially important policy developments could include:
- use of windfall tax money and the environmental task force for insulation projects,
 - agreements with mortgage lenders to provide green mortgages, and
 - ensuring released council house sales receipts are used in high efficiency projects.

Target 4 - Improve Lighting and Appliance Efficiency

Labour policy⁴ gives support to both labelling and mandatory standards for household appliances. A combination of these is the key to transforming efficiency in the appliance market. For lighting, incentives to install efficient lights through utility funded programmes are more appropriate. Recent calculations show that cost effective reductions of 17% by 2010 could be achieved¹³, equivalent to savings of 10 TWh/year. The reduction in CO₂ in 2010 is 0.9 MtC.

Both labelling and standards are best undertaken at the European level. Labelling policies are increasingly well developed, but proposals for mandatory standards are restricted so far to refrigeration. Relevant policy measures are therefore to:

- support moves for mandatory standards on all major appliances, and
- require expanded utility-funded support for high efficiency lighting incentives.

C. Business Energy Use

Labour published no detailed policies for improving energy efficiency in the industrial and service sectors (except for CHP). However, Government policy is that "through the tax system, environmental pollution should be discouraged"¹⁴ and there is a general commitment to "a long term, gradual change in the way the economy is organised, to ensure that it.....discourages 'bads' such as pollution and resource use"⁴.

Target 5 - Improve Business Energy Efficiency

An effective approach will require a combination of policies. The knowledge that real energy prices will rise would provide a signal to businesses of the importance of energy efficiency. Recent research has estimated that a gradually introduced energy tax of \$9 per barrel (increasing prices by about 40%) would reduce emissions by 8

"Government policy is that 'through the tax system, environmental pollution should be discouraged and there is a general commitment to 'a long term, gradual change in the way the economy is organised, to ensure that it.....discourages 'bads' such as pollution and resource use'."

An energy tax linked to reductions in other business taxes (notably on labour) would improve the competitiveness of UK business as a whole."

MtC/year¹⁴. This is well within what is achievable by technical measures which are cost effective even at current prices. The effectiveness of a tax would depend on other measures. Support for investment, training, R&D, green technology and energy management would aid industry respond effectively. With this package of measures, there should be a reduction in CO₂ in 2010 of 8.0 MtC.

An energy tax linked to reductions in other business taxes (notably on labour) would improve the competitiveness of UK business as a whole. But for energy intensive industries, which are the largest polluters, there could be problems unless other countries undertook similar policies. If energy taxes are judged undesirable in these sectors, an alternative would be negotiated agreements on phased emissions reduction. These should be linked to assessments of cost effective potential savings from the Best Practice Programme (BPP). In addition, the option of trading emission allowances would improve the scope for cost effective action. Policies to be considered should include:

- a phased business energy tax,
- support for green technologies and energy management,
- negotiated agreements linked to the BPP
- emissions targets and low energy purchasing policies for all public sector bodies.

D. The Transport Sector

Transport has the highest projected emissions growth of any sector. Road transport is particularly important. Some fiscal measures are already in place - the policy of a 5% annual increase in excise duty is already included in the baseline projection. Government policies contain no additional commitments on fuel taxes and reject explicit measures to limit car ownership, so these are not considered here. Increasing diesel use is undesirable for other environmental reasons.

Target 6 - Improve Vehicle Efficiency

In the baseline projection emissions grow at broadly the same rate (1.5% pa) over

the period 2000-2010 as the lower (more plausible) end of traffic growth forecasts. The implication is that vehicle efficiency changes little, consistent with trends from the recent past.

The Government has a commitment to "efficient and clean cars....with substantially reduced emission levels" and there will be a review of vehicle excise duty to that end¹. Labour is also committed to "introduce minimum fuel efficiency standards for all cars sold"⁴. This would clearly best be undertaken at the EU level.

The EU Environment Council has agreed, in principle, a standard of 120 g/km, equivalent to 5 litres per hundred kilometres (l/100km) for a petrol car, but with no fixed date. This could be made effective from 2005, as the European Parliament wants. Complementary measures would be early incentives for efficient vehicles through a differentiated vehicle excise tax and support for development of very high efficiency vehicles. Average fuel efficiency of cars in the United Kingdom should then fall to 6 litres/100km by 2010. Assuming that the existing level comes to 8.1 litres/100km¹⁵, this would result in a reduction in CO₂ in 2010 of 8.5 MtC.

Policies needed to achieve this goal are:

- early agreement of EU wide standards for 2005,
- fiscal incentives to discourage high consumption cars, and
- support for development of very high efficiency vehicles.

Target 7 - Reduce Road Traffic

Labour's transport policy notes the need to move beyond predict and provide, and to set targets for restraining growth in car use¹⁶. Car ownership in Britain is lower than that in most European countries, but annual mileage per vehicle is 20% higher than in Germany and the Netherlands¹⁷. A target of bringing vehicle use in line with these countries, i.e. reducing road transport annual mileage by 20%, by 2010 would have a big effect on emissions. Even taking into

"Appliance energy efficiency is critical in controlling domestic electricity use. The single market of the EU is again the most appropriate level for action. Mandatory standards are required to provide clarity and confidence for industry to invest in better models."

public opinion are opposed to any increase. The difficulty stems from the long-standing inefficiency of the UK housing stock. Rather than resisting energy tax reform, it would be worthwhile for the UK to support it, but with a derogation for UK households whilst housing inefficiency is tackled.

B. Vehicle Standards

Without tough efficiency standards, it is unlikely the UK target will be achieved. Given the nature of the industry, the EU is the appropriate level for this action. There is agreement on the need for a 120 g/km standard, but the previous Government (and some other states) resisted a 2005 start date. The new Government needs to take a strong stand. It should be a priority for the UK presidency of the Environment Council.

C. Appliance Standards

Appliance energy efficiency is critical in controlling domestic electricity use. The single market of the EU is again the most appropriate level for action. Mandatory standards are required to provide clarity and confidence for industry to invest in better models. This issue should receive a high priority under the UK presidency in the Energy Council.

D. Renewable Energy

The government should reverse UK policy and, at minimum, support the Commission Green Paper 12% target for 2010. Assuming the Commission produces a White Paper in 1997, a high priority for UK presidency of the Energy Council should be the corresponding action plan.

E. Demand Side Management

If single markets for electricity and gas

are to be created, it is important that there is a legal framework for energy efficiency responsibilities of energy suppliers and regulators. The proposed directive on rational planning techniques has faced opposition in Council, partly due to the inconsistency of the original draft with liberalisation. The UK Presidency of the Energy Council should build support for the amended draft.

Conclusions

It is possible to achieve a 20% reduction in UK CO₂ emissions by 2010 using policies and measures which either already form part of Government policy, or which are clearly consistent with its aims. However, it will not be easy. Significant policies and measures are required in electricity supply, homes, business and transport. The target is certainly unlikely to be achieved without all of the following:

- a major programme of home energy efficiency funded by a levy on the monopoly energy distributors
- priority for renewable energy and CHP in electricity planning,
- shifting corporate taxation towards energy,
- tough European standards for vehicle and appliance efficiency, and
- a package of transport measures to stabilise and reverse road traffic growth.

The bulk of the emissions reductions come from improving the efficiency of energy use. It is well established that these measures are cost effective, but are not currently adopted due to a variety of market barriers. The 20% reduction programme outlined would therefore not, as often imagined, be a burden on the economy. On the contrary, there would be many benefits:

- improved competitiveness of the economy,
- reductions in other pollution, with health and environmental benefits,
- lower fuel bills and warmer homes for many households,
- bigger markets for, and more jobs in, new green businesses, and
- reduced congestion on the roads.

"Critical decisions on energy and environment taken at the EU level need to be consistent with the goals of the UK and other member states."

account improved vehicle efficiency there would be a reduction in CO₂ in 2010 of 7.0 MtC.

The changes to transport policy needed to achieve this are too complex to describe in detail here, but broadly consist of:

- development of an efficient and integrated public transport system,
- measures to encouraging cycling and walking,
- severe restraint on car use in urban areas via parking restrictions, pedestrianisation, road pricing etc., and
- land use planning changes to limit longer term traffic growth.

E. Overall Results

The combined effect of the measures listed above is summarised in Table 2.

Emissions are reduced by 35.4 MtC from the baseline projection of 161.8 MtC in 2010 to 126.4 MtC. This is 31.9 MtC (20.2%) below the 1990 value.

EUROPEAN POLICIES

Whilst much can be achieved by the UK acting alone, many of the policies need, or would benefit from, some co-operation with other countries, especially our EU partners. Critical decisions on energy and environment taken at the EU level need to be consistent with the goals of the UK and other member states. Important areas of EU policies in achieving domestic targets are:

A. Energy Taxation

Shifting the balance of business taxation towards energy is consistent with the Commission proposal to introduce harmonised minimum excise duties on fuels, which the Conservative Government opposed. A European approach is preferable because it would minimise the problem of competitiveness for energy intensive sectors. The problem for any UK Government is household energy taxation, where policy and

Table 2
Summary of Measures

Measure	CO2 Reduction in 2010	Contribution to Target (%)
VAT reduction	-0.3	-1
10% renewable electricity	3.5	10
10GW of CHP	2.0	6
Home energy efficiency	5.8	16
Improved lights and appliances	0.9	3
Business energy efficiency	8.0	23
Increased road vehicle efficiency	8.5	24
Reduced road traffic	7.0	20
Total	35.4	101

"...a substantial expansion of renewable energy is crucial. Increased support for research and technology is required for potentially important technologies which are not yet commercial, in particular solar electricity."

therefore limited. The targets outlined below for new supply are assumed to be met half by displacing new gas-fired capacity and half by reducing use of existing coal or oil plant."

Target 1 - Increase Renewable Energy Generation to 10% by 2010

This is an explicit target from the Labour Party environment policy document 'In Trust for Tomorrow'. In the baseline projection, this would require generation of 38 TWh/year by 2010. This is well within estimates of what is technically possible at prices below 4 p/kWh, largely from hydropower, wind, wastes and energy crops⁴. Baseline projections include only 20 TWh from renewables, so the policy related increase is 18 TWh. This gives a reduction in CO₂ in 2010 of 3.5 MtC.

Achieving this target will require continued support by subsidy or supplier obligation within the liberalised electricity market. In addition, to avoid conflict within the land use planning system, better guidance to and partnership with local planning authorities is needed.

In the longer term, a substantial expansion of renewable energy supply is crucial. Increased support for research and development is required for potentially important technologies which are not yet commercial, in particular solar electricity.

Measures required include:

- continuation of the Non-Fossil Fuel Obligation (NFFO),
- reform of renewables support to allow for new electricity market structures,
- consultation on targets and planning guidance for local authority Structure Plans,
- redirection of Government energy R&D funding towards renewable energy.

Target 2 - Increase Combined Heat and Power (CHP) Capacity to 10GW by 2010

This is also an explicit target from 'In Trust for Tomorrow'. Assuming an

average load factor of 40% (current average is 44%⁷), CHP would then generate 35 TWh/year. The baseline projection for construction of new gas-fired power stations in the period 2000-2010 is 13 GW, so there is no doubt that this CHP capacity can be accommodated by the electricity system. The baseline projection for CHP implies 18 TWh/year of generation, so the policy related increase is 17 TWh/year. It is assumed that the fuel burnt is gas with a marginal efficiency of 85% (with emissions of 60 gC/kWh). This gives a reduction in CO₂ in 2010 of 2.0 MtC.

CHP use is generally economic and will be assisted by market liberalisation. However, policy measures are required to address regulatory hurdles and to ensure the resource is properly considered in planning new electricity generation capacity.

Polices and measures required therefore include:

- regulatory reform so prices reflect the full benefits of small scale generation, and
- early planning guidance giving a strong presumption in favour of CHP.

B. Household Energy Use

Government policy includes a commitment to the reduction of VAT on domestic fuel from 8% to 5%¹. This will result in an increase in CO₂ emissions, but, because demand is price inelastic, the effect is rather small. Using the same elasticities as the DTI energy model⁴, it is estimated that the change above baseline in 2010 would be 0.2% of total emissions. The increase in CO₂ in 2010 is 0.3 MtC.

Target 3 - A Major Home Energy Efficiency Programme

Government policy promises "a major push to promote energy conservation - particularly by the promotion of home energy efficiency schemes"¹ and more detailed policy sets "a target for the domestic sector of a one million tonne reduction in carbon emissions every year"⁴.

From EU commission
Office in DC

Commission Staff Working Paper

Climate change - Analysis of proposed EU emission reduction objectives for Kyoto

Table of Contents

1. INTRODUCTION
2. THE GENERAL FRAMEWORK
3. TRANSPORT
 - 3.1 Background
 - 3.2 Reduction potential
 - 3.3 Costs
 - 3.4 Policy instruments
 - 3.5 Other measures
4. INDUSTRY
 - 4.1 Reduction potential
 - 4.2 Costs
 - 4.3 Policy instruments
5. ENERGY INDUSTRY
 - 5.1 Reduction potential
 - 5.2 Costs
 - 5.3 Policy instruments
6. DOMESTIC AND TERTIARY SECTORS
 - 6.1 Introduction
 - 6.2 Domestic and commercial sectors - appliances
 - 6.3 Buildings
7. POWER/HEAT PRODUCTION
 - 7.1 Introduction
 - 7.2 Thermal efficiency
 - 7.3 Fuel switching
 - 7.4 Co-generation
 - 7.5 Electricity and renewables
8. RENEWABLES
 - 8.1 Reduction potential
 - 8.2 Costs
 - 8.3 Policy instruments
9. CROSS SECTORAL POLICIES
 - 9.1 Removal of fossil fuel subsidies
 - 9.2 Taxation of Energy Products
 - 9.3 Research and Development EU-Policy
 - 9.4 CO2 emission trading in the EU
 - 9.5 Joint implementation
10. OTHER GREENHOUSE GASES
 - 10.1 Methane emissions
 - 10.2 Nitrous oxide emissions
 - 10.3 HFC, PFC and SF6 emissions
11. OVERALL ASSESSMENT OF REDUCTION TARGET
12. OVERALL ASSESSMENT OF COSTS

- 12.1 Introduction
- 12.2 Compliance costs
- 12.3 Macro-economic impacts
- 12.4 Distribution of costs
- 12.5 Environmental benefits
- 13. CONCLUSIONS

Annex: Analysis of Costs

Commission Staff Working Paper

Climate Change - Analysis of proposed EU emission reduction objectives for Kyoto

1. INTRODUCTION

1. On 3 March 1997 the EU Council of Environment Ministers adopted a negotiating position on climate change that, *inter alia*, established a quantified emission reduction objective for inclusion in the Community's protocol proposal to the UN Framework Convention on Climate Change (UNFCCC). This proposal sets a 15% reduction of emissions for three greenhouse gases (CO₂, CH₄, N₂O) by 2010, individually or jointly, compared to 1990 for all industrialised countries that are parties to the Convention. At the 19/20 June Environment Council Ministers also agreed to include in the EU's negotiating proposal an intermediate reduction objective of at least 7.5% for 2005. The EU commitment to reduce greenhouse gases is consistent with scientific findings pointing to a discernable human influence on climate and indicating that climate change could lead to adverse ecological and socio-economic impacts.
2. This Commission Staff Working Paper analyses the potential for achieving these proposed emission reductions for the EU economy by looking at five sectors, -transport, industry, domestic and tertiary and power/heat. This is done by first, examining the available technical potential which can be realized only with additional policy measures. This part of the technical potential is what remains after the so-called base-line or autonomous reduction in intensity has been estimated and deducted. Where available, these are specified for all sectors by using bottom-up approaches which identify the disaggregated economic costs of realising the remaining available technical potential. This technical potential takes into account existing energy-efficient technology and technology which can be ready for commercialisation during the given timespan of thirteen years.
3. Secondly, proposed policies and measures or those under development for realizing the given technical potentials are listed. Measures and policies that cut across all sectors, such as fiscal ones, are also evaluated. Finally, a comprehensive assessment is made of the overall cost of achieving the EU negotiating objective by using a number of bottom-up and top-down economic models developed by the Commission.

2. THE GENERAL FRAMEWORK

4. The EU's negotiating position on quantified reduction objectives includes three greenhouse gases carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) based on a weighted total, using global warming potential (GWP) with 100 year time horizon). The Council has agreed to add the fluorocarbon gases HFC, PFC and SF₆ to the existing basket of gases by the year 2000. By far the most important of the three gases in the basket is CO₂, responsible for approximately 80 % of the impact when the gases are weighted according to their so-called "global warming potential". CO₂ emissions are also the most difficult to reduce since, unlike other emissions arising from fossil fuel use such as NO_x and SO₂, there are as yet no end of pipe solutions for CO₂. Business-as-usual scenarios for CH₄ and N₂O indicate a likely reduction of emissions and the possibility even for a significant reduction. This implies that a cost-effective reduction of the overall emission of the three gases might include a higher reduction of CH₄ and N₂O emissions than 15 % and a lower reduction than 15 % for CO₂. However, because of the high

relative weight of CO₂ it will still be necessary to achieve a reduction of CO₂ above 10% in order to meet a 15 % overall target.

5. Analysis of climate change has, therefore, generally focused on CO₂. In May of this year, the Commission adopted a Communication on the energy dimension of climate change (COM(97) 196 final) on which the Energy Council adopted conclusions on the 27 May 1997. The Commission was invited to prepare an action programme in the field of energy and climate change for the post-Kyoto period and to develop initiatives for increasing the share of renewables; the application of combined Heat and Power and for the improvement of the efficiency of products and industrial processes.
6. Current estimates indicate that energy related CO₂ emissions of the EU-15 in 1990 amounted to around 3200 Mtonnes. If estimates of CH₄ and N₂O are taken into account the CO₂ equivalent of the basket of three gases is around 3900 Mtonnes in 1990. In the absence of new policies and measures to address climate change, emissions can be expected to increase. A number of studies and models on future CO₂ developments in the EU (pre-Kyoto scenario used in the Commission's Communication - *The Energy Dimension of Climate Change*¹, continuing Commission work on a Kyoto Advanced Technology Scenario using the PRIMES + POLES and GEM - E3 analysis² and work undertaken by the University of Utrecht for the Council Ad-Hoc Group) estimate that the increase in total EU CO₂ emissions on a business-as-usual (BAU) basis - no change in policies by 2010 compared to 1990 - could be of the order of 5 to 10%. This range reflects the different assumptions used in the models. For the analysis in this Communication the pre-Kyoto scenario is used which assumes an 8% increase in total CO₂ emissions by 2010 compared to 1990.
7. CH₄ emissions, however, may drop by around 13 % to 15% in 2010 compared to 1990 with current developments (BAU) according to a Commission Communication on methane³ whereas N₂O emissions might stabilise. Taking into account the global warming potential⁴ of these two gases, this would mean that on a BAU basis overall emissions of the three gases (in CO₂ equivalents) would increase by only 5% in 2010 compared to 1990.
8. A cost-effective strategy to reduce by 2010 the global warming potential of green house gases by 15 per cent compared to 1990 requires a multi-gas approach. There are indications that on average abatement costs for reducing CO₂-equivalent emissions from CH₄ and N₂O are lower than those for CO₂. If, for practical reasons, the focus of this Paper is on CO₂ it is because the volume of emission reductions achieved with respect to this gas is crucial to the success of a comprehensive climate policy. Assuming an 8 % increase in CO₂ emission by 2010 under the pre-Kyoto scenario, the EU will need to reduce its CO₂ emissions by around 740 Mtonnes by 2010 if it is to meet it's objective.
9. Table I shows, the pre-Kyoto projection in which energy related total CO₂ emissions increase by 8% from 1990 to 2010 and the sectoral distribution of this increase which will be used as the reference in discussing below each sector's emissions. The sectoral distribution in the table is made according to Eurostat categories. The transport sector includes all types of transport - rail, road, air and inland navigation; industry includes all branches with the exception of the energy sector; electricity and heat production covers all fossil fuel electricity production including auto-production by industry and cogeneration and district heating; the household/tertiary sector includes households, agriculture, small industry, commerce and administration etc and finally the energy industry covers internal

¹ Com (97)196 final of 14.5.97.

² P. Capros, E. Kokkolakis, L. Mantzos and P. Valette (1997) Evaluation of EU Policies and Measures for Kyoto Targets. May. NTUA/CEC, Athens/Brussels.

³ Strategy Paper for reducing methane emissions (COM(96) 577 final) of 15.11.96.

⁴ GWP of 11 for CH₄ 270 for N₂O for a 100 year time horizon is used (IPCC) Scientific Assessment Climate Change 1992. The Supplementary Report, CUP, Cambridge, UK).

energy use in mines and power stations and refineries. It should be noted that it is not possible to allocate the emissions in a precise sectoral basis, for instance a part of transport emissions, notably freight, could be attributed to other activities such as industry. It will be a task of the specialised services to strengthen and broaden this analysis, particularly in the light of the outcome of the Kyoto Conference in December. Following an analysis of CO₂ emissions in these sectors, possible reductions in other greenhouse gases, particularly CH₄ and N₂O, are then discussed.

Table I - Sectoral Distribution of energy-related CO₂ emissions - Mtonnes

Sector/year	1990	2010	% inc/dec
Transport	743	1032	+ 39%
Industry	626	532	- 15%
Energy Industry	141	158	+ 12%
Domestic/Tertiary	654	680	+ 4%
Electricity/Heat	1036	1057	+ 2%
Production			
Total emissions	3200	3459	+ 8%

Source: Pre-Kyoto scenario based on Eurostat data (Excludes international marine bunkers but includes international air transport)

3. TRANSPORT

3.1. Background

10. The transport sector which currently accounts for about 26% of total EU CO₂ emissions is expected to experience a further increase in CO₂ emissions by 2010. In the pre-Kyoto scenario, an increase of around 39% between 1990 and 2010 is predicted. This makes transport the fastest growing source of EU-wide increases in CO₂ predicted emissions over this period. The assumed 39 % increase in transport CO₂ emissions in the pre-Kyoto scenario by 2010 could be overestimated. There is evidence that before 2010 traffic growth will flatten out as traffic saturation approaches in a number of major European regions and this is not taken into account in the pre-Kyoto scenario.
11. The CO₂ growth trend for transport is mainly linked to the expected increase in traffic volumes, particularly in road and in air transport, which have a relatively high CO₂ emissions per unit of transport. In this situation, technical improvements, operational measures and a shift towards more energy-efficient transport modes, as well as transport demand management will be necessary. For measures addressing traffic volumes and the balance between different transport modes, there can be a significant potential for "win-win" for environment and for transport.
12. Transport is to a large extent a derived demand based on commuting and industrial practices, the development of the single market and growth in tourism. If no policy action is taken, the expected economic growth and other changes in those sectors will translate into a significant expansion of freight and passenger transport services and fuel use. This must be taken into account in assessing emissions from transport.

3.2. Reduction potential

energy efficiency and passenger cars

13. Passenger cars account for about half of transport-related CO₂ emissions, and a strong growth in CO₂ emissions from cars is forecast. The Community has set the objective of an average CO₂ emission figure for new cars of 120 g/km by 2005 and at the latest by 2010.
14. If an intermediate objective of 130 g/km CO₂ were to be reached by 2005 and the final objective of 120 g/km by 2010, a reduction of around 19% in the average CO₂ emissions of the passenger car fleet can be achieved by 2010 (situation in the pre-Kyoto scenario in 2010) with normal changes in the average vehicle fleet composition. This means that the increase in CO₂ emissions from the passenger car fleet between 1990 and 2010 could be limited to 12 to 13%.
15. Overall, and with the various assumptions which have been made above, it is estimated that the measures included above have a potential for reducing CO₂ emissions from transport in the EU by about 15% (155 Mtonnes) by 2010 over the pre-Kyoto scenario. This would mean that transport CO₂ emissions would increase by about 18% by 2010 (over 1990) instead of by 39%. In quantitative terms this means an increase in CO₂ emissions of 134 Mtonnes instead of 289 Mtonnes under the pre-Kyoto scenario - a saving of around 155 Mtonnes.

common transport policy

16. A shift towards a more energy efficient transport system could, if fully implemented lead to a significant reduction in the growth rate of CO₂ emissions from transport because the measures used generally aim at removing inefficiencies in the transport system. This is particularly true for a shift from road and air to rail or combined transport. The intensification of the current policy approach aimed at achieving sustainable mobility holds, therefore, significant potential for cutting transport CO₂ emissions.
17. The Commission believes that the above policies, especially from road transport to rail and combined transport are expected to reduce CO₂ emissions by around 5% in relation to the expected emissions in 2010 under the pre-Kyoto scenario.

3.3. Costs

18. As regards passenger cars, there is a significant fuel-efficiency improvement potential in which additional costs for those improvements are likely to be more than balanced by fuel savings. The first steps in this process are likely to be at negative costs since fuel savings will more than offset the investments required for increased efficiency. However, further fuel efficiency gains will require more engineering and could, therefore, be more costly. Overall, however, the 19% reduction in CO₂ is achievable at low costs since the fuel costs saving tend to outweigh the additional investment costs.⁵ This economic consideration needs to be reflected in the decisions on future fuel efficiency of cars.
19. The Common Transport Policy is developed for a number of policy reasons. These transport policies are aimed at improving the efficiency and accessibility of the transport system and are likely to have ancillary CO₂ benefits which are difficult to quantify. A swift implementation of the Common Transport Policy could have significant low cost benefits for reducing CO₂ emission from transport. This will also produce other benefit for society such as less congestion and noise, fewer accidents and a reduction in emissions of other gases.

3.4. Policy instruments

20. As regards emission reduction from passenger cars, one approach is to significantly increase the cost of car use through taxation measures but these would have to be

⁵ See: Capros et al. footnote 2 and Andrews, G., H. Kirby and M. Page (1996) Fuel consumption: Modelling Trends and the effects of technological change, Report to the Department of Transport for the Vehicle Market Model Project.

substantial to achieve the full exploitation of the economic potential. The full exploitation of the existing economic potential will only be achieved by specific policies to address the manufacturers and/or the market. This will need the full implementation of all the elements of the Community strategy, i.e. an effective and ambitious agreement with the automobile industry, fiscal measures and fuel-economy labeling.⁶

21. The Community has embarked on a number of policies in the context of the Common Transport Policy over the past few years which are expected to make a significant contribution to the reduction of CO₂ emissions.
 - **Revitalisation and liberalisation of the railway sector:** This policy has been pursued with a number of Council Directives⁷ which give increased managerial independence to railway undertakings, make an important step towards opening the railway market to competition and will improve the inter-operability of the European high-speed rail system. The Commission has set out the next steps in this effort with its *White Paper on a Strategy for Revitalising the Community's Railways* (COM(96) 421 final).
 - **Improved intermodality:** Special emphasis is put on rail transport and combined transport as an alternative to road and air transport, and on the interconnection of different modal networks. With its *Communication on Short Sea Shipping* (COM(95) 317 final), the Commission has launched an action programme to improve the potential of this sector. Further progress in developing combined transport for freight will be made through the development of European Rail Freight Freeways (COM(96) 421 final; COM(97) 242), and an action programme to improve intermodality as a mode-independent door-to-door service based on a variety of modal transport alternatives (COM(97) 243 final).
 - **Fair and efficient pricing:** Based on the Commission's *Green Paper on Fair and Efficient Pricing in Transport* (COM(95) 691 final), a debate has been launched on a better internalisation of the true costs, including environmental damage of transport in order to establish better patterns and future sustainability. Specifically for the reduction of CO₂ emission from cars, the Commission Communication (COM(95)689 final) discusses different options.

3.5. Other measures

22. There are also other measures which could make a significant contribution to constraining CO₂ emission growth in sectors within transport which are a major source of CO₂ emissions and/or exhibit strong growth in CO₂ emissions, i.e. urban transport, road freight transport and aviation. More specifically, integrated strategies including improved public transport, pricing instruments and other transport demand management measures in urban transport, and improved efficiency through better routing and logistics and higher loading rates in road haulage can deliver significant reductions in transport CO₂ emissions. In terms of European Support for RTD, the Commission has focussed efforts through the Task force - "The car for tomorrow". In aviation, energy efficiency improvements appear to be possible through technical and operational improvements if the appropriate incentives are given. The Commission is examining the implications of kerosene taxation for reducing CO₂ emissions from aviation and will report back to the Council in 1998.
23. In conclusion, the above analysis shows that a reduction potential of 155 Mtonnes, mainly coming from increased vehicle efficiency and modal shifts towards railways, combined transport and public transport which is not reflected in the pre-Kyoto scenario, is available.

Other measures, together with a likely flattening out of growth in traffic, could provide significant additional reduction potential, not all of this will be achieved and so only a

⁶ Commission Communication COM(95) 689 final; Council conclusions of 25.6.1996.
⁷ 91/440/EEC, 95/18/EC, 95/19/EC and 96/48/EC.

modest reduction potential (25 Mtonnes) is estimated. This gives an estimated overall reduction potential of 180 Mtonnes from transport.

4. INDUSTRY

4.1. Reduction potential

24. Industry accounted for 626 Mtonnes of CO₂ in 1990 in the pre-Kyoto scenario, derived from direct consumption of fossil fuels, plus a share of the emissions from the use of electricity and heat from the power sector. There are uncertainties in earmarking this last element so it is difficult to establish an accurate figure for total CO₂ emissions from this sector but, given that industry accounts for over a third of EU final energy consumption, for the purpose of this analysis total CO₂ emissions from industry are estimated to be around 1150 Mtonnes.
25. CO₂ emissions of heavy industry⁸ which in this sector is a large consumer of energy are estimated to be around 570 Mtonnes (1992)⁹. Average energy efficiency improvement rates of the industries vary across sectors and between Member States. Firms in this sector have a strong interest in energy efficiency improvements since it is a major way in which to improve their competitiveness. In spite of such continuous improvements, there are a number of studies that have identified considerable technical and economic potential for further energy efficiency improvements of between 15 to 23% based on the adoption of best-practice technologies that have been used in a number of Member States across the EU¹⁰. The best example here is the Netherlands where industry, in a number of sectors covering 90% of energy consumption, has agreed to Long-Term Agreements aimed at improving energy efficiency (reduction of energy consumption per tonne of product) by 20% over 10 years.
26. A stepping up of the rate of efficiency improvement to say 2% per annum by the adoption of such best practices, similar to those adopted in the Netherlands, may require some additional investment above normal replacement but these will often be recovered in the lifetime of the equipment through lower fuel costs. Bottom-up models based on technical economic potential, indicate that with annual efficiency improvements, reduction potential of 110 to 130 Mtonnes of CO₂ is available from heavy industry alone. These estimates probably cover the upper end of the range of emission reduction potential and a realistic assessment of the reduction potential for heavy industry would be around 80 Mtonnes of CO₂. When other industrial sectors such as cement, food production, textiles, transport equipment and engineering are included in the assessment, sectors which also have some reduction potential then a reduction potential of 100 Mtonnes of CO₂ for industry in general is not unreasonable.

4.2. Costs

27. Lifecycle analysis generally shows that the direct economic benefits of energy efficiency improvements using best technologies available in industry are often greater than the costs, i.e. the net CO₂ reduction costs are negative. This analysis is based on the assumption that there are no dramatic movements in energy prices either up or down.

⁸ This category includes the iron and steel, non-ferrous, chemical, building materials and pulp and paper industries.

⁹ Blok and Phylipsen - Common Policies and measures for greenhouse gas emission limitation and reduction; for Dublin Workshop, September 1996, Utrecht University, NL 1996

¹⁰ The reduction of specific energy consumption means the reduction of energy input per tonne of product

Further information is required on equipment costs if the least-cost technological potential is to be identified.

4.3. Policy Instruments

28. In order to achieve a reduction in emissions of 100 Mtonnes it would be necessary to have more effective policies. Industry is cautious about committing itself if the problems of "free riders" and carbon leakage - the move of industrial activities outside the EU - are not addressed. Action should be taken in co-operation with industry, in order to prevent such competitive distortions and could include:
- long-term Environmental and Energy Efficiency Agreements based on eg sectoral performance in the form of target values for products, market shares for efficient products, etc
 - the inclusion of energy efficiency among the basic obligations of industrial operators under Council Directive 96/61/EC on Integrated Pollution Prevention and Control (IPPC) and as an element in the definition of Best Available Techniques (BAT)
 - energy efficiency standards labelling and procurement guidelines for industrial and integrated processes/electric motors pump, fans compressors lighting and ventilation system and energy using components in industry. These are activities presently being carried out or being planned under the auspices of the SAVE programme.
 - the inclusion of energy, management, savings and choice in the eco-management and audit scheme (EMAS)
 - energy efficiency obligations in the new Large Combustion Plant Directive
 - mechanism for information sharing and monitoring
 - wide implementation of Demand Side Management (DSM)
 - RTD efforts and innovative policy initiatives to ensure cleaner and more efficient technologies in the market. The Fourth RTD Framework Programme (in particular JOULE THERMIE) and the Fifth RTD Framework Programme are expected to meet these issue
 - the promotion by governments and private enterprise of financial instruments such as third party financing contracts for industry
29. There is also a need for co-ordination of some of these initiatives at the international level in order to avoid competitiveness problems, particularly for those sectors which are the most energy and carbon intensive and are export oriented. For this reason a broad commitment by industrialised countries to common policies is required.

5. ENERGY INDUSTRY

5.1. Reduction potential

30. The energy industry (refineries and energy use in mines and power stations), which accounted for only 141 Mtonnes of CO₂ in 1990, provides energy for final end-use in industry, transport and the domestic tertiary sectors. The fossil fuel consumption and emissions are, in the main, related to refineries producing fuels for the transport sector. To the extent that emissions are reduced in the transport sector through greater fuel efficiency and less fuel is needed from refineries, there would be a positive impact on emissions

from the energy sector. Moreover, If there were to be some rationalisation and adjustment in this sector which is suffering from over-capacity it is likely that the more inefficient and higher emitting plants will be the ones in line for rationalisation. Although it is not possible to quantify exactly the reduction potential of rationalisation and the use of Best Practice technologies, if one takes this factor into account together with reduced demand for motor fuel compared to BAU some analysts estimate that a reduction of around 20 Mtonnes of CO₂ could be achieved from this sector. This potential could, however, be less if further reductions in the sulphur content of oil products are factored in.

5.2. Costs

31. Detailed cost estimates on emission reducing measures in the refinery sector are difficult to obtain. Some of the measures such as eliminating flaring can be achieved with simple low cost measures. Other steps that require the use of more advanced technology in the form of improved manufacturing and separation processes that use less energy will require investments and could be more costly. It is also difficult to factor in the fact that cleaner fuels, for instance, lower sulphur levels, currently require more energy at the manufacturing stage in refineries.

5.3. Policy instruments

32. In the Netherlands, for example, oil companies have entered into a voluntary agreement ensuring that, between 1989 and 2000, there will be an improvement in the energy consumption per unit of output of fuels with year 2000 specifications as compared with the energy they would have needed back in 1989 in order to produce fuels with the same (year 2000) specifications. This agreed improvement amounts to a total of 10% for the whole of the period. This type of voluntary agreement could also be established in other Member States, particularly those where new investments are required in the short and medium term. Measures similar to those listed in section 4.3 dealing with industry could also be used to realise emission reductions from this sector.

6. DOMESTIC AND TERTIARY SECTORS

6.1. Introduction

33. This sector which covers the residential, commercial and public service sectors accounted in 1990 for approximately 650 Mtonnes of CO₂ emissions from direct fossil fuel inputs. This sector is also the largest consumer of electricity and so indirectly accounts for a large share of emissions from the power sector, estimated at 500 Mtonnes in 1990 for the purpose of this analysis. CO₂ emissions will continue to increase in this sector over the forecast period. As in the transport sector a number of studies indicate that significant reduction potentials exist with respect to domestic and tertiary sectors¹¹.

¹¹ Energy Efficient Office Technologies in Europe DG XVII 31/1/94.
the Megawatt power: The cost and potential of electrical efficiency Western Europe, (Energy Power in Greenhouse.) Krause, Olivier and Koomey
GEA studies 1993/95 on energy efficiency standards for domestic refrigerators, washing machines, driers and dishwashers (DG XVII).

6.2. Domestic and commercial sectors - appliances

6.2.1. Reduction potential

34. Household electrical appliances account for nearly 50% of residential electricity consumption which is equivalent to over 100 Mtonnes of CO₂. The most energy efficient equipment sold can often use 50% less energy than the average stock. In the commercial sector considerable potential exists for reducing energy use with respect to office equipment, lighting, heating and cooling. As regards commercial enterprises where energy is often not a major cost input, the scope for reduction is more limited. Nevertheless, there is considerable potential for energy saving through the use of more efficient equipment such as lighting, heating and cooling and electric motors¹². Although the analysis focuses on electrical appliances there is also scope for energy saving and emission reduction by the use of more efficient appliances for cooking, heating and wash-drying using primary energy such as gas.

6.2.2. Costs

35. The private financial return of more efficient appliances due to fuel saving is generally positive but the users are often insensitive to gains which are not directly perceptible and spread out over a long time into the future. In this context, it is necessary to act together with the manufacturers. The major difficulty here is that the perceived impact of such energy efficiency measures on appliance manufacturers' competitiveness is often much larger than the actual economic effect as is demonstrated by discussions on efficiency standards for refrigerators. The impact of such energy efficiency measures on the overall economy is generally positive.

6.2.3. Policy instruments

36. Energy efficiency standards and labeling schemes for appliances and equipment can play an important role in meeting the EU's CO₂ reduction objective but standards set so far do not fully exploit the reduction potential. The EU has already developed a mandatory energy efficiency labeling scheme which covers the principal "white goods", and has also developed mandatory standards for refrigerators/freezers in a directive and is now in the process of negotiating agreements on energy efficiency for a more extensive product range - TVs and VCRs, personal computers, washing machines, dryers etc. A dynamic set of efficiency standards has to be adapted for all the major energy consuming domestic and commercial appliances (refrigerators, washing machines, electric water heaters, electric motors etc.) The level of efficiency has to be based on the minimum of Life Cycle Cost (LCC) analysis and should be periodically reviewed to take into account technological progress. A combination of policies and measures, including standards, labeling, technology procurement and incentives is needed to transform the markets of such efficient products. This was successfully demonstrated by the experience in the USA. The potential for reduction in CO₂ from more efficient standards can be realised if more effective policy mechanisms are implemented such as

- establishment of dynamic efficiency standards/based on Life Cycle Cost analysis either through regulation or negotiated agreement
- technology procurement for energy-efficient products
- favourable legislative framework for utilities to carry out demand-side management programmes as foreseen by the proposed Rational Planning Techniques Directive
- information programmes and dissemination of best practice and best available technologies

¹² It is estimated that there is a 30 % efficiency potential since electric motors are used in most processes. More efficient motors have the potential to save around 15 Mtonnes of CO₂ (30 TWh) in the industrial sector and 20 Mtons of CO₂ in the tertiary sector by 2010. The overall reduction potential in this sector is difficult to estimate but could be of the order of 60 Mtonnes.

- additional RTD efforts focussing on renewable energy resources, especially windpower, biomass and hydropower as described in chapter 8.

37. Moreover, appropriate measures, including the alteration of fiscal instruments, will have to be considered in case the forthcoming deregulation of the electricity industry jeopardises an effective climate policy.

6.3. Buildings

6.3.1. Reduction potential

38. Energy use in the residential and commercial sectors, in particular for space heating and hot water, accounts for around 30% of all energy use in the Union. Energy use for space heating and water heating in residential housing and commercial buildings can be substantially reduced with state of the art techniques such as high efficiency windows, improved insulation, heat pumps and passive solar energy, thereby reducing emissions from this sector by at least 50%. In the KATren analysis, savings of around 41 Mtonnes of CO₂ are estimated as possible in the period up to 2010.

6.3.2. Costs

39. As regards improvements of energy efficiency in existing buildings such as through improved insulation, better regulated boilers, double glazing, the capital costs are more than offset by savings in fuel even with increases in comfort levels. Other improvements such as improved efficiency standards in new buildings and high performance boilers can be more costly but even these investments also have attractive pay back periods.

6.3.3. Policy instruments

40. However, given the low natural rate of turnover in the building stock, 1% per annum in the EU, new policy initiatives are required that could accelerate the process of improving energy efficiency in buildings through renovation schemes. Such energy efficiency improvements which on their own could in some cases prove costly could be done in the framework of general upgrading of building stock which aim at improving overall building standards which currently do not fully exploit the reduction potential. At Community level these could include

- implementation of SAVE Directive 93/76 EEC which requires Member States' programmes for the promotion and implementation of energy certification in buildings, individual metering of energy and hot water consumption, third party financing in the public sector, thermal insulation of new buildings, regular inspection of boilers larger than 15 kw. and energy audits in industry
- incentives for installation of cost effective energy equipment and material in buildings
- development of codes and standards in lighting, HVAC, hot-water heating and other important energy use in buildings
- developing links between land planning and the promotion of CHP
- financial/fiscal incentives.
- additional RTD actions
- promotion of energy service companies in building sector
- development of planning technologies for the promotion of CHP, district heating and other energy efficient and environmentally friendly heating and cooling systems.

41. In conclusion, studies show that a significant reduction potential exists for electricity use in the domestic and tertiary sector which amounts to around 180 Mtonnes of CO₂ emission reduction. There is also considerable potential in the building sector and in the direct use of fossil fuels by the domestic and tertiary sectors. If other end users, such as small and medium-sized industry, agriculture and the public sector, are included, the total reduction potential is well over 200 Mtonnes of CO₂. The whole of the reduction potential is unlikely to be fully exploited in the 2010 perspective but assuming only 50 % of the

potential is realised this would lead to at least a saving of 100 Mtonnes of CO₂. There are well documented studies that show that most energy saving measures are economically attractive at current energy prices (negative costs) and others are low cost. Policy instruments that could achieve a speedy improvement in energy efficiency need to focus on removing the barriers identified in these studies and on strengthening incentives. In this context there would also be scope for developing a comprehensive approach to promote sustainable consumption patterns. To facilitate such a reorientation of consumer behaviour and choice, it is necessary to promote consumer awareness and to provide them with appropriate education, reliable information and advice.

7. POWER/HEAT PRODUCTION

7.1. Introduction

42. CO₂ emissions from the electricity/power sector accounted for almost a third of EU CO₂ emissions in 1990. "In the pre-Kyoto scenario, growing electricity and heat demand gives rise to increasing CO₂ emissions from the power generation sector. However, CO₂ growth in this sector is smaller than the average growth of emissions of all sectors. This is due to fuel switching, improvements in the efficiency of electricity and heat generation and to some extent a decoupling of electricity and heat demand from GDP growth. Nevertheless, in 2010 electricity and heat production could still account for some 30% of total energy related CO₂ emissions. Although it is recognised that the EU negotiating position for Kyoto requires a significant contribution from power and heat generation, the increasing role of electricity for modern production and communication processes needs to be taken into account. Increasing electricity use can be compatible with overall CO₂ emission reduction to the extent that this helps decrease the material and energy intensity of economic activities eg electric arc steelmaking. If the EU reduction objective is to be achieved it is evident that this sector will have to make a significant contribution.
43. As indicated above in the sections on industry and the domestic/tertiary sector one of the most effective ways in which to reduce CO₂ emissions from the power sector is to reduce end-use electricity demand. The electricity industry can play an important role here by developing energy services and demand management options. In an increasingly competitive market, firms in this sector may find such options a profitable way of developing business. A major factor in the reduction of greenhouse gas emissions from the power sector will be the implications of competitive and liberalised energy markets in the Union.
44. Additional reductions of CO₂ emissions in this sector can also be achieved by actions on the supply side supporting, notably
- higher average thermal efficiencies in power generation
 - fuel switching leading to a lower level of carbon intensity in fuel inputs
 - co-generation of power and heat
 - greater use of renewables in electricity generation

7.2. Thermal efficiency

7.2.1. Reduction potential

45. Some of the potential arising from fuel switching, higher average thermal efficiencies and co-generation is already included in the pre-Kyoto scenario, which explains the expected low increase in CO₂ emissions from the power sector between 1990 to 2010. However, there still remains considerable technical reduction potential in this sector.

46. In a increasingly competitive and liberalised energy market there are pressures on the industry to reduce costs and maximise efficiency on the supply side which could bring benefits for reductions in CO₂. For the EU as a whole due to improvements in load efficiency and changes in the fuel mix (greater use of gas and an increasing penetration of combined cycle gas turbine (CCGT) production) the average thermal efficiency has been pushed up from around 36 % to 38 % between 1985 and 1994. This means that many power plants are currently operating at below 38% efficiency which is low compared to state of the art technologies.
47. In the pre-Kyoto scenario average thermal efficiency of fossil based power plants is expected to increase to over 41% by 2010. The substitution of old plants that have a low efficiency and high CO₂ emissions by new power plants with thermal efficiencies of around 50 % could significantly boost the average thermal efficiency of power plant in the EU even further. This has been the case in the UK which between 1990 and 1995 succeeded in achieving a much higher thermal efficiency and significantly reducing CO₂ emissions from power generation due to a switch to gas away from coal and with new efficient generating technologies such as CCGT plants and co-generation. An average thermal efficiency of 45% in the EU by 2010 is achievable and is estimated that this could save around 50 Mtonnes of CO₂¹³. This saving has to be seen in conjunction with the future development of co-generation in the EU which is analysed in section 7.4 below.

7.2.2. Costs

48. New power generation, depending on the availability of gas, is likely to be in the form of CCGT gas fired plants which have a capital cost per Kw of around half that of conventional plants. Achieving higher thermal efficiencies in existing plants through retrofitting or accelerating the retirement of less efficient fossil fired fuel power plants could be more costly. However, it should be noted that in the UK power producers have been able to reduce electricity prices to industrial customers over the last five years even though the industry has scrapped plant earlier than anticipated or invested to improve the efficiency of many existing coal-fired power plants. As well as benefits from reduced CO₂ emissions these developments have also brought other benefits in particular a reduction in acidifying pollutants.

7.2.3. Policy Instruments

49. The Commission should encourage in its dialogue with the industry, *inter alia*, the development and the introduction of the most efficient technologies so as to ensure that the level of thermal efficiency is substantially increased in the period to 2010. Negotiated agreements or other mechanisms need to be explored in the on-going dialogue with the electricity industry that would for instance aim at obtaining certain minimum levels of thermal efficiency by 2010. RTD efforts also need to be pursued taking into consideration both competitiveness and CO₂ emission reduction objectives.

7.3. Fuel switching

7.3.1. Reduction potential

50. Fuel switching in the power sector to lower carbon intensity fuels in the perspective of 2010 involves essentially switching from coal to gas. Nuclear produces about a third of the EU's electricity is not considered since major increases in nuclear capacity are not foreseen up to 2010. This situation will have to be reviewed in the post- 2010 period as existing nuclear power plants come due for replacement. Currently around two thirds of the fuel supply of thermal power stations comes from solid fuels with oil and gas accounting for around 15% and 17% respectively. According to the pre-Kyoto scenario the share of gas in this sector could increase to around 31% by 2010 particularly given the

¹³ OECD coal fired power generation-trends in the 1990s. - IEA coal research (IEAPER/33, April 1997).

framework of increasing competition in both the electricity and gas sectors in the EU which gives power generators the option to switch from coal to gas using in many cases gas fired combined cycle technology which has a much greater efficiency than existing conventional thermal power stations. A significant element of fuel switching is already incorporated into the pre-Kyoto scenario with the factoring in of an important element of co-generation, however, it is estimated that an additional reduction potential of 50 Mtonnes of CO₂ is available from this switch in conjunction with increased use of CHP in particular for district heating and increased use of gas in industrial sectors.

7.3.2. Costs

51. The switch to gas from other fossil fuels will in the main develop because the economies of increased gas use, particularly in power generation is more attractive. The availability of competitively priced gas in Europe in the near future taken together with liberalisation of gas systems is likely to produce a gas price that will ensure the growing role of gas in most new power system investments. The development of Trans European Networks (TEN's) for gas will be facilitated in certain Member States by the use of EU financial instruments.

7.3.3. Policy instruments

52. In order to help achieve an even greater penetration of gas the EU should develop the gas infrastructure in the EU through the TEN programmes and secure competition into the gas industry.

7.4. Cogeneration

7.4.1. Reduction potential

53. Co-generation - the production of both electricity and heat (CHP) - accounts for around 10% of EU electricity production, although in three Member States it is already around 30%. Combined cycle technology can produce electricity with an efficiency of about 55% and by using also the heat, efficiencies of up to 80% can be secured. In order to secure the full energy efficiency benefits, the starting point should be the heat demand so that the electricity becomes the by-product. If co-generation were to take a larger share of the EU electricity market, large savings in CO₂ would be possible. It has been estimated that if CHP achieved a 30% share up to 290 Mtonnes of CO₂ would be saved. Part of this reduction has been factored into the pre-Kyoto scenario but a substantial potential still remains to be developed if an EU average of 30% were to be achieved. Since this would probably be based on gas it would include some of the benefits from fuel switching mentioned above. However, even on a conservative estimate of an increase from 9% to 18% of co-generations share in electricity production by 2010, it would produce an additional saving of around 100 Mtonnes of CO₂.

7.4.2. Costs

54. For industrial cogeneration preliminary research indicates that for baseload power production and taking all costs into account a 75 MWe industrial CHP plant would produce electricity at a unit cost around 40% below the unit cost of a 500 MWe coal plant. The cost differential is smaller when comparing CHP with CCGT generating plant, but it is still in CHP's favour by about 10 % to 20 %. Overall, it is reasonable to assume that industrial co-generation is a low-cost option in reducing CO₂ emissions in a more liberalised market where prices reflect costs. Co-generation linked with district heating is

likely to be more expensive due to the investments required, although in this category decentralised systems are more economic than centralised systems.

7.4.3. Policy instruments

55. To date co-generation has not been able to make more rapid progress due to a number of technical and institutional barriers, particularly as regards tariffs. It is essential, therefore, that in developing the regulatory regime for a more liberalised and competitive electricity market fair rules encouraging co-generation are developed.¹⁴ A Communication from the Commission on a EU strategy to promote co-generation is now in the final stages of preparation. Some extended RTD efforts need to be developed for example in the JOULE-THERMIE Programme.

7.5. Electricity and renewables

7.5.1. Reduction potential

56. The Commission in its Green Paper - *Energy for the Future. Renewable Sources of Energy*¹⁵ has taken the view that the doubling of renewable energy sources from 6% to 12% by 2010 is a realistic objective. If through the more rapid penetration of windpower and biomass, which are now close to being competitive with electricity generation from fossil fuels, half of this increase in renewables (3%) was in electricity production then this would increase renewable production by around 90 TWH in 2010. If electricity production from renewables displaces the most inefficient plants, which are likely to be conventional coal fired power plants, the saving in CO₂ emissions could at least be 100 Mtonnes. In a longer perspective, renewables would, however, find it more difficult to compete with state of the art CCGT power plants.

7.5.2. Costs

57. Forecasts for costs of electricity from centralised and decentralised renewable energy technologies show that wind, small hydro and biomass, including waste, are competitive with conventional systems¹⁶. The rapid development of renewable energy technologies and the prospect for further cost reduction, so that they can compete even with electricity production from CCGT power plants, will ensure that the cost of support measures, if required, will be small if they are well designed.

7.5.3. Policy instruments

58. The penetration of competitive or near competitive renewables into the energy sector depends a great deal on the development of Community instruments. This is possible through the use of instruments such as carbon taxes, emission trading integrated resource planning and demand side management mechanisms and negotiated agreements¹⁷. This option can be expected to lead to significant cost savings and are in line with electricity market liberalisation since they give the sector the choice to pick the most cost-effective set of measures. These options should also ensure that the emission reduction objectives are met if appropriate monitoring and enforcement mechanisms are set up. The potential applicability and positive cost/benefit analysis of small-scale heat and power production from biomass should also be encouraged through Community instruments. European RTD efforts are already linked to these issues but should be reinforced.

¹⁴ An assessment of the impact of liberalisation of the European Electricity and Gas Market on Cogeneration, Energy Efficiency and the Environment. Cogen Europe, December 1996
¹⁵ COM(96) 576 of 20 November 1996

¹⁶ The European Renewable Energy Study II - Prospects for Renewable Energy in 30 European countries 1995-2020 - DG XVII, 1996.

¹⁷ The Commission has proposed a Directive related to Integrated Resources Planning

59. In conclusion, the analysis shows that power generating industry has a reduction potential of at least 300 Mtonnes of CO₂ which can be achieved at low cost. However, the realisation of this potential is highly dependent on policies, in particular the progressive liberalisation of the electricity and gas systems.

8. RENEWABLES

8.1. Reduction potential

60. Renewable energy resources which currently only play a small role in the EU's energy system have the potential to make a significant contribution to reducing the Community's CO₂ emissions since they use energy resources that release relatively little carbon in net terms. The stocks of some renewables, such as forests and forest products, can also act as carbon sinks if they increase. The Community has a forest strategy which includes measures to enlarge the forest area and vitalise forests thereby enhancing their ability to assimilate CO₂. Some indication has been given above of the contribution renewables could make to reducing emissions from the electricity sector. Renewables can also make an important contribution to other Community goals such as regional development and employment since most renewables are by definition local energies, they are often more labour intensive than technologies based on conventional technologies and many less developed regions in the Community have considerable potential for the development of renewables.
61. Some of these renewable energies, such as hydro, biomass and wind, are already well-developed in some of the Member States. Hydropower and biomass currently account for 96% of renewable energy production. However, in spite of the development of appropriate and well-developed technologies that in some areas are cost-competitive, (for instance, wind and biomass for electricity, solar energy for water heating), the current share of renewable energies in the Community's total primary energy consumption is only around 6% due in the main to the existence of a number of market and structural barriers.
62. The Commission in its recent Green Paper on a strategy to increase the penetration of renewables in the Community market argues that their share of gross inland energy consumption can be doubled to 12% by 2010 if these barriers can be overcome and if, in some cases, assistance is given to kick-start these technologies. It is estimated that this doubling of renewables in the EU would represent a saving of around 200 Mtonnes of CO₂. If a Best Practices approach, as advocated in the TERES II report, was followed a reduction of 500 Mtonnes of CO₂ would be possible, albeit by 2020.

8.2. Costs

63. Cost estimates of renewable technologies vary widely due to different assumptions made in calculations and the form of final energy delivered by the renewable energy. Some renewable energies such as wind and biomass for electricity have made remarkable advances in reducing costs and are now competitive with conventional power production. Other renewables such as photovoltaics or biomass for biofuels still have to make progress in becoming competitive and may not develop substantially before 2010, however, for small scale decentralized applications they may still be as cheap as conventional options. It is likely that even a substantial penetration of the most cost effective renewables by 2010, such as a doubling of their share in EU gross inland energy consumption, would entail some costs.

8.3. Policy Instruments

64. The Commission's Green paper on renewables has indicated that a doubling of the share of renewables in the EU (to 12%) will require the development of strong policies and

measures. A forthcoming White paper, planned for publication before the year-end, will set out the Commission's policy direction for the future development of renewables, together with a comprehensive and detailed action plan. Recent studies¹⁸ have identified numerous policy mechanisms that could be effective for promoting renewables in a liberalised internal energy market such as

- obligations for renewable energy
 - mechanisms for increasing payments for renewables such as the UK Non-Fossil Fuel Obligation (NFFO), renewable energy credits
 - uniform minimum buy back tariffs for renewable energy supplies
 - an increased focus of RTD programmes and resources on renewable energy technologies and particularly their rapid penetration
 - financial engineering to favour renewable energy.
65. In conclusion, section 7.5 on electricity and renewables has already identified that there is at least 100 Mtonnes of reduction potential available in this sector. Wider use of biomass in co-generation and passive solar heating could also make a significant contribution and overall for renewables a 200 Mtonnes of CO₂ reduction potential is estimated. Provided appropriate policies are pursued, the cost of some support measures is unlikely to be large.

9. CROSS SECTORAL POLICIES

9.1. Removal of fossil fuel subsidies

66. Reforming coal and electricity subsidies in the EU can have beneficial impacts for the environment as well the economy as a whole¹⁹. Although the impacts depend heavily on national circumstances A study estimated the decrease in CO₂ emission resulting from the removal of subsidies at 100 Mtonnes CO₂ in 2010. Such reforms some of which are now in place are expected to lead to positive overall economic effects, although there could be some adjustment costs for other sectors. Proposed EU action in this field could consist of ensuring that the measures in place to phase out subsidies that run counter to a cost-effective climate strategy and which create unfair competition are implemented and wherever possible the subsidies are phased out more quickly. In conclusion, removing energy subsidies has a potential for emission reductions. Some of this potential is already included in the reduction potential of the power sector and so to avoid double counting it is not included as a specific item in the overall assessment
67. The monetary equivalent of the subsidies to fossil fuels is estimated at around 9.7 bn Ecu (av 1990-1995) for Germany, UK, and Spain. This is equivalent to 0.1% of the EU's GDP in 2010. As regards the removal of subsidies from coal, account is not taken here of the reduction in methane emissions which could be significant as a result of the decline in deep mined coal production.

9.2. Taxation of Energy Products

68. On 12 March 1997, the Commission adopted a proposal for a Council Directive restructuring the Community framework for the taxation of energy products (COM (97)30).

¹⁸ Renewable Energy Strategies for Europe, Vol II M. Grubb and R. Vigotti (RIIA- 1997)
Future support of renewable energy in the UK - options and merits C. Mitchell -Energy and Environment, Vol. 7, No.3 (1996)

¹⁹ Reforming Coal and Electricity Subsidies. Working Paper Z. Laurie Michaelis OECD July 1996.

The new proposal enlarges the scope of the Community minimum rate system beyond mineral oils - to cover all energy products, including mineral oils, natural gas and solid fuels and electricity. The main objective is to strengthen the internal market by eliminating distortions between different types of fuels. In addition, it encourages Member States to shift the burden of taxation away from employed labour and towards the use of natural resources which damage the environment.²⁰

69. Even though the proposal has internal market aspects as its driving force it also takes account of environmental policy objectives. Firstly, the expansion of the scope will widen the application of the Community taxation provisions to CO₂ emitting products from 40% to nearly 90%. Under the new proposal the Community minimum levels of taxation on mineral oils (agreed in 1992 and therefore in many cases substantially below the rates applied by Member States) are up-rated and minimum levels are introduced for other energy products than mineral oils. The proposed increases in minimum rates are spread out over a period of four years. In order not to harm the competitiveness of European firms, the proposal contains some mandatory and optional exemptions for energy intensive industries. However, all users (polluters) pay something since exemptions for energy intensive firms only apply to the amount of the tax that exceeds 1% of their sales value.
70. Secondly, the proposal supports Member States if they wish to pursue more ambitious environmental policies. Member States are free to apply taxes on CO₂ emission or other emissions, taxes on energy or excise duties in order to fulfill the minimum level of taxation. The proposal also enables Member States to use differential levels of taxation depending on the environmental quality of products. In addition Member States may also rebate some or all of the tax on electricity generated from renewable sources such as solar, wind, tidal and geothermal or apply exemptions and reductions for various forms of transport.
71. In conclusion the analysis suggests that the proposal will result in a reduction in CO₂ emissions by 0.5% to 1.7% from the year 2002 onwards compared to the pre-Kyoto scenario. The study that is consistent with the pre-Kyoto scenario points to a reduction - equivalent to - around 50 Mtonnes CO₂ in 2010.
72. Estimates on the macro-economic costs of the proposed Directive made by three separate models confirm that when the tax revenues are used in a budget neutral way to reduce employers non-wage costs, the proposal will have positive impacts on GDP and employment. For the EU as a whole, GDP is estimated to be 0.02% to 0.20% higher than without the proposal in the year 2005. Overall employment in the EU is expected to be 150.000 to 450.000 persons higher in the same period.
73. Previous studies on the 1992 tax proposal suggested that more significant reductions in CO₂ emissions of 9 to 10% (around 350 Mtonnes of CO₂), compared to the pre-Kyoto scenario, are indeed achievable and could have more significant positive impacts on employment (0.4 to 0.9%) and GDP (+0.14% to 1.0%) if the revenues are recycled and used to reduce social security contributions. Other options such as non-recycling, reducing VAT or income taxes could lead to a small decrease in GDP (-0.1 to -1.2%) and employment (-0.3 to 0.8%).

9.2.3. Policy instruments

²⁰ White Paper "Growth, Competitiveness, Employment", and more recently in the Commission's "Confidence Pact for Employment" (1995) and the fiscal strategy presented in October 1996 (COM(96)546 of 22.10.96) and endorsed by the European Council in Dublin in December 1996.

74. Approval of the proposal to the Council will have both positive effects on the EU climate policy and other policy objectives. Moreover, a further proposal to deal with the situation in 2002 and beyond will have to be made which could make a more significant contribution to the climate objective.

9.3. EU-Policy in the Field of Research and Technological Development (RTD)

9.3.1. Reduction potential

75. The EU RTD Framework programme, the overall EU RTD policy instruments, contributes substantially to other Community policies and in particular to the Environment policy. The provision of the scientific and technological bases needed to support sustainable development and environmental protection is mentioned among the major overall scientific and technological objectives of the Fourth Framework programme (1994-98). These objectives are spelled out in more detail across the different specific programmes through which the Framework programme is implemented, in particular in the programmes on Environment and climate, Non-nuclear energy (Joule-Thermie), Industrial and materials technologies, transport and agriculture (FAIR). In order to complement the expertise available within the Union, these objectives were also taken into account in the Copernicus Programme for research cooperation with Central and Eastern Europe and in the INCO-DC Programme for research cooperation with Developing Countries. The Framework Programme addresses especially the Climate Change issue at three levels.

76. In addition to the Framework RTD programme, two other programmes important in the area of realizing reduction potential are the five-year programmes SAVE II and ALTENER. These non-technological programmes are multi-sectoral, and are designed to promote the rational use of energy and renewable energy, respectively. The purpose of the programmes is to create an environment in which investments in energy efficiency and renewables will be accelerated and whereby they will be recognised as market opportunities. ALTENER is the only Community programme which focuses exclusively on renewable energy sources.

9.3.2. Costs

77. The Fourth Framework programme represents a maximum overall amount of 13.1 billions Ecu, of which Ecu 914 millions are allocated to research in Environment and climate, Ecu 1067 millions to Joule-Thermie, Ecu 1833 millions to Industrial and materials technologies and Ecu 263 millions to transport. SAVE II which runs until the end of 2000 has an indicative budget of 45 MEcu. ALTENER I which concludes at the end of 1997 has a budget of 43.5 MEcu.

9.3.3. Policy Instruments

78. This important contribution from the Fourth Framework programme will be confirmed and extended in the Fifth Framework programme (1998-2002) for which the Commission presented its proposal on 30.4.1997. An overall amount of Ecu 16.3 billions is proposed for three major themes and three horizontal actions. Climate change and other environment related issues are not only substantially covered under the first theme "Unlocking the resources of the living world and the ecosystem" but are also widely taken into account throughout the proposal, in particular under the key-action advanced energy systems and services of the third theme "Competitiveness and sustainable growth". The preservation of the environment is set out as one of the fundamental criteria for selection of priority research areas." SAVE I has for similar reasons been extended for an additional five years in the form of SAVE II after evaluations showed that this relatively small programme in terms of overall budget has had an important effect on general energy policy implementation by Member States. This effect has been the result of directives and of capacity building at national and regional level related to energy efficiency, obtained through pilot projects, studies and network-building. ALTENER II has been proposed

with a budget of 30 MEcu for two years to renew ALTENER as it has been shown to play an important role in promoting renewable energy sources in the Community.

9.4 CO₂ emission trading in the EU

79. The analysis has shown that the EU reduction objective for 2010 can be achieved at a acceptable cost with sensible policies and measures. If marginal costs substantially differ then consideration could be given to implementing future CO₂ emissions targets by an emission trading mechanism. The feasibility of an EU wide CO₂ emission trading scheme has been documented in a number of studies²¹. Such a scheme within the EU could be implemented either between firms or between Member States; only emission trading between firms is considered here.
80. The potential cost savings could be significant, especially as policy targets become more stringent. Emission trading schemes within the EU would enable firms with high abatement costs to buy CO₂ abatement obligations from firms with lower marginal costs. By doing so the EU target could be achieved at lower overall cost than only through sectoral policy measures, supplementary to domestic reduction, and would be introduced in sectors in which no policies and measures are foreseen.
81. A EU bubble for various sectors within which individual firms would trade would have to be limited to sectors with a small number of companies to keep transaction costs low. If the scheme were limited to power/heat generation and heavy industry within EU it could cover approximately 50% of current CO₂ emissions in the EU.
82. There are also questions which need to be resolved related to the method of allocating initial quotas and the implications for the EU internal target sharing differentiation and to the monitoring and enforcement of compliance. Furthermore, we need to bear in mind how an EU emission trading system could be combined with an eventual international emission trading system or a Joint Implementation scheme.

9.5. Joint implementation

83. The European Union Proposal for a Protocol contains a provision for Joint Implementation (JI). This would allow industrialised country parties, in order to contribute to implementing their reduction objective, to undertake concrete projects with each other and with other parties which have made a notification of their intention to be bound by commitments on emission limitation and reduction objectives. This means that one party can take over part of the emission reduction obligation of another party. The EU proposal sees JI only covering a modest part of the commitments made by industrial countries.
84. JI projects offer the possibility to achieve emission reductions at lower costs through investing in emissions mitigation measures in a country with lower marginal abatement costs²². A number of pilot projects are underway and some of the host countries are Associated countries, an example is the upgrading of the municipal heating system in the City of Decin in the Czech Republic through energy efficiency improvements and boiler conversion financed by Denmark and the U.S.A. The EU position is that JI projects should supplement domestic policies and measures which should provide the main contribution to the overall reduction target of a Party, and shall bring about real, measurable and long term environmental benefits related to the mitigation of climate

²¹ See, for instance, Heister, J. et al. (1992), The use of tradable emission permits for limiting CO₂ emissions, in European Economy, The economics of limiting CO₂ emissions, Special edition N°1 or Grubb, M. et al. (1997), Implementing the European CO₂ Commitment - A Joint Policy Proposal, Royal Institute of International Affairs, London, 2nd edition

²² See the conclusion of the Workshop "Differentiation, Joint Implementation and Tradable Permits" DG XII, Brussels 3-4 July 1997

change. They shall be assessed on a project basis and credits shall be allocated on an annual basis.

85. In carrying out JI projects a set of agreed rules have to be applied. Guide-lines need to be developed and agreed upon on matters such as calculating project baselines, incremental impact of a project on emission levels, and methods for monitoring and verification²³.
86. The potential contribution of JI depends on the differences in abatement costs between the EU and other Parties to the Convention. They also depend on the transaction costs: costs of finding partners, agreeing and obtaining approval. Recent work with the POLES model show that an additional reduction in 2010 of around 200 Mtonnes CO₂ in Associated Countries below the baseline would be cost-effective to achieve a 15% reduction in CO₂ emissions compared to 1990 jointly with the EU-15. This would reduce the costs by 40% from 30 bn down to 18 bn Ecu.
87. More significant reductions in costs could be feasible through JI with the CIS countries but would depend strongly on the assumed baseline.
88. In order to ensure transparency and verification of compliance with the Community reduction commitment a central monitoring of JI projects will be needed. The Commission suggests that this will be done through the existing monitoring mechanism and will propose, if necessary, an appropriate amendment to the Council Decision establishing a Monitoring Mechanism for CO₂ and other greenhouse gas emissions²⁴.
89. The rules for JI should be as clear and simple as possible so as to reduce transaction costs while still guaranteeing that the environmental objectives are met. This can be promoted by having clear and transparent rules for approving JI projects. JI can also be stimulated by allocating a ceiling for emissions up front to specific sectors and individual companies, as is the case in the USA emission trading program for sulphur dioxide, so as to reduce discussions on the baseline for emissions on a project by project basis.
90. A more developed JI mechanism could be of particular interest to the Associated countries since it could provide better access to financial resources that could help them to realise strategic objectives in the development of their infrastructures, especially in the electricity and transport sectors while at the same creating more flexibility for the EU in shaping its pre-accession aid.
91. A certain amount of the Community reduction commitment under the Protocol could be achieved through JI projects provided progress can be made in meeting the concerns mentioned above but this might constitute only a small part of the overall EU effort for 2010.

10. OTHER GREENHOUSE GASES

10.1. Methane emissions

10.1.1. Reduction potential

92. Methane is the second most important greenhouse gas in the EU basket. In 1990 agriculture accounted for 45 %, waste 32 % and energy 23 % of EU methane emissions. Calculations, referred to in the Commission's Communication on methane (COM (96)

²³ A Research Project on these issues "Accounting and accreditation of Activities Implemented and Jointly under the FCCC and Oslo Protocol" is currently being undertaken within the EC RTD Programme on environment and climate

²⁴ Council Decision 93/389/EEC

557), indicate that in 2010 compared to 1990 a reduction of methane emissions of up to 13% to 15% is feasible with current policies. A reduction of 40% over the same period is estimated to be the maximum technically feasible assuming that significant policy changes are made.

10.1.2. Costs

93. The costs of this extra 25% reduction of CH₄ (from around 15% to around 40%), equivalent to around 100 Mtonnes of CO₂, can be estimated at around 20 to 30 Ecu/tonne of CO₂ equivalent reduced which gives an annual cost of around 2bn Ecu to 3bn Ecu. However, this additional 25% (see COM(96) 557 final) methane reduction may allow CO₂ to be reduced by 12% instead of 15%. It should be noted that this additional 25% reduction assumes a 60% reduction of methane emissions in the waste sector and reductions of 34% in agriculture and energy. As far as agriculture is concerned, further analysis is required to ensure that only measures are pursued that are technically feasible, politically acceptable and consistent with other policy objectives. It is therefore uncertain, how much of the reduction potential of methane above 15 % will actually take place.

10.1.3. Policy instruments

94. Policy measures aiming at improved treatment of waste, methane recovery in new and existing landfills, best available recovery techniques in coal mines, minimising emissions in the production on-shore and off-shore of oil and natural gas and minimum leakage standards and more frequent control of gas pipelines need to be pursued. For agriculture, a better storage and treatment of animal manure is a promising option and there is a need for analysing how the Common Agriculture Policy (CAP) and Rural Development policies can assist such a development, for example, in the form of incentives or investment aid for covered manure storage combined with biogas utilisation, notably at larger intensive animal production units. Research into the possibilities for improved feeding of animals should also be encouraged in the Community's agricultural research programme.

10.2. Nitrous Oxide emissions

10.2.1. Reduction potential

95. Emissions of N₂O in 1990 amounted to 0.9 Mtonnes, equivalent to around 300 Mtonnes of CO₂.²⁵ Reductions in N₂O emissions from industry, in particular the nylon producing sector, which accounts for a third of total N₂O emissions can lead to a reduction of 30% in N₂O emissions in the year 2010.²⁶ N₂O emissions from energy use (power stations) will remain stable up to 2010 since most new power plants are likely to be gas fired and the lower N₂O emissions from such plants will more than offset the growth in electricity production. N₂O emissions from agriculture are estimated to fall due to reduced fertilizer use and this trend should be further assisted by enhancing the agri-environmental component of the CAP in the context of Agenda 2000. The reductions in these sectors will more than offset increases in N₂O from transport due to catalytic converters. Consequently, estimated reductions in N₂O could be between 70 to 95 Mtonnes of CO₂ (equivalent).

10.2.2. Costs

96. A 15 % reduction of N₂O (0.285 Mtonnes) could cost around 120 Ecu/ton of N₂O or 0.45 Ecu/ton of CO₂ equivalent, in total 0.03 bn Ecu.²⁷

²⁵ AEA Interim Report for the Commission on Emission Inventories

²⁶ First Synthesis report of Common Policies and Measures, Expert Group, 27th January 1997

²⁷ Cost Effectiveness of emission reducing measures for nitrous oxides in the Netherlands. D. Jager, K. Blok and M. Van Brummelen. Ecotys, Utrecht, May 1996

10.2.3. Policy Instruments

97. As regards emissions from industry, steps can be taken to ensure that agreements cover all producers. In agriculture, increased support should be given to environmentally friendly farming practices, such as best practice in fertiliser use. Intensified research in the energy sector to reduce N₂O emissions from fluidised bed combustion and improve catalytic technology is required.

10.3. HFC, PFC and SF₆ emissions

98. Information on these gases is more uncertain than on the previous gases. However, in the Community's negotiating position there is a commitment to develop policies and measures to reduce emissions of these gases. In the work of the ad hoc Council Group a reduction potential equivalent to 200 Mtonnes for CO₂ has been identified.

11. OVERALL ASSESSMENT OF REDUCTION TARGET

99. Table II gives estimates of the potential CO₂ emission reductions possibilities for the main sectors in the EU. It is estimated that there are CO₂ emission reduction possibilities of around 300 Mtonnes in the power sector, 180 Mtonnes in transport, 200 Mtonnes from the end user sectors and 100 Mtonnes from renewables. A larger reduction potential exists, but it may be more difficult to exploit in the 2010 time-scale. About 50 Mtonnes of this overall CO₂ reduction is expected to be achieved as a result of the acceptance of the Commission proposal for a Council Directive restructuring the Community framework for the taxation of energy products (COM (97)30). The quantities reflect the implementation of a series of policies and measures that have been referred to in this Working Paper. For each sub-sector the reduction that is achievable depends on the detailed formulation of the measures.

Table II - Estimates of possible potential CO₂ emission reductions (Mtonnes CO₂) per sector in EU

Sector	Emission Reduction Possibilities
Transport	180
of which	
- passenger car	100
- intermodal shift	50
- other measures	30
Industry	100
Energy Industry	20
Domestic/Tertiary	100
Renewables/Heat	100
Power generation	300
of which	
- fossil fuel switching	50
- cogeneration/ thermal efficiency	150
- renewables/electricity	100
TOTAL	800

12. OVERALL ASSESSMENT OF COSTS

12.1. Introduction

100. Research efforts into the costs of curbing climate change have intensified over the last years not only within EU but also in the USA, Japan, the OECD and in the framework of the UN/IPCC. This section reflects the state of play with respect to cost estimates (the Annex provides details).

12.2. Compliance costs

101. Compliance costs are the net direct costs incurred in the form of investments, fuel costs and savings and other operating expenses. Estimates suggest that these may range from around 15bn to around 35 bn Ecu/yr in 1990 prices (0.2 to 0.4% of GDP) for a 15% reduction in CO₂ emissions in 2010 compared to 1990. Adding the gases N₂O and CH₄ is not expected to drastically alter this picture²⁸. The large range mainly reflects different assumptions on the existence of zero costs options and on whether or not the EU target is met at minimum cost across all Member States and sectors.
102. The lower cost estimates in the existing studies all have in common that a large part of the reduction can be met at zero or low costs. Such options might be achieved through the introduction of the 5 liter car, extended use of CCGT power plants and cogeneration (with continued availability of gas at low prices) beyond the measures included in the base line and the cheapest tranches of wind and small scale hydro. The low case also presupposes that the EU target is met at least-cost across sectors and Member States. A 15 % uniform reduction of all three greenhouse gases within the EU may not be cost-effective. Costs might be lowered further if more significant reductions of methane and nitrous oxides than for CO₂ are implemented but additional analysis is required
103. The higher estimates assume that the zero cost options are to a large extent already implemented in the reference case, the EU target would not be allocated efficiently over the sectors and Member States or energy prices and GDP growth are unfavorable. Indeed, inefficient ways of allocating emissions reductions across measures and Member States might increase the costs.
104. There is always the possibility that both the higher and the lower estimates of these compliance costs might be overestimated rather than underestimated. Costs might be underestimated since the engineering based costs estimates do not include the so-called transaction costs (the costs of collecting information and implementation). Possible negative impacts on welfare caused by decreases in comfort (e.g. some diminished performance with a 5 liter car) and choices (e.g. resulting from demand management) are also not included.
105. On the other hand, these compliance costs may be overestimated since the cost estimates assume implementation of the measures only in the EU. Joint implementation of emissions reductions would be able to substantially reduce costs (by 10% to 50%). Costs may also be overestimated since they do not incorporate positive secondary effects resulting from the more rapid cost saving technological progress that might occur if energy efficiency and renewables options are implemented on a larger scale. Finally, the estimates may also tend to be too high since they ignore the use of horizontal market

²⁸ There are only small (around 0.1 bn Ecu) additional costs of reducing methane beyond current policy (0.16 m Ecu) since a 13 % to 15% reduction compared to 1990 is expected with current policies. A 15% reduction in nitrous oxides is expected to cost less than 0.1 bn ECU.

based instruments such as removal of subsidies and/or energy taxation which are likely to reduce emissions while at the same time improving overall economic efficiency.

106. As an overall conclusion, annual compliance costs of meeting the EU emission reduction objective are estimated to be between 15 and 35 bn Ecu. These costs might be lowered by lowering transaction costs, pursuing joint implementation, removing existing inefficiencies and reducing especially those greenhouse gases which can be reduced at low costs.

12.3. Macro-economic impacts

107. Evidence on the so called welfare costs, related to altered consumption patterns, is usually restricted to estimates on the impacts on macro-economic performance. EU wide studies suggest that significant reductions in CO₂ emissions could result in a variety of GDP effects ranging from small positive impacts of up to 1% of GDP to negative impacts on GDP of up to 1.5%. The above impacts are likely to be overestimated since the studies do not fully account for joint implementation, all technical options and technical progress. The macro-economics impacts on both GDP and employment can thus be positive or negative depending on the initial economic situation and on how tax revenues are used. The effects are always small in relation to the expected growth in GDP of 50% from 1990 to 2010 and should be viewed as redirecting economic development and growth towards sustainability.
108. Positive impacts mainly occur if the revenues of carbon/energy taxation (or the proceeds of auctioned tradable permits) are used to cut the indirect labor costs paid by employers. In case of high levels of unemployment positive impacts on GDP and employment can be expected. If tax revenues are not used to lower labour costs the economic impacts generally tend to be negative. Such model simulations do not usually consider the positive impact of budget consolidation on economic growth for cases where unsustainable trends in public finance prevail.

12.4. Distribution of costs

109. Although EU-wide compliance and welfare costs might be limited, the distribution of the costs across Member States and sectors is nevertheless an area of concern. Burden sharing schemes might imply an uneven distribution of compliance and welfare costs across Member States. Clearly, this will tend to affect the implementation and political feasibility of the proposed reductions.
110. The same applies to the sectoral distribution of costs. Even with cost-effective policies some economic sectors might still face losses which might not be fully compensated. For these sectors the situation can only be improved if other industrialized countries agree to make substantial efforts as well. If this is not the case pragmatic measures such as export subsidies may have to be taken to compensate for the loss of international competitiveness and the shift of relative prices.
111. Without comparable efforts in other developed countries the CO₂ reduction achieved in the EU might also be partially undone because production and carbon emissions could be shifted outside the EU (carbon leakage). For this reason, and because the EU contribution to the global problem is limited, coordinated action at a global level is essential to achieve the proposed reductions.

12.5. Environmental benefits

112. The costs estimates mentioned above neglect the positive economic impact from reduced damage due to air pollution. Preliminary values on the benefits due to CO₂ reductions range from 2 to 590 US \$/ton C. The estimate depends on the assumptions made on

discount rates, climate sensitivity, the reference point for the emissions and the weight attached to damage in developing countries. Accounting for all these factors suggests that the global benefits of a 15% reduction in CO₂ emissions in the EU would be between 0.3bn and 101 bn Ecu /yr. Such benefits include many factors such as ecosystem preservation whose value is still underestimated and difficult to assess²⁹. These benefits depend very much on the value attached (the discount rate) to future damage.

113. This estimate does not yet reflect the avoided damage costs (secondary benefits) due to the reduction in other pollutants. The strategy would reduce sulphur dioxide, nitrogen oxides sulphur and particulate emissions compared to current legislation by at least 15% to 25%. The associated benefits (mainly mortality and morbidity) can be estimated at 11bn to 32 bn Ecu (see Annex for details). In addition, the reduction in CO₂ emissions would also cut the annual compliance costs from the Commission's proposed acidification strategy by at least 4 bn Ecu each year.
114. The total benefits related to the reduction in greenhouse gases are difficult to express and quantify in monetary terms. Available estimates suggest that these benefits might range from 15 bn to 137 bn Ecu per year. This estimate taken together with the direct compliance costs would imply that the proposed emission reduction could on balance bring net benefits.

13. CONCLUSIONS

115. The feasibility of achieving the EU 15% reduction objective depends on the technical reduction potential, on whether this reduction potential can be secured without damaging effects on the economy and finally on the readiness of all the actors concerned in society, in particular governments, to take the relevant decisions to realise this potential. This Commission Staff Working Paper has shown that there is sufficient low cost reduction potential to enable the EU to achieve its 15% reduction objective for 2010 without major economic disruption. The analysis has identified in a number of sectors that there is more than enough reduction potential for CO₂ alone - around 800 Mtonnes- and this could be even more if the full reduction possibilities of other gases in the basket, such as methane, and the use of JI are taken into account.
116. The sectoral analysis has shown that in general the proposed 15% emission reduction can be achieved through low cost and in some cases negative cost policies and measures. The model analysis shows that annual compliance costs could lie between 15 bn and 35 bn Ecu which corresponds to around 0.2 and 0.4% in 2010 of GDP. This reduction cost can be put into perspective if one compares this range to the cost of subsidies given to the fossil fuel sector which averaged 10 bn Ecu in the period 1990-1995. If all environmental benefits are taken into account such as reduced damage from air pollution the 15% reduction objective of the EU could provide a positive benefit. The differences between the two cost assessments stems from the analytical framework used in each case. However, both approaches show that the proposed 15% emission reduction objective for 2010 can be achieved with manageable impact on the EU economy and could be positive when externalities are taken into account. Such a challenge is a no regret policy for sustainable development, already identified within the 5th Environment Programme and the 5th RTD Framework Programme.
117. This Paper has also set out a number of proposals for policies and measures that can be used to realise this emission reduction potential. Many of these policies and measures at Community level are fully developed proposals and are on the Council's table or in the pipeline. Others still need to be further refined. The actual combination of policies and

²⁹ R. Constanza et al "The value of the World's Ecosystems services and natural Capital. Nature Vol 387, 15 May

measures and their implementation at national and Community's level will of course, have an important bearing on the overall cost.

118. In conclusion, the Commission believe that there is a sufficient emission reduction possibilities available to meet the EU proposed 15% emission reduction for 2010 compared to 1990. The analysis has also shown that with sensible policies and measures and international co-operation, emissions can be reduced with manageable impact or even with benefit to the economy. However, such policies only make a significant contribution to the worldwide climate challenge if efforts are made jointly with other countries

1/10/97

Communication From the Commission

**To The Council, the European Parliament,
The Economic and Social Committee And
The Committee Of The Regions**

Climate Change - The EU Approach for Kyoto

1. Introduction

On 3 March 1997 the EU Environment Council adopted a negotiating position on climate change that, *inter alia*, established a quantified emission reduction objective for inclusion in the Community's protocol proposal to the UN Framework Convention on Climate Change (UNFCCC). This proposal sets a 15% reduction of emissions for three greenhouse gases carbon dioxide (CO₂), methane, (CH₄), and nitrous oxide (N₂O) by 2010, individually or jointly, compared to 1990 for all industrialised countries that are parties to the Convention. At the 19/20 June Environment Council, Ministers also agreed to include in the EU's negotiating proposal an intermediate reduction objective of at least 7.5% for 2005. The EU position covers an average reduction for a basket of three greenhouse gases. At this stage no decision has been taken on specific targets for the three gases.

The EU position in the negotiations has been widely debated both inside the EU and at the international level, particularly among other industrialized countries. Reactions have varied widely from positive recognition of an ambitious policy to over sceptical questioning of the technical, economic or political feasibility of the targets and in some cases outright opposition.

This Communication seeks to place the EU negotiating position in an overall context and is designed to show both that it is technically feasible and that within a sound policy framework it is economically manageable to arrive at a reduction of greenhouse gas emissions of 15% by the year 2010 despite the underlying upward trend. The targets were agreed because of their environmental necessity and on the basis of studies showing that the targets are technically and economically feasible using in the main currently available technologies and practices. These targets are based on the assumption that other industrialised countries will make comparable commitments. It is also recognized that implementing the targets will be politically challenging.

The EU negotiation position covers a basket of three greenhouse gases. By far the most important of these is CO₂, responsible for approximately 80 % of the impact when the gases are weighted according to their so-called "global warming potential". CO₂ emissions are also the most difficult to reduce since, unlike other emissions arising from fossil fuel use such as NO_x and SO₂, there are as yet no end of pipe solutions for CO₂. Business-as-usual scenarios for CH₄ and N₂O indicate a likely reduction of emissions and the possibility even for a significant reduction. This implies that a cost-effective reduction of the overall emission of the three gases might include a higher reduction of CH₄ and N₂O emissions than 15 % and a lower reduction than 15 % for CO₂. However, because of the high relative weight of CO₂ it will still be necessary to achieve a reduction of CO₂ above 10% in order to meet a 15 % overall target.

For these reasons the focus of this Communication is on CO₂ emission reductions. The special circumstances concerning the other two gases are dealt with in chapter 6.

A Commission Staff Working Paper prepared in parallel with this Communication sets out a fuller technical and economic justification underlying the EU negotiation position and explains in greater detail where the necessary reductions in greenhouse gas emission

are expected to take place, the likely economic impact of the measures and the possible instruments to implement the policies. This paper also outlines a number of EU proposals already on the table which, when adopted, will facilitate limitations and reductions in greenhouse gas emissions.

This Communication examines the 2010 EU negotiating position which has been the focus of international debate and is also more important in a long-term climate strategy. It is essential to bear in mind that the core of any strategy to protect the global climate aims at a significant switch from the long-term trend for greenhouse gases to increase globally to a significant decrease. This requires action now with the benefits spread over a longer time frame.

2. Why is action necessary now?

The First Conference of the Parties to the Framework Convention on Climate Change, held in Berlin in April 1995, decided to initiate negotiations on the necessary commitments for industrialized countries to limit and reduce greenhouse gas emissions in the years after 2000. The EU was always a strong supporter of the Berlin Mandate. The Second Assessment Report from the Inter-governmental Panel on Climate Change (IPCC), published early 1996, has confirmed the view, already held by the EU, that it is urgent to initiate the necessary changes in production and consumption patterns that will allow the long-term reduction of global greenhouse gas emissions necessary to meet the long term objective of the Climate Convention. The EU has recognised that failure to do so could have potentially damaging effects in the long-term since society needs to have a realistic timeframe for change to take place in an open and transparent way.

Whereas the negotiations on the Climate Convention in the early nineties were based on the precautionary principle (action may be needed even in the absence of the final proof of the damage), the Second Assessment Report goes a step further by acknowledging that the "balance of scientific evidence suggests that there is a discernible anthropogenic influence on the global climate". The global problems associated with climate change could have a substantial negative impact on global agricultural production and productivity, reduce biological diversity, lead to land loss and population displacement and increase a number of vector-borne diseases. The damages are likely to be proportionately more significant for the developing countries.

It is important to underline that the scientific evidence of climate change (including research reported in, or initiated after the second IPCC Second Assessment Report) indicates that unacceptable social, economic and ecological impacts could occur in the coming decades. This calls for a precautionary approach. Moreover, much of the expected negative impact of climate change is likely to occur in countries that have only marginally contributed to causing the problem and without the financial resources to compensate for any possible damage. If industrialised countries do not act now to mitigate climate change future generations will not only be confronted with the cost of climate change impacts but the economic costs associated with limiting emissions could be much greater since there will be less time to make the adjustment.

A particular reason to initiate early action on CO₂ emission reductions is the long lead time necessary before policy decisions show their full impact on the emissions. Many "traditional" environmental problems offer relatively fast end-of-pipeline solutions or modifications of existing technology: reducing SO₂ emissions, eliminating lead from gasoline or phasing out of CFC's. This is not the case for CO₂.

Since CO₂ emissions are inherently linked to use of fossil fuels (coal, oil, gas) and since no economical removal technology exists as yet, the only way to reduce CO₂ emissions is through modification of structures, processes, equipment and behaviour which directly or indirectly use fossil fuels. Because of the very long lifetime of investments in the transport and energy sector and because of the relatively long lifetime of many energy consuming goods (cars, refrigerators, etc.) a CO₂ emission strategy will need a much longer horizon for implementation than for most other environmental problems.

As chapter 7 explains, early action by industrialised countries is also a prerequisite for limiting the growth in greenhouse gas emissions from developing countries. The latter is a development that is expected to be increasingly important in coming years.

3. Possibilities to reduce CO₂ emissions.

All CO₂ emission reduction possibilities have a cost impact and the more society is prepared to pay, the greater the range of reduction possibilities. In this Communication, among the actions to reduce greenhouse gas emissions either through investments incorporating existing efficient technologies or the application of new technical approaches and practices, only those that can be expected to be politically acceptable are considered. In this context such reduction possibilities must not be excessively costly and should not have unacceptable social and distributional effects. These emission reduction possibilities have been the subject of numerous studies in recent years and how to realise this potential has been an essential part of the preparations within the EU for the negotiations of a climate protocol.

For the analysis of the reduction possibilities in the various sectors of the EU economy the pre-Kyoto scenario in Table I is used as a reference. It assumes an 8% increase in total CO₂ emissions by 2010 compared to 1990 provided no additional new measures are taken.

Table I - Sectoral Distribution of CO₂ emissions in EU - Mtonnes

Sector/year	1990	2010	% inc/dec
Transport	743	1032	+ 39%
Industry	626	532	- 15%
Energy Industry	141	158	+ 12%
Domestic/Tertiary	654	680	+ 4%
Electricity/Heat Production	1036	1057	+ 2%
Total emissions	3200	3459	+ 8%

Source: Pre-Kyoto scenario based on Eurostat data (Excludes international marine bunkers but includes international air transport)

Table I shows that it will be important to address the transport sector where the inherent tendency to continuous strong growth will pose a challenge for the achievement of any emission reduction target. Table I shows a 39 % increase in CO₂ emissions from transport between 1990 and 2010, much of which will come from road and air transport. In this context, it should be noted that because energy prices to end-users in the transport sector are generally higher than elsewhere in the economy, targeted action aimed at removing existing market failures and inefficiencies in transport is required to significantly cut emissions at low costs.

The Council has already adopted a CO₂ emission target which corresponds to an improvement in the average fuel economy of new cars in the market in the order of 30% by 2005, over today's average. Future fuel use is not fully taken into account at the moment of vehicle purchase. However, vehicle fuel economy can be improved at low cost with available technology. To this end, the Commission is currently discussing with the automobile industry the possibility of an effective and transparent environmental agreement in which the industry would commit itself to reducing the CO₂ emissions from cars. Other elements of the strategy are fiscal measures and fuel economy labelling to influence the vehicle market.

The uncompleted internal market in rail and the existing barriers to intermodal transport are other examples of transport inefficiencies whose removal would also imply low cost energy savings. The Commission has already proposed several measures to address these issues. For example, the liberalisation and revitalisation of the Community's railways is expected to bring down transport costs and enhance service quality in rail, thereby attracting traffic that currently goes by road. Similarly, the implementation of the action programme proposed by the Commission in its Communications on the Citizens' Network about Improving Public Transport and on Freight Intermodality should lead to a greater use being made of alternatives to road and air transport.

Finally, measures to improve transport pricing proposed by the Commission should enhance transport efficiency, both within and across modes.

Although it is clear that these policy approaches require significant adjustments in the transport system, their implementation would hold out the prospect of major environmental, transport and economic benefits. The Commission is establishing a report on a strategy for the reduction in the growth of CO₂ emissions from transport that will be adopted in the near future.

The industrial sector is characterized by very different energy intensity ratios and CO₂ emissions from one sub-sector to another. In general, the most energy intensive sectors, particularly those exposed to international competition, already pay close attention to energy efficiency for sound economic reasons, notably lower final energy prices of faced by international competitors. For other industrial sectors a number of market barriers together with the low world energy prices which have applied for more than 10 years have pushed the issue down the list of priorities. Even though direct industrial CO₂ emissions are becoming relatively less important in overall emissions there is evidence from several Member States that these can still be further reduced in most sectors. The Dutch experience of an approximately 2% annual increase in energy efficiency since

1990, achieved in the framework of negotiated agreements is particularly convincing in this context.

The role of the electricity sector in meeting the challenge of climate change is a key one. This is recognized by both the electricity supply industry, Member States' authorities and the Commission. The Commission's services have completed an in-depth review with Eurelectric and other stakeholders on electricity's contribution in achieving both sustainable development and greenhouse gas reductions. Developing energy services is recognised as fundamental to these objectives and this linked to improved supply technology, greater fuel switching and increased use of non-fossil fuels will lead to substantial reductions in emission levels.

Taken together reduction potential from the electricity sector reflects improved end-use efficiency thus reducing overall demand, and greater production efficiencies.

On the end-use side there are numerous ways to improve efficiencies, both in the industrial and in the domestic and tertiary sectors. Refrigerators, computers, TV's, washing machines, light bulbs are only a few examples where use of existing technology will allow the same level of service with much less energy consumption. Electric motors used extensively in industry can similarly be improved. The EU has already developed mandatory energy efficiency labeling scheme for the principal "white goods" and mandatory standards for refrigerators/freezers to improve efficiency. The Commission is now negotiating standards on a more extensive product range with the relevant industrial sectors.

Likewise on the supply side the overall thermal efficiency of existing fossil fuel power plants in the EU was around 38% in 1994 compared with new power plants that typically offer efficiencies of around or even above 50%. There is, therefore, some scope for reducing CO₂ emission through an accelerated closing of low efficiency old plants. Additional reductions will result from switching from coal to natural gas as planned in several Member States. Combined heat and power production could further add to the reduction possibilities. It is estimated that increasing co-generation's share of EU electricity production from the present level of 9 % to 18% in 2010 could save up to 150 Mtonnes of CO₂.

The Commission's believes that doubling the share of renewables in the EU energy consumption from the present 6% of overall energy consumption to 12% in 2010 while being a challenge to the electricity industry is a realistic target. Windpower and increased use of biomass in electricity generation are the most competitive uses of renewables. Without at least half of the increase in renewables taking place in the electricity sector the 12% is not likely to be met. The experience from Denmark where installed wind power capacity is coming close to 1000MW and accounts for around 5 % of electricity consumption is a convincing example that the Commission's objective is not unrealistic. A recent Commission Green Paper has underlined that the realisation of this potential will require strong measures such as access of renewables to grid systems, obligations for renewable energies, increased payments for renewables and financial engineering in favour of renewables. A forthcoming White paper will set out the Commission's policy

direction for the future development of renewables, together with a comprehensive and detailed action plan. Publication is planned by the end of this year.

Most of the possibilities for reduction in emissions contained in the Commission Staff Working Paper have, at least in a qualitative way, been accepted for a number of years. It is equally true that in certain areas technological development has increased the potential or brought down the cost of a number of technical solutions to a more acceptable cost range.

It is however disappointing that the use of most available climate friendly technology has been modest. Low energy prices and expectations of this continuing is an important factor in explaining this. The fact that up-front investment is more important than long term overall cost for both industry and private consumers is another part of the explanation. The result is that despite the cost of different measures varying considerably there already exists a large amount of "no-cost" or "low-cost" possibilities to reduce greenhouse gas emissions.

Conclusion

In conclusion, what part of this greenhouse gas emission technical reduction potential can be tapped depends on what levels of economic, social or political cost are deemed acceptable. Work carried out so far shows that it is possible to identify technical reduction possibilities for reducing CO₂ emissions of 800 Mtonnes. This would be sufficient to achieve a 15% reduction of CO₂ emissions by 2010 compared to 1990 instead of the 8% increase in this gas foreseen in the business-as-usual scenario in Table 1. When implemented with the right mix of cost-effective policies, this technically feasible reduction potential can become both economically manageable and political acceptable.

Table II gives estimates of the potential CO₂ emission reductions possibilities for the main sectors in the EU. It is estimated that there are CO₂ emission reduction possibilities of around 300 Mtonnes in the power sector, 180 Mtonnes in transport, 200 Mtonnes from the end user sectors and 100 Mtonnes from renewables. The Commission underlines that these reductions in CO₂ emissions will be a challenge for the political decision makers. The quantities reflect the implementation of a series of policies and measures similar to the ones suggested in the following chapter. For each sub-sector, the reduction that is achievable depends on the detailed formulation of the measures.

The Commission Staff Working Paper sets out in more detail the measures that will have to be taken to achieve these CO₂ emission reduction possibilities.

Table II - Estimates of possible potential CO₂ emission reductions (Mtonnes CO₂) per sector in EU

Sector	Emission Reduction Possibilities
Transport	180
of which	
- passenger car	100
- intermodal shift	50
- other measures	30
Industry	100
Energy Industry	20
Domestic/Tertiary	100
Renewables/Heat	100
Power generation	300
of which	
- fossil fuel switching	50
- cogeneration/ thermal efficiency	150
- renewables/electricity	100
TOTAL	800

4. Elements for a Climate Change Strategy

A successful climate strategy needs to be comprehensive, cost-effective, technically and politically feasible and avoid negative social or regional side effects from the policy necessary to implement it. This Communication does not aim at prescribing such a strategy in detail but, attempts to outline the possible elements for a successful strategy. The development of a full strategy will only be possible when the result of Kyoto is known.

Any EU strategy while being effective in meeting the interim targets also needs to initiate a process of technological and behavioral changes that curbs the growing greenhouse gas emissions and sets them on a sustainable path which will meet the requirement for continued reductions at and beyond 2010. That implies the need to address both the emission intensity of economic activities as well as the growth in demand for goods and services which trigger the increase in greenhouse gas emissions.

The choice of the right strategy with the right mixture of instruments is not only important from the technical or economic point of view, it is the core of the political challenge of making progress to protect the global climate. In the development of this strategy it will be necessary to ensure that the action is taken in the right way, ~ both to ensure a cost-effective strategy and to avoid negative social, equity or regional side effects from policy implementation.

The Commission is therefore convinced that a comprehensive strategy that brings all these elements together is a top priority. The Commission has already tabled a number of proposals including:

- the Communication - Energy Dimension of Climate Change¹ and the Council Conclusions on it in which the Council invites the Commission to come forward with an action programme in the energy sector to address climate change in the energy sector in the context of common and co-ordinated policy measures
- the extension of SAVE II to the year 2000 with a budget of 45 Mecu and a proposal for an ALTENER II programme
- a proposal for Rational Planning Techniques in the supply and demand cycle
- a Communication setting out a strategy for reducing CO₂ emissions from cars
- proposals, in the context of the Common transport policy, for the revitalisation and liberalisation of the railway sector and for European Rail Freight Freeways, in order to encourage the shift of freight from road to rail
- a proposal for a Council Directive to restructure the Community framework for the taxation of energy products (COM(97)30)
- a proposal for Fifth Framework Programme for RTD covering the period 1998 to 2002 for which an overall amount of 16.3 bn Ecu is proposed.

The Commission, however, is convinced that proposals on the table and in the pipeline are not sufficient to meet the targets proposed by the EU and depending on the outcome in Kyoto will make additional proposals that will reduce significantly CO₂, some of which are already listed in the working programme, to complete the strategy that will allow the EU to meet its post-Kyoto commitments. Additional proposals could be:

- a proposal aimed at significantly increasing the share of renewable energies in the EU's energy consumption by 2010 along the lines spelled out in the Commission's recent Green Paper
- a proposal to increase significantly by 2010 the share of cogeneration - the production of electricity and heat - in the EU's electricity production
- a series of actions regarding standardization, harmonisation and liability to promote intermodal freight transport
- revision of the Trans-Europe Network guidelines to integrate strategic environmental considerations

¹ Com (97) 196 final of 14.5.97

- proposals to significantly improve the overall thermal efficiency of power plants; increased penetration of co-generation would be a particular effective way to improve thermal efficiency.

In addition potential exists for developing a comprehensive approach to promote sustainable consumption patterns with a positive impact on climate policy goals. To facilitate such reorientation of consumer behaviour and choice, it is necessary to promote consumer awareness and to provide them with appropriate education, reliable information and advice.

A comprehensive strategy calls for the use of a broad range of **policy instruments**. Traditional regulatory measures will play a role in some cases (examples of regulation are, banning the use of HFC's for self chilling cans, higher efficiency standards for certain electrical equipment). However, in many areas more flexibility for economic sectors offers obvious advantages.

Economic incentives - positive as well as negative - are one way to secure a high level of flexibility and can often achieve an objective more rapidly and at a fraction of the cost of regulation.

In this context it is important to be aware that the use of *fiscal incentives* does not imply higher taxes overall. In areas already subject to taxation, incentives can be created through differentiation (as was done to promote lead-free gasoline). Switching the tax burden from labour to energy and carbon intensive production is a revenue-neutral possibility likely to reduce barriers and to increase the acceptance by the consumer of cost-effective technologies.

Some of the key challenges will be to identify and to implement policy measures that allow the exploitation of energy efficiency improvements in the existing stock of buildings and equipment. The social discount rate employed is the one used in public policy decisions. Private discount rates can of course be higher. For this reason measures are needed to bridge the gap between the social rate of return and the private rate of return used by business and commerce when they take their investment decisions.

There are also other *market based options* such as changes in the current structure of subsidies. The present trend for phasing out subsidies on energy products such as coal should be continued and accelerated where this brings benefits for emission reduction. At the same time using short-term and temporary subsidies to encourage renewables or clean technologies is an additional option available.

Negotiated agreements between public authorities and specific industrialized sectors. These offer, in principle, maximum flexibility for industry to act in a cost-effective way. The Commission has recently issued a Communication outlining the conditions under which Negotiated Agreements would be useful instruments.

Technical options used to achieve the EU emission reduction objectives up to 2010 are mainly based on existing technologies. The role of new technological research and development is limited for this time horizon. Additional efforts are needed to diminish the

cost of existing advanced technologies given that at present they are not always competitive.

Furthermore, *socio-economic research* is necessary, in order to understand better the barriers to the application of available technologies to realise emission reduction possibilities and organisational aspects of the integration of new technologies. The impacts of economic instruments both at the micro and sectoral levels and the condition for behavioural change (including consumption patterns) also need to be researched.

In relation to RTD, it is very important to underline the need for continued focused research that will assess the socio-economic and ecological impacts of climate change (especially at the regional level) and will develop the necessary technical solutions to reduce greenhouse gases beyond 2010 and to cope with possible adverse impacts. Such research efforts could also be an advantage for EU competitiveness and lead to improved opportunities for EU exporters of such technologies.

Above, many possibilities for reducing emissions in the EU have been identified. However, the implementation of measures to capture this potential and to reduce emissions, particularly above the normal rate of equipment replacement, is unlikely to take place in the absence of strong action. No one instrument will be sufficient for achieving the Community's emission target. It will require a combination of actions.

Any policy or strategy must, therefore ensure the broadest possible co-operation and acceptance of all stakeholders: governments, industry, trade unions and the public at large. Several sectors of society and several regions of Europe will have to cope with significant changes if an overall 15% reduction of greenhouse gas emissions in the EU is to be achieved over the next 13 years. Options that have a favourable benefit on employment and economic growth should be pursued.

While liberalization is generally conducive to higher efficiency it is less supportive of investments that pay off in the long-term rather than in the short-term. The globalization of capital markets have been followed by expectations from investors of rapid profits from invested capital. The profitability of the more cost-effective measures to reduce CO₂ emissions, however, often need longer periods to pay back the investment. This is a problem that will have to be addressed politically as part of the implementation of any future strategy. Investors need the certainty of a firm commitment to reductions to persuade them to invest in cost-effective efficient measures.

Policies to break the growth trend in emissions will have to attack the problem from two sides. They will have to reduce the emission intensity of relevant economic activities, and they will have to curb growth in demand for goods and services triggering the emission of greenhouse gases. In consequence, the environmental success of any strategy will depend on these policies' ability to stimulate the necessary technological and behavioral changes. Their political, economic and social success will depend on their economic and distributional implications. To this end, a least-cost strategy, based on a multi-gas, cross-sectoral and multi-country approach, not yet developed in detail, should be pursued.

5. Economic Implications

Even a comprehensive strategy based on a least-cost approach is not costless but comes at a price. Production processes and products will have to be adjusted to become less polluting or fuel and energy consuming, new technologies will have to be developed, and the dissemination of existing cleaner technologies will have to be accelerated, the replacement of old and pollution intensive production facilities by more modern and environmentally friendly capital stock will have to be accelerated and consumption patterns and habits will have to be changed. All this entails costs: resource costs for developing and implementing new technologies, adjustment and distributional costs for adjusting to an altered framework for supply and demand and for different demand and supply dynamics and other welfare costs resulting from an interference in production and consumption decisions to limit greenhouse gas emissions. This will make the implementation of such a policy a challenging process.

However, most of the above cost components will at least partially be compensated for by cost savings: investing in a more fuel and energy intensive production process or product will lead to fuel and energy savings², reducing excessive use of fertilizers in agriculture will reduce input costs. Moreover, a reduction in the demand for polluting products and services frees financial resources for alternative uses. The wider emission-reducing technology is spread the more likely will it be that economies of scale come into play and substantially reduce mitigation and resource costs, potentially putting in place a virtuous circle. Most efforts will also have secondary benefits: reducing the use of fertilizers in agriculture will also be beneficial for the quality of groundwater; reducing demand for traffic services will also improve ambient air quality; reducing noise, congestion and accidents, or reducing fuel consumption will contribute to less acidification. It should be noted that the total environmental benefits that can result from avoided ecological damage of adverse climate impacts (with associated social and economic benefits) are difficult to calculate accurately. It is essential, however, that they are taken into consideration in the overall assessment.

The costs:

Estimating the net costs of a strategy to combat greenhouse gas emissions would require detailed and reliable information on mitigation costs, preferably at the individual enterprise level, for the whole economy, and across all relevant greenhouse gases. Moreover, the degree and effects of adjusting production and consumption patterns in line with the planned policy objectives would have to be quantified as would welfare costs resulting from interferences into production and consumption patterns. The same holds

² Indeed, replacing an old coal-fired power plant by a plant based on combined cycle gas turbine production is normally a win-win situation for both the environment and the power generator, investing in a car with improved fuel efficiency comes at zero lifetime costs for the car-owner in Europe as long as the investment costs of the efficiency-improving technology are not too high.

for offsetting cost savings and side effects. Finally, the different cost components, including offsetting cost reductions and resource savings do not necessarily match over sectors, regions or in time. Typically, policy measures require substantial investment in mitigation technologies or changed demand patterns before resource cost savings, side benefits and the core benefits can be enjoyed. Also sectors and firms providing mitigation technologies or benefiting from changed consumption behaviour are not identical with those who have to invest in cleaner production.

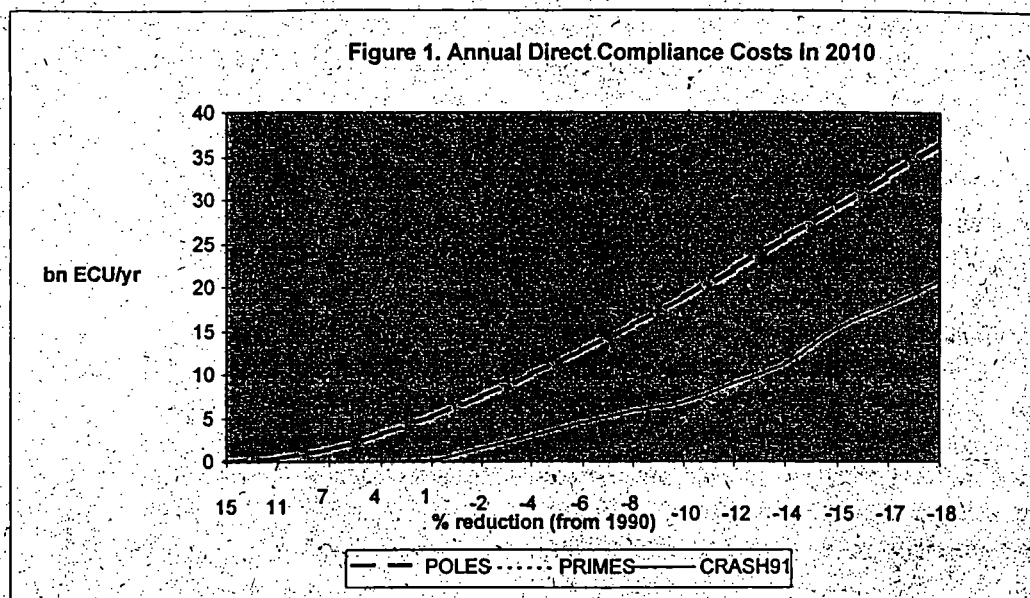
This information is not yet available on a sufficiently detailed and broad scale. Nevertheless, there exist numerous efforts to quantify the overall costs connected to a policy aiming at a reduction in greenhouse gas emissions. These estimates are using bottom-up and top-down approaches, often based on partial information, simplified assumptions, and often reflecting only parts of the economy and economic effects. Notwithstanding these shortcomings, they give a first rough impression of the issues at stake, quantified in money terms.

For a 15% reduction in CO₂ emissions compared to 1990 estimates of the direct compliance costs related to energy supply/demand mitigation actions³ range from around 15bn Ecu to about 35 bn Ecu annually by 2010. This corresponds to roughly 0.2 and 0.4 % of GDP in the year 2010. This estimate is based on CO₂ alone since adding methane and nitrous oxide is not expected to alter this drastically⁴. A cost-effective multi-gas strategy could even be somewhat less costly. The lower cost figure assumes that a part of the reduction can be achieved through zero or low net cost measures, i.e. resource costs related to the introduction of more efficient mitigation technologies are expected to be (almost) totally paid off through fuel and energy savings over the life cycle. The lower cost estimates are also based on the assumption that the political decision-making process manages to pursue the cost-effective solutions for reducing CO₂ emissions, i.e. to pursue those policies which allow the reduction target to be met at least costs. This requires that CO₂ is reduced by those quantities and in those countries and sectors where it can be done more cheaply.

Figure 1 depicts the annual direct compliance costs (in 2010) as a function of the emission reduction compared to 1990. A reduction of 15% compared to 1990, when effected in a least cost way, might cost between 15 bn and 30 bn Ecu, depending on the model. POLES estimates suggest costs of 30 bn Ecu (35 bn Ecu if the emissions are not based on the least-costs). Costs are high also because POLES assumes a 15% increase in CO₂ emissions compared to the 8% increase in emissions in the pre-Kyoto scenario. The results of PRIMES are only available for reductions of up to 12% in emissions. If these results are extrapolated to a 15% reduction in emissions a similar range of costs is obtained compared to other models.

³ The Commission Staff Working Paper provides more details on this and the following.

⁴ The Commission Staff Working Paper provides more detail on this.



The estimates are assuming discount rates of 8%⁵ and are based on existing technologies. New technologies and the exploitation of substantial economies of scale once there are prospects for fast growing markets for these technologies may reduce mitigation costs. Moreover, work under IPPC has recently confirmed that the possibility to 'apply' Joint Implementation could significantly (up to 50%) reduce the overall cost figure. The Community has actively supported Joint Implementation in the protocol negotiations and there is evidence that a number of industrialized countries such as the Associated Countries, can offer relatively cheap CO₂ reduction potential.

Similarly, emission trading in principle offers scope for overall cost reduction. It is, however, important to make sure that an eventual emission trading system will be set up in such a way that it ensures that the overall reduction objectives are met.

The assessment of the macro-economic impact shows wider ranges. While the direct static effects, as a result of higher resource cost, are negative, the overall impact, when considering the traditional multiplier effects are much more difficult to predict and depend to a large extent on the policy package chosen. The Commission Staff Working Paper reports on different studies that have tried to assess overall costs. Not all studies have taken the 15 % reduction by 2010 as their basis. Estimates in available studies range from a positive impact on GDP of close to 1 % to a negative impact of up to 1.5 %. That implies that the absolute GDP level might be 1.5% lower with than without climate policy. These observations are in line with a recent report from World Resources Institute (WRI) and with the IPPC second assessment report. Positive impacts can occur if the

⁵ Poles and Primes results are based on a 8% discount rate and CRASH91 uses 5% to 8% (depending on the country). These are discount rates that are usually applied for public policy decision making. Similar discount rate levels are used in AUTO-oil and the acidification strategy and recommended by international organisations such as the OECD. Private discount rates might of course be higher.

revenues or carbon/energy taxation (or the revenues from selling tradable permits) are used in an effective way, such as reducing labour costs for employers or giving investment tax credits.

It is important to note that in spite of the uncertainty none of the cost figures are disturbingly high compared to the overall GDP, or compared to the expected 50 % growth in GDP between 1990 and 2010.

The underlying assumption for the EU policy on climate change is that other industrialized countries undertake comparable commitments to cut greenhouse gas emissions. With unilateral action in the EU alone, the changes in industrial structure and costs would be much larger. Energy-intensive industries would relocate to outside the EU. Moreover, energy consumption in the EU might fall but rise elsewhere (since global energy prices would fall). As a result carbon dioxide emissions in the rest of the world would increase (carbon leakage) which would partially undo the efforts of the EU to reduce global emissions.

The benefits:

The benefits of any climate strategy are difficult to quantify in monetary terms. This is especially so because of the global and inter-generational nature of the climate change issue. Further complications arise because of the difficulties of attaching money values to categories such as ecological preservation and human health impacts.

The benefits, both primary and secondary, of emission reduction are often less obvious and the cost estimates mentioned above neglect the positive economic primary and secondary benefits from reduced damage due to less air pollution. Estimates of the primary (climate) benefits depend on the assumptions made on discount rates, climate sensitivity, the reference point for the emissions and the weight attached to damage in developing countries. Accounting for all these factors suggests that the global benefits of a 15% reduction in CO₂ emissions in the EU would be between 0.3bn and 101 bn Ecu /yr.

These estimated benefits are for the world as a whole and only part of them will benefit the EU. The large range of estimates for the benefits mainly depends on the value attached to damage occurring in the distant future. If this value is very high (the discount rate is zero) damage in the future is worth as much as damage now. If the value is low (e.g. a discount rate of 10 %) the value of 100 Mecu of damages in 50 years ahead would be worth less than 1 Mecu now. The choice is basically political.

The above estimate does not yet reflect the avoided damage costs (secondary benefits) due to the reduction in other pollutants. The strategy would not only reduce greenhouse gases but would also reduce sulphur dioxide, nitrogen oxides sulphur and particulate emissions compared to current legislation by 15% to 25% if not more. The associated benefits (on mainly human health, agriculture and infrastructure damages) can be estimated to be at least 11bn to 32 bn Ecu. In addition, the reduction in CO₂ emissions

would also cut the annual compliance costs from the Commission's proposed acidification strategy by at least 4 bn Ecu each year.

The total (primary and secondary) benefits related to the reduction in greenhouse gases are difficult to express and quantify in monetary terms. Available estimates suggest that these might range from 15 to 137 bn Ecu per year. This estimate taken together with the direct compliance costs, would imply that the proposed emission reduction could on balance bring net benefits if one attaches a high value to damage in the far future.

Improving overall the allocation of resources, e.g. through a better restructuring of tax systems will tend to have, positive overall effects on employment. CO₂ emission reductions are often linked to the more labour intensive solutions, i.e. imported fuels could be replaced by domestically-produced mitigation technologies. Although this is difficult to quantify in general terms, it has to be an important element in the detailed elaboration of a climate change strategy after Kyoto.

Finally, it is necessary to emphasise the strong case for collective action, first and foremost by the industrialised countries. Unilateral action would imply that the EU would carry the full costs of the policy alone. At the same time other countries would benefit without having contributed to the solution. Coordinated action ensures that environmental costs and benefits for the EU would be better balanced. Joint action with other industrialized countries is therefore essential to overcome the imbalance that would be created by unilateral action and is the only way that the parties can arrive at an effective climate policy.

Conclusion

Although the overall costs might look to be relatively manageable at the aggregate level, costs could be substantially higher at the disaggregated level, e.g. for specific sectors and could have a significant impact on their international competitiveness if other industrialised countries do not take on comparable commitments. The extent to which the costs are politically and socially acceptable depends on the willingness of society to invest in a European policy that addresses global warming. This will crucially depend on the commitments of other industrialized countries described in chapter 7. Joint action is a condition for a proper balance of costs and benefits for all countries concerned.

Mitigation costs differ between economies, regions, sectors and firms, and also between greenhouse gases. These differences and the numerous leverage points and policy measures for reducing greenhouse gas emissions make the choice of the policy mix and the geographical coverage of a comprehensive climate policy a crucial issue. Policy makers should struggle for implementing a policy mix which achieves the aimed-at emission reduction at least cost. This holds both domestically and internationally. The more instruments and measures are available and the broader the geographical coverage the cheaper and the more politically acceptable a cost-effective strategy will turn out to be. Moreover, common and co-ordinated policies and measures could open a new and less costly vector of cost-effective policies, inter alia because it would make policies globally more environmental efficient, e.g. through limiting the risk of carbon leakage.

6. Other Greenhouse Gases

Methane is the second most important greenhouse gas in the EU basket. In 1990 agriculture accounted for 45 %, waste 32 % and energy 23 % of EU methane emissions. Calculations, referred to in the Commission's Communication on methane (COM (96) 557), indicate that in 2010 compared to 1990 a reduction of methane emissions of up to 13% to 15% is feasible with current policies. A reduction of 40% over the same period is estimated to be the maximum technically feasible assuming that significant policy changes are made.

The costs of this extra 25% reduction of CH_4 (from around 15% to around 40%), equivalent to around 100 Mtonnes of CO_2 , can be estimated at around 20 to 30 Ecu/tonne of CO_2 equivalent reduced which gives an annual cost of around 2bn Ecu to 3bn Ecu. However, this additional 25% methane reduction may allow CO_2 to be reduced by 12% instead of 15%. It should be noted that this additional 25% reduction assumes a 60% reduction of methane emissions in the waste sector and reductions of 34% in agriculture and energy. As far as agriculture is concerned, further analysis is required to ensure that only such measures are pursued that are technically feasible, politically acceptable and consistent with other policy objectives. It is therefore uncertain, how much of the reduction potential of methane above 15% will actually take place.

Policy measures aiming at improved treatment of waste, methane recovery in new and existing landfills, best available recovery techniques in coal mines, minimising emissions in the production on-shore and off-shore of oil and natural gas and minimum leakage standards and more frequent control of gas pipelines need to be pursued. For agriculture, a better storage and treatment of animal manure is a promising option and there is a need for analysing how the Common Agriculture Policy (CAP) and Rural Development policies can assist such a development, for example, in the form of incentives or investment aid for covered manure storage combined with biogas utilisation, notably at larger intensive animal production units. Research into the possibilities for improved feeding of animals should also be encouraged in the Community's agricultural research programme.

Emissions of Nitrous oxide, N_2O , in 1990 amounted to 0.9 Mtonnes, equivalent to around 300 Mtonnes of CO_2 . Reductions in N_2O emissions from industry, in particular the nylon producing sector, which accounts for a third of total N_2O emissions can lead to a reduction of 30% in N_2O emissions in the year 2010. N_2O emissions from energy use (power stations) are expected to remain stable up to 2010 since most new power plants are likely to be gas fired and the lower N_2O emissions will more than offset growth in electricity production. N_2O emissions from agriculture are estimated to fall due to reduced fertilizer use and this trend should be further assisted by enhancing the agricultural component of the CAP in the context of Agenda 2000. The reductions in these sectors will more than offset increases from transport due to catalytic converters. Consequently, estimated reductions in N_2O could be between 70 to 95 Mtonnes of CO_2 (equivalent).

The reduction of N₂O (0.285 Mtonnes) could cost around 120 Ecu/ton of N₂O or 0.36 Ecu/ton of CO₂ equivalent , in total 0.03 bn Ecu. As regards policy instruments, steps can be taken to ensure that as regards emissions from industry agreements cover all producers. In agriculture, increased support should be given to environmentally friendly farming practices, such as best practice in fertilizer use. In the energy sector intensified research to reduce N₂O emissions from fluidised bed combustion of fossil fuels needs to be pursued and improved catalytic technology is required in the transport sector.

7. All industrialized countries must be committed to comparable action

Implementing reductions in greenhouse gas emissions that will imply significant changes in production and consumption pattern, is not possible for individual countries or groups of countries such as the European Community. Many industries operate in an environment with increasing global competition where relatively small cost margins are important. More and more economic sectors compete for capital in a global market where short term profit is important. And several important industrial sectors in Europe have faced or are facing overcapacity that make changes difficult to achieve.

Experience with the implementation of the Climate Convention since Rio makes it evident that only in a global regime of shared responsibility and comparable commitment will it be possible to change the trend in emissions which is necessary. This is why the EU proposal is a negotiation position and not a unilateral commitment. It is based on the assumption that other industrialized countries must and can act in the same way and it is linked to the proposal to identify common and co-ordinated policies and measures to achieve the targets. It has been argued that agreed common and co-ordinated policies and measures will reduce the flexibility for parties to the protocol in implementing their commitments. The EU position is based on the belief that in some cases : global co-ordination of policies and measures makes it easier to pursue cost-effective solutions and it reduces the political resistance to take action that will easily be seen as applying to only some parties to the protocol.

It is important to underline that the potential for CO₂ emission reductions identified in the EU for achieving the proposed EU target by 2010 are available to other industrialized countries as well. Significant improvement in fuel efficiency in cars and electricity consumption in appliances can be achieved throughout the world. Higher performance of fossil fueled power plants or accelerating the use of renewables can also be achieved as well as improved energy efficiency in industry.

It is also clear that many of these measures can also apply in developing countries. There is reason to believe that even without legal commitment by developing countries, a significant carry-over effect is likely to be observed. Fuel efficiency of cars is basically decided by international producers based in Europe, US and Japan and cars exported to or produced in countries outside these countries will not continue with higher specific fuel consumption. The same will hold true in several other areas.

8. Developing Countries

The Climate Convention, as well as the Berlin Mandate, recognise that industrialised countries must take the lead in reducing greenhouse gas emissions. Industrialised countries emission accounted for 75 % of global emissions in the base year 1990 and on a per capita basis CO₂ emissions in industrialised countries are on average 10 times as high as in developing countries.

It is also generally true that the ongoing and expected development in developing countries is likely to lead in future to much higher emissions from these countries, although on a per capita basis most developing countries will remain well below emission levels in industrialised countries.

The answer to the challenge is three fold. The first answer is a reinforcement of the obligation on industrialised countries to act now. Only through political and technological leadership will it be possible to create a situation that will bring developing countries closer into the global process.

The second answer. Both greenhouse gas emissions and the economic capability to limit or reduce greenhouse gas emissions vary enormously among developing countries. It is important, therefore, that the more developed among the developing countries gradually assume bigger responsibilities when their level of development justifies it. There is no room for free riders on this issue. This reflects the fact that both greenhouse gas emissions and the economic capability to limit or reduce greenhouse gas emissions vary enormously among developing countries.

Finally, if the industrialised countries apply and develop technologies that have low greenhouse gas emissions in order to meet their emission reduction commitments many of these are also likely to be applied in the developing countries in reducing their emissions. The Commission recognises that to facilitate this technology transfer the Community will need to focus and to expand its technical and financial cooperation with the developing countries.

9. Conclusions

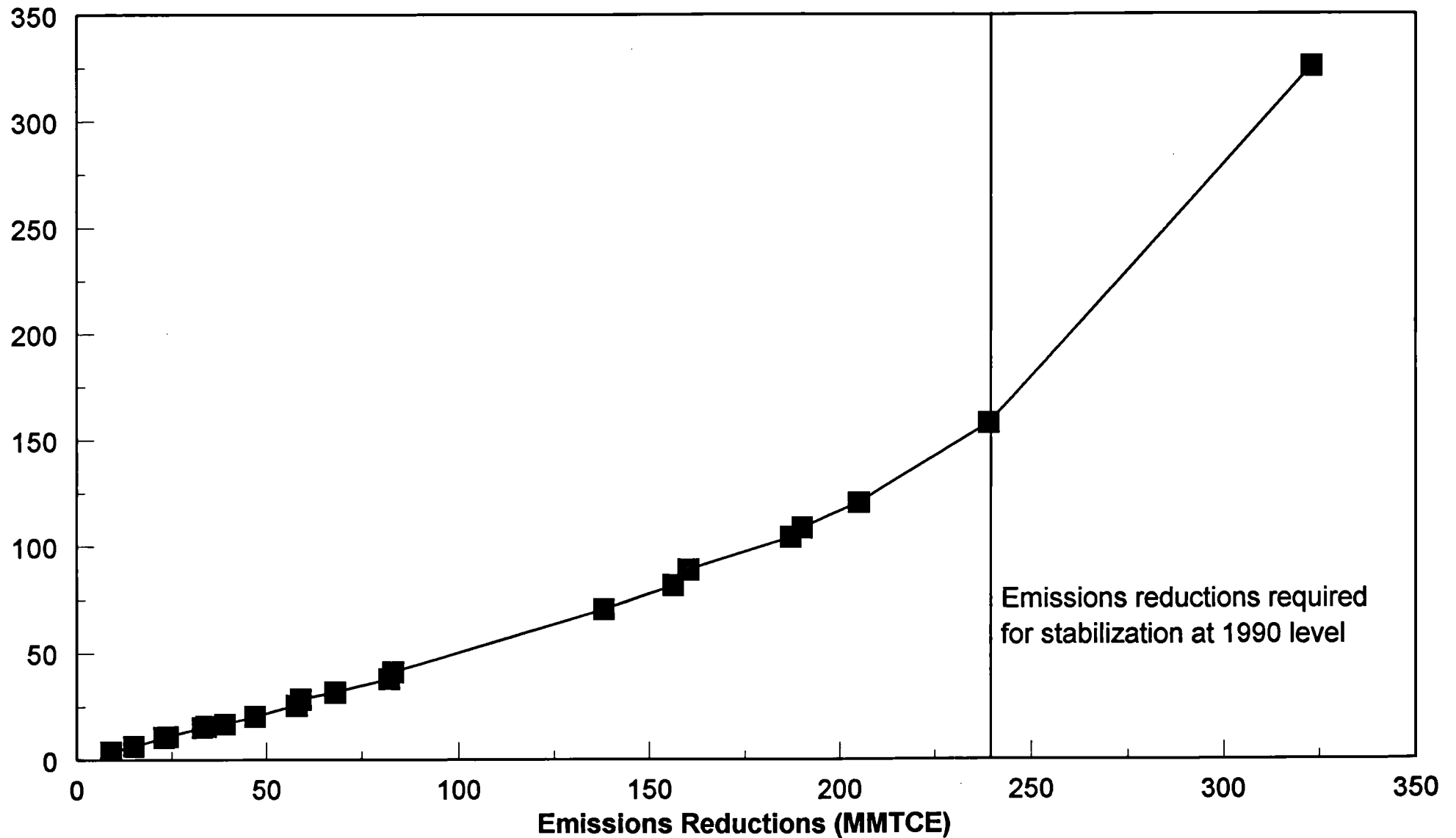
In conclusion the Commission underlines:

- that the potential future damage and cost resulting from anthropogenic climate change makes it imperative to urgently reduce greenhouse gas emissions
- that industrialised countries must continue to take the lead
- that the emission reduction targets are technically feasible and economically manageable in the EU only if all industrialised countries make comparable reduction efforts
- that many of the measures identified within this Communication for a cost-effective strategy, are equally applicable to other industrialised countries

- that the choice of the right mixture of instruments is essential for a cost-effective climate strategy.
- that given the political challenge and the need for action, the involvement of all parts of society will be needed.
- that the Commission will develop a more detailed Climate Change strategy after the emission reduction commitments have been agreed in Kyoto

Western Europe Carbon Emissions Reductions Marginal Abatement Cost Curve, 2010

Carbon Price (\$/ton)



Emissions reductions required
for stabilization at 1990 level

Model: SGM



Mark R. Hopkins
10/10/97 11:08:03 AM

Record Type: Record

To: Randall W. Lutter/CEA/EOP
cc: Joseph E. Aldy/CEA/EOP
Subject: EU Working Paper - cost analysis



Randy 101010EY.D ,

You were interested in the EU cost curves--well, I received an email with the EU Commission Working Paper file attached this morning. I am attaching the second file -- the Annex that provides an analysis of the costs -- for you to look over if you want. (It seems to give you most of what you asked for, and unfortunately the ERP is my priority at the moment). On the second page is a chart with the different simulations and the average and marginal costs per CO2 ton. (The costs are in Ecu -- today's exchange rate is US\$1 = .891 Ecu, so multiply all the costs by 1.12 to get dollars). If you would like to see the complete working paper let me know -- I have the file and a paper copy available.

Mark

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1/10/97

Communication From the Commission

**To The Council, the European Parliament,
The Economic and Social Committee And
The Committee Of The Regions**

Climate Change - The EU Approach for Kyoto

1. Introduction

On 3 March 1997 the EU Environment Council adopted a negotiating position on climate change that, *inter alia*, established a quantified emission reduction objective for inclusion in the Community's protocol proposal to the UN Framework Convention on Climate Change (UNFCCC). This proposal sets a 15% reduction of emissions for three greenhouse gases carbon dioxide (CO₂), methane, (CH₄), and nitrous oxide (N₂O) by 2010, individually or jointly, compared to 1990 for all industrialised countries that are parties to the Convention. At the 19/20 June Environment Council, Ministers also agreed to include in the EU's negotiating proposal an intermediate reduction objective of at least 7.5% for 2005. The EU position covers an average reduction for a basket of three greenhouse gases. At this stage no decision has been taken on specific targets for the three gases.

The EU position in the negotiations has been widely debated both inside the EU and at the international level, particularly among other industrialized countries. Reactions have varied widely from positive recognition of an ambitious policy to over sceptical questioning of the technical, economic or political feasibility of the targets and in some cases outright opposition.

This Communication seeks to place the EU negotiating position in an overall context and is designed to show both that it is technically feasible and that within a sound policy framework it is economically manageable to arrive at a reduction of greenhouse gas emissions of 15% by the year 2010 despite the underlying upward trend. The targets were agreed because of their environmental necessity and on the basis of studies showing that the targets are technically and economically feasible using in the main currently available technologies and practices. These targets are based on the assumption that other industrialised countries will make comparable commitments. It is also recognized that implementing the targets will be politically challenging.

The EU negotiation position covers a basket of three greenhouse gases. By far the most important of these is CO₂, responsible for approximately 80 % of the impact when the gases are weighted according to their so-called "global warming potential". CO₂ emissions are also the most difficult to reduce since, unlike other emissions arising from fossil fuel use such as NO_x and SO₂, there are as yet no end of pipe solutions for CO₂. Business-as-usual scenarios for CH₄ and N₂O indicate a likely reduction of emissions and the possibility even for a significant reduction. This implies that a cost-effective reduction of the overall emission of the three gases might include a higher reduction of CH₄ and N₂O emissions than 15 % and a lower reduction than 15 % for CO₂. However, because of the high relative weight of CO₂ it will still be necessary to achieve a reduction of CO₂ above 10% in order to meet a 15 % overall target.

For these reasons the focus of this Communication is on CO₂ emission reductions. The special circumstances concerning the other two gases are dealt with in chapter 6.

A Commission Staff Working Paper prepared in parallel with this Communication sets out a fuller technical and economic justification underlying the EU negotiation position and explains in greater detail where the necessary reductions in greenhouse gas emission

are expected to take place, the likely economic impact of the measures and the possible instruments to implement the policies. This paper also outlines a number of EU proposals already on the table which, when adopted, will facilitate limitations and reductions in greenhouse gas emissions.

This Communication examines the 2010 EU negotiating position which has been the focus of international debate and is also more important in a long-term climate strategy. It is essential to bear in mind that the core of any strategy to protect the global climate aims at a significant switch from the long-term trend for greenhouse gases to increase globally to a significant decrease. This requires action now with the benefits spread over a longer time frame.

2. Why is action necessary now?

The First Conference of the Parties to the Framework Convention on Climate Change, held in Berlin in April 1995, decided to initiate negotiations on the necessary commitments for industrialized countries to limit and reduce greenhouse gas emissions in the years after 2000. The EU was always a strong supporter of the Berlin Mandate. The Second Assessment Report from the Inter-governmental Panel on Climate Change (IPCC), published early 1996, has confirmed the view, already held by the EU, that it is urgent to initiate the necessary changes in production and consumption patterns that will allow the long-term reduction of global greenhouse gas emissions necessary to meet the long term objective of the Climate Convention. The EU has recognised that failure to do so could have potentially damaging effects in the long-term since society needs to have a realistic timeframe for change to take place in an open and transparent way.

Whereas the negotiations on the Climate Convention in the early nineties were based on the precautionary principle (action may be needed even in the absence of the final proof of the damage), the Second Assessment Report goes a step further by acknowledging that the "balance of scientific evidence suggests that there is a discernible anthropogenic influence on the global climate". The global problems associated with climate change could have a substantial negative impact on global agricultural production and productivity, reduce biological diversity, lead to land loss and population displacement and increase a number of vector-borne diseases. The damages are likely to be proportionately more significant for the developing countries.

It is important to underline that the scientific evidence of climate change (including research reported in, or initiated after the second IPCC Second Assessment Report) indicates that unacceptable social, economic and ecological impacts could occur in the coming decades. This calls for a precautionary approach. Moreover, much of the expected negative impact of climate change is likely to occur in countries that have only marginally contributed to causing the problem and without the financial resources to compensate for any possible damage. If industrialised countries do not act now to mitigate climate change future generations will not only be confronted with the cost of climate change impacts but the economic costs associated with limiting emissions could be much greater since there will be less time to make the adjustment.

A particular reason to initiate early action on CO₂ emission reductions is the long lead time necessary before policy decisions show their full impact on the emissions. Many "traditional" environmental problems offer relatively fast end-of-pipeline solutions or modifications of existing technology: reducing SO₂ emissions, eliminating lead from gasoline or phasing out of CFC's. This is not the case for CO₂.

Since CO₂ emissions are inherently linked to use of fossil fuels (coal, oil, gas) and since no economical removal technology exists as yet, the only way to reduce CO₂ emissions is through modification of structures, processes, equipment and behaviour which directly or indirectly use fossil fuels. Because of the very long lifetime of investments in the transport and energy sector and because of the relatively long lifetime of many energy consuming goods (cars, refrigerators, etc.) a CO₂ emission strategy will need a much longer horizon for implementation than for most other environmental problems.

As chapter 7 explains, early action by industrialised countries is also a prerequisite for limiting the growth in greenhouse gas emissions from developing countries. The latter is a development that is expected to be increasingly important in coming years.

3. Possibilities to reduce CO₂ emissions.

All CO₂ emission reduction possibilities have a cost impact and the more society is prepared to pay, the greater the range of reduction possibilities. In this Communication, among the actions to reduce greenhouse gas emissions either through investments incorporating existing efficient technologies or the application of new technical approaches and practices, only those that can be expected to be politically acceptable are considered. In this context such reduction possibilities must not be excessively costly and should not have unacceptable social and distributional effects. These emission reduction possibilities have been the subject of numerous studies in recent years and how to realise this potential has been an essential part of the preparations within the EU for the negotiations of a climate protocol.

For the analysis of the reduction possibilities in the various sectors of the EU economy the pre-Kyoto scenario in Table I is used as a reference. It assumes an 8% increase in total CO₂ emissions by 2010 compared to 1990 provided no additional new measures are taken.

Table I - Sectoral Distribution of CO₂ emissions in EU - Mtonnes

Sector/year	1990	2010	% inc/dec
Transport	743	1032	+ 39%
Industry	626	532	- 15%
Energy Industry	141	158	+ 12%
Domestic/Tertiary	654	680	+ 4%
Electricity/Heat	1036	1057	+ 2%
Production			
Total emissions	3200	3459	+ 8%

Source: Pre-Kyoto scenario based on Eurostat data (Excludes international marine bunkers but includes international air transport)

Table I shows that it will be important to address the transport sector where the inherent tendency to continuous strong growth will pose a challenge for the achievement of any emission reduction target. Table I shows a 39 % increase in CO₂ emissions from transport between 1990 and 2010, much of which will come from road and air transport. In this context, it should be noted that because energy prices to end-users in the transport sector are generally higher than elsewhere in the economy, targeted action aimed at removing existing market failures and inefficiencies in transport is required to significantly cut emissions at low costs.

The Council has already adopted a CO₂ emission target which corresponds to an improvement in the average fuel economy of new cars in the market in the order of 30% by 2005, over today's average. Future fuel use is not fully taken into account at the moment of vehicle purchase. However, vehicle fuel economy can be improved at low cost with available technology. To this end, the Commission is currently discussing with the automobile industry the possibility of an effective and transparent environmental agreement in which the industry would commit itself to reducing the CO₂ emissions from cars. Other elements of the strategy are fiscal measures and fuel economy labelling to influence the vehicle market.

The uncompleted internal market in rail and the existing barriers to intermodal transport are other examples of transport inefficiencies whose removal would also imply low cost energy savings. The Commission has already proposed several measures to address these issues. For example, the liberalisation and revitalisation of the Community's railways is expected to bring down transport costs and enhance service quality in rail, thereby attracting traffic that currently goes by road. Similarly, the implementation of the action programme proposed by the Commission in its Communications on the Citizens' Network about Improving Public Transport and on Freight Intermodality should lead to a greater use being made of alternatives to road and air transport.

Finally, measures to improve transport pricing proposed by the Commission should enhance transport efficiency, both within and across modes.

Although it is clear that these policy approaches require significant adjustments in the transport system, their implementation would hold out the prospect of major environmental, transport and economic benefits. The Commission is establishing a report on a strategy for the reduction in the growth of CO₂ emissions from transport that will be adopted in the near future.

The industrial sector is characterized by very different energy intensity ratios and CO₂ emissions from one sub-sector to another. In general, the most energy intensive sectors, particularly those exposed to international competition, already pay close attention to energy efficiency for sound economic reasons, notably lower final energy prices of faced by international competitors. For other industrial sectors a number of market barriers together with the low world energy prices which have applied for more than 10 years have pushed the issue down the list of priorities. Even though direct industrial CO₂ emissions are becoming relatively less important in overall emissions there is evidence from several Member States that these can still be further reduced in most sectors. The Dutch experience of an approximately 2% annual increase in energy efficiency since

1990, achieved in the framework of negotiated agreements is particularly convincing in this context.

The role of the electricity sector in meeting the challenge of climate change is a key one. This is recognized by both the electricity supply industry, Member States' authorities and the Commission. The Commission's services have completed an in-depth review with Eurelectric and other stakeholders on electricity's contribution in achieving both sustainable development and greenhouse gas reductions. Developing energy services is recognised as fundamental to these objectives and this linked to improved supply technology, greater fuel switching and increased use of non-fossil fuels will lead to substantial reductions in emission levels.

Taken together reduction potential from the electricity sector reflects improved end-use efficiency thus reducing overall demand, and greater production efficiencies.

On the end-use side there are numerous ways to improve efficiencies, both in the industrial and in the domestic and tertiary sectors. Refrigerators, computers, TV's, washing machines, light bulbs are only a few examples where use of existing technology will allow the same level of service with much less energy consumption. Electric motors used extensively in industry can similarly be improved. The EU has already developed mandatory energy efficiency labeling scheme for the principal "white goods" and mandatory standards for refrigerators/freezers to improve efficiency. The Commission is now negotiating standards on a more extensive product range with the relevant industrial sectors.

Likewise on the supply side the overall thermal efficiency of existing fossil fuel power plants in the EU was around 38% in 1994 compared with new power plants that typically offer efficiencies of around or even above 50%. There is, therefore, some scope for reducing CO₂ emission through an accelerated closing of low efficiency old plants. Additional reductions will result from switching from coal to natural gas as planned in several Member States. Combined heat and power production could further add to the reduction possibilities. It is estimated that increasing co-generation's share of EU electricity production from the present level of 9 % to 18% in 2010 could save up to 150 Mtonnes of CO₂.

The Commission's believes that doubling the share of renewables in the EU energy consumption from the present 6% of overall energy consumption to 12% in 2010 while being a challenge to the electricity industry is a realistic target. Windpower and increased use of biomass in electricity generation are the most competitive uses of renewables. Without at least half of the increase in renewables taking place in the electricity sector the 12% is not likely to be met. The experience from Denmark where installed wind power capacity is coming close to 1000MW and accounts for around 5 % of electricity consumption is a convincing example that the Commission's objective is not unrealistic. A recent Commission Green Paper has underlined that the realisation of this potential will require strong measures such as access of renewables to grid systems, obligations for renewable energies, increased payments for renewables and financial engineering in favour of renewables. A forthcoming White paper will set out the Commission's policy

direction for the future development of renewables, together with a comprehensive and detailed action plan. Publication is planned by the end of this year.

Most of the possibilities for reduction in emissions contained in the Commission Staff Working Paper have, at least in a qualitative way, been accepted for a number of years. It is equally true that in certain areas technological development has increased the potential or brought down the cost of a number of technical solutions to a more acceptable cost range.

It is however disappointing that the use of most available climate friendly technology has been modest. Low energy prices and expectations of this continuing is an important factor in explaining this. The fact that up-front investment is more important than long term overall cost for both industry and private consumers is another part of the explanation. The result is that despite the cost of different measures varying considerably there already exists a large amount of "no-cost" or "low-cost" possibilities to reduce greenhouse gas emissions.

Conclusion:

In conclusion, what part of this greenhouse gas emission technical reduction potential can be tapped depends on what levels of economic, social or political cost are deemed acceptable. Work carried out so far shows that it is possible to identify technical reduction possibilities for reducing CO₂ emissions of 800 Mtonnes. This would be sufficient to achieve a 15% reduction of CO₂ emissions by 2010 compared to 1990 instead of the 8% increase in this gas foreseen in the business-as-usual scenario in Table I. When implemented with the right mix of cost-effective policies, this technically feasible reduction potential can become both economically manageable and political acceptable.

Table II gives estimates of the potential CO₂ emission reductions possibilities for the main sectors in the EU. It is estimated that there are CO₂ emission reduction possibilities of around 300 Mtonnes in the power sector, 180 Mtonnes in transport, 200 Mtonnes from the end user sectors and 100 Mtonnes from renewables. The Commission underlines that these reductions in CO₂ emissions will be a challenge for the political decision makers. The quantities reflect the implementation of a series of policies and measures similar to the ones suggested in the following chapter. For each sub-sector, the reduction that is achievable depends on the detailed formulation of the measures.

The Commission Staff Working Paper sets out in more detail the measures that will have to be taken to achieve these CO₂ emission reduction possibilities.

Table II - Estimates of possible potential CO₂ emission reductions (Mtonnes CO₂) per sector in EU

Sector	Emission Reduction Possibilities
Transport	180
of which	
- passenger car	100
- intermodal shift	50
- other measures	30
Industry	100
Energy Industry	20
Domestic/Tertiary	100
Renewables/Heat	100
Power generation	300
of which	
- fossil fuel switching	50
- cogeneration/ thermal efficiency	150
- renewables/electricity	100
TOTAL	800

4. Elements for a Climate Change Strategy

A successful climate strategy needs to be comprehensive, cost-effective, technically and politically feasible and avoid negative social or regional side effects from the policy necessary to implement it. This Communication does not aim at prescribing such a strategy in detail but, attempts to outline the possible elements for a successful strategy. The development of a full strategy will only be possible when the result of Kyoto is known.

Any EU strategy while being effective in meeting the interim targets also needs to initiate a process of technological and behavioral changes that curbs the growing greenhouse gas emissions and sets them on a sustainable paths which will meet the requirement for continued reductions at and beyond 2010. That implies the need to address both the emission intensity of economic activities as well as the growth in demand for goods and services which trigger the increase in greenhouse gas emissions.

The choice of the right strategy with the right mixture of instruments is not only important from the technical or economic point of view, it is the core of the political challenge of making progress to protect the global climate. In the development of this strategy it will be necessary to ensure that the action is taken in the right way, ~ both to ensure a cost-effective strategy and to avoid negative social, equity or regional side effects from policy implementation.

The Commission is therefore convinced that a comprehensive strategy that brings all these elements together is a top priority. The Commission has already tabled a number of proposals including:

- the Communication - Energy Dimension of Climate Change¹ and the Council Conclusions on it in which the Council invites the Commission to come forward with an action programme in the energy sector to address climate change in the energy sector in the context of common and co-ordinated policy measures
- the extension of SAVE II to the year 2000 with a budget of 45 Mecu and a proposal for an ALTENER II programme
- a proposal for Rational Planning Techniques in the supply and demand cycle
- a Communication setting out a strategy for reducing CO₂ emissions from cars
- proposals, in the context of the Common transport policy, for the revitalisation and liberalisation of the railway sector and for European Rail Freight Freeways, in order to encourage the shift of freight from road to rail
- a proposal for a Council Directive to restructure the Community framework for the taxation of energy products (COM(97)30)
- a proposal for Fifth Framework Programme for RTD covering the period 1998 to 2002 for which an overall amount of 16.3 bn Ecu is proposed.

The Commission, however, is convinced that proposals on the table and in the pipeline are not sufficient to meet the targets proposed by the EU and depending on the outcome in Kyoto will make additional proposals that will reduce significantly CO₂, some of which are already listed in the working programme, to complete the strategy that will allow the EU to meet its post-Kyoto commitments. Additional proposals could be:

- a proposal aimed at significantly increasing the share of renewable energies in the EU's energy consumption by 2010 along the lines spelled out in the Commission's recent Green Paper
- a proposal to increase significantly by 2010 the share of cogeneration - the production of electricity and heat - in the EU's electricity production
- a series of actions regarding standardization, harmonisation and liability to promote intermodal freight transport
- revision of the Trans-Europe Network guidelines to integrate strategic environmental considerations

- proposals to significantly improve the overall thermal efficiency of power plants; increased penetration of co-generation would be a particular effective way to improve thermal efficiency.

In addition potential exists for developing a comprehensive approach to promote sustainable consumption patterns with a positive impact on climate policy goals. To facilitate such reorientation of consumer behaviour and choice, it is necessary to promote consumer awareness and to provide them with appropriate education, reliable information and advice.

A comprehensive strategy calls for the use of a broad range of policy instruments. Traditional regulatory measures will play a role in some cases (examples of regulation are, banning the use of HFC's for self chilling cans, higher efficiency standards for certain electrical equipment). However, in many areas more flexibility for economic sectors offers obvious advantages.

Economic incentives - positive as well as negative - are one way to secure a high level of flexibility and can often achieve an objective more rapidly and at a fraction of the cost of regulation.

In this context it is important to be aware that the use of *fiscal incentives* does not imply higher taxes overall. In areas already subject to taxation, incentives can be created through differentiation (as was done to promote lead-free gasoline). Switching the tax burden from labour to energy and carbon intensive production is a revenue-neutral possibility likely to reduce barriers and to increase the acceptance by the consumer of cost-effective technologies.

Some of the key challenges will be to identify and to implement policy measures that allow the exploitation of energy efficiency improvements in the existing stock of buildings and equipment. The social discount rate employed is the one used in public policy decisions. Private discount rates can of course be higher. For this reason measures are needed to bridge the gap between the social rate of return and the private rate of return used by business and commerce when they take their investment decisions.

There are also other *market-based options* such as changes in the current structure of subsidies. The present trend for phasing out subsidies on energy products such as coal should be continued and accelerated where this brings benefits for emission reduction. At the same time using short-term and temporary subsidies to encourage renewables or clean technologies is an additional option available.

Negotiated agreements between public authorities and specific industrialized sectors. These offer, in principle, maximum flexibility for industry to act in a cost-effective way. The Commission has recently issued a Communication outlining the conditions under which Negotiated Agreements would be useful instruments.

Technical options used to achieve the EU emission reduction objectives up to 2010 are mainly based on existing technologies. The role of new technological research and development is limited for this time horizon. Additional efforts are needed to diminish the

cost of existing advanced technologies given that at present they are not always competitive.

Furthermore, *socio-economic research* is necessary, in order to understand better the barriers to the application of available technologies to realise emission reduction possibilities and organisational aspects of the integration of new technologies. The impacts of economic instruments both at the micro and sectoral levels and the condition for behavioural change (including consumption patterns) also need to be researched.

In relation to RTD, it is very important to underline the need for continued focused research that will assess the socio-economic and ecological impacts of climate change (especially at the regional level) and will develop the necessary technical solutions to reduce greenhouse gases beyond 2010 and to cope with possible adverse impacts. Such research efforts could also be an advantage for EU competitiveness and lead to improved opportunities for EU exporters of such technologies.

Above, many possibilities for reducing emissions in the EU have been identified. However, the implementation of measures to capture this potential and to reduce emissions, particularly above the normal rate of equipment replacement, is unlikely to take place in the absence of strong action. No one instrument will be sufficient for achieving the Community's emission target. It will require a combination of actions.

Any policy or strategy must, therefore ensure the broadest possible co-operation and acceptance of all stakeholders: governments, industry, trade unions and the public at large. Several sectors of society and several regions of Europe will have to cope with significant changes if an overall 15% reduction of greenhouse gas emissions in the EU is to be achieved over the next 13 years. Options that have a favourable benefit on employment and economic growth should be pursued.

While liberalization is generally conducive to higher efficiency it is less supportive of investments that pay off in the long-term rather than in the short-term. The globalization of capital markets have been followed by expectations from investors of rapid profits from invested capital. The profitability of the more cost-effective measures to reduce CO2 emissions, however, often need longer periods to pay back the investment. This is a problem that will have to be addressed politically as part of the implementation of any future strategy. Investors need the certainty of a firm commitment to reductions to persuade them to invest in cost-effective efficient measures.

Policies to break the growth trend in emissions will have to attack the problem from two sides. They will have to reduce the emission intensity of relevant economic activities, and they will have to curb growth in demand for goods and services triggering the emission of greenhouse gases. In consequence, the environmental success of any strategy will depend on these policies' ability to stimulate the necessary technological and behavioral changes. Their political, economic and social success will depend on their economic and distributional implications. To this end, a least-cost strategy, based on a multi-gas, cross-sectoral and multi-country approach, not yet developed in detail, should be pursued.

5. Economic Implications

Even a comprehensive strategy based on a least-cost approach is not costless but comes at a price. Production processes and products will have to be adjusted to become less polluting or fuel and energy consuming, new technologies will have to be developed, and the dissemination of existing cleaner technologies will have to be accelerated, the replacement of old and pollution intensive production facilities by more modern and environmentally friendly capital stock will have to be accelerated and consumption patterns and habits will have to be changed. All this entails costs: resource costs for developing and implementing new technologies, adjustment and distributional costs for adjusting to an altered framework for supply and demand and for different demand and supply dynamics and other welfare costs resulting from an interference in production and consumption decisions to limit greenhouse gas emissions. This will make the implementation of such a policy a challenging process.

However, most of the above cost components will at least partially be compensated for by cost savings: investing in a more fuel and energy intensive production process or product will lead to fuel and energy savings², reducing excessive use of fertilizers in agriculture will reduce input costs. Moreover, a reduction in the demand for polluting products and services frees financial resources for alternative uses. The wider emission-reducing technology is spread the more likely will it be that economies of scale come into play and substantially reduce mitigation and resource costs, potentially putting in place a virtuous circle. Most efforts will also have secondary benefits: reducing the use of fertilizers in agriculture will also be beneficial for the quality of groundwater; reducing demand for traffic services will also improve ambient air quality; reducing noise, congestion and accidents, or reducing fuel consumption will contribute to less acidification. It should be noted that the total environmental benefits that can result from avoided ecological damage of adverse climate impacts (with associated social and economic benefits) are difficult to calculate accurately. It is essential, however, that they are taken into consideration in the overall assessment.

The costs:

Estimating the net costs of a strategy to combat greenhouse gas emissions would require detailed and reliable information on mitigation costs, preferably at the individual enterprise level, for the whole economy, and across all relevant greenhouse gases. Moreover, the degree and effects of adjusting production and consumption patterns in line with the planned policy objectives would have to be quantified as would welfare costs resulting from interferences into production and consumption patterns. The same holds

² Indeed, replacing an old coal-fired power plant by a plant based on combined cycle gas turbine production is normally a win-win situation for both the environment and the power generator, investing in a car with improved fuel efficiency comes at zero lifetime costs for the car-owner in Europe as long as the investment costs of the efficiency-improving technology are not too high.

for offsetting cost savings and side effects. Finally, the different cost components, including offsetting cost reductions and resource savings do not necessarily match over sectors, regions or in time. Typically, policy measures require substantial investment in mitigation technologies or changed demand patterns before resource cost savings, side benefits and the core benefits can be enjoyed. Also sectors and firms providing mitigation technologies or benefiting from changed consumption behaviour are not identical with those who have to invest in cleaner production.

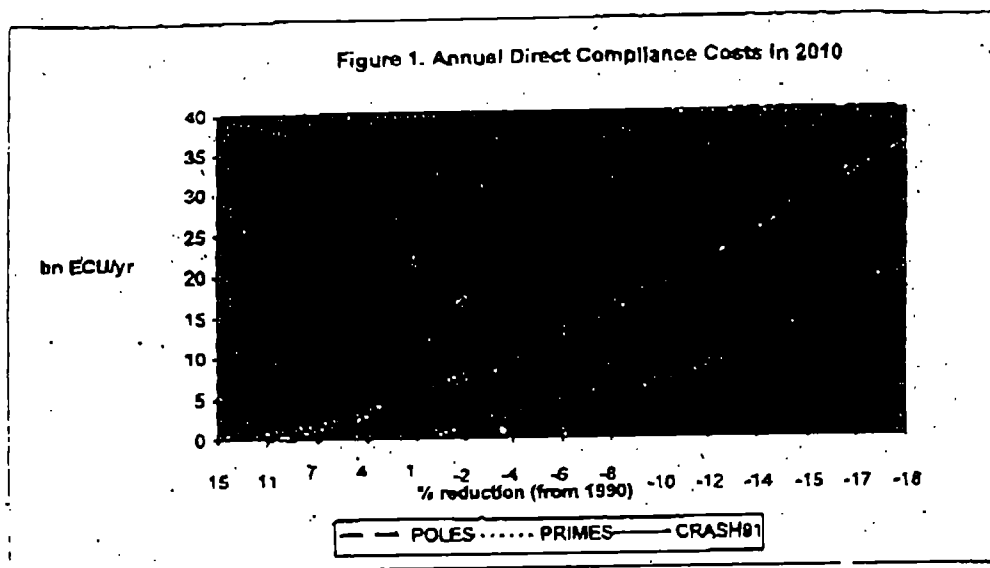
This information is not yet available on a sufficiently detailed and broad scale. Nevertheless, there exist numerous efforts to quantify the overall costs connected to a policy aiming at a reduction in greenhouse gas emissions. These estimates are using bottom-up and top-down approaches, often based on partial information, simplified assumptions, and often reflecting only parts of the economy and economic effects. Notwithstanding these shortcomings, they give a first rough impression of the issues at stake, quantified in money terms.

For a 15% reduction in CO₂ emissions compared to 1990 estimates of the direct compliance costs related to energy supply/demand mitigation actions³ range from around 15bn Ecu to about 35 bn Ecu annually by 2010. This corresponds to roughly 0.2 and 0.4 % of GDP in the year 2010. This estimate is based on CO₂ alone since adding methane and nitrous oxide is not expected to alter this drastically⁴. A cost-effective multi-gas strategy could even be somewhat less costly. The lower cost figure assumes that a part of the reduction can be achieved through zero or low net cost measures, i.e. resource costs related to the introduction of more efficient mitigation technologies are expected to be (almost) totally paid off through fuel and energy savings over the life cycle. The lower cost estimates are also based on the assumption that the political decision-making process manages to pursue the cost-effective solutions for reducing CO₂ emissions, i.e. to pursue those policies which allow the reduction target to be met at least costs. This requires that CO₂ is reduced by those quantities and in those countries and sectors where it can be done more cheaply.

Figure 1 depicts the annual direct compliance costs (in 2010) as a function of the emission reduction compared to 1990. A reduction of 15% compared to 1990, when effected in a least cost way, might cost between 15 bn and 30 bn Ecu, depending on the model. POLES estimates suggest costs of 30 bn Ecu (35 bn Ecu if the emissions are not based on the least-costs). Costs are high also because POLES assumes a 15% increase in CO₂ emissions compared to the 8% increase in emissions in the pre-Kyoto scenario. The results of PRIMES are only available for reductions of up to 12% in emissions. If these results are extrapolated to a 15% reduction in emissions a similar range of costs is obtained compared to other models.

³ The Commission Staff Working Paper provides more details on this and the following.

⁴ The Commission Staff Working Paper provides more detail on this.



The estimates are assuming discount rates of 8%⁵ and are based on existing technologies. New technologies and the exploitation of substantial economies of scale once there are prospects for fast growing markets for these technologies may reduce mitigation costs. Moreover, work under IPPC has recently confirmed that the possibility to apply Joint Implementation could significantly (up to 50%) reduce the overall cost figure. The Community has actively supported Joint Implementation in the protocol negotiations and there is evidence that a number of industrialized countries such as the Associated Countries, can offer relatively cheap CO₂ reduction potential.

Similarly, emission trading in principle offers scope for overall cost reduction. It is, however, important to make sure that an eventual emission trading system will be set up in such a way that it ensures that the overall reduction objectives are met.

The assessment of the macro-economic impact shows wider ranges. While the direct static effects, as a result of higher resource cost, are negative, the overall impact, when considering the traditional multiplier effects are much more difficult to predict and depend to a large extent on the policy package chosen. The Commission Staff Working Paper reports on different studies that have tried to assess overall costs. Not all studies have taken the 15 % reduction by 2010 as their basis. Estimates in available studies range from a positive impact on GDP of close to 1 % to a negative impact of up to 1.5 %. That implies that the absolute GDP level might be 1.5% lower with than without climate policy. These observations are in line with a recent report from World Resources Institute (WRI) and with the IPPC second assessment report. Positive impacts can occur if the

⁵ Poles and Primes results are based on a 8% discount rate and CRASH91 uses 5% to 8% (depending on the country). These are discount rates that are usually applied for public policy decision making. Similar discount rate levels are used in AUTO-oil and the acidification strategy and recommended by international organisations such as the OECD. Private discount rates might of course be higher.

revenues or carbon/energy taxation (or the revenues from selling tradable permits) are used in a effective ways, such as reducing labour costs for employers or giving investment tax credits.

It is important to note that in spite of the uncertainty none of the cost figures are disturbingly high compared to the overall GDP, or compared to the expected 50 % growth in GDP between 1990 and 2010.

The underlying assumption for the EU policy on climate change is that other industrialized countries undertake comparable commitments to cut greenhouse gas emissions. With unilateral action in the EU alone, the changes in industrial structure and costs would be much larger. Energy-intensive industries would relocate to outside the EU. Moreover, energy consumption in the EU might fall but rise elsewhere (since global energy prices would fall). As a result carbon dioxide emissions in the rest of the world would increase (carbon leakage) which would partially undo the efforts of the EU to reduce global emissions.

The benefits:

The benefits of any climate strategy are difficult to quantify in monetary terms. This is especially so because of the global and inter-generational nature of the climate change issue. Further complications arise because of the difficulties of attaching money values to categories such as ecological preservation and human health impacts.

The benefits, both primary and secondary, of emission reduction are often less obvious and the cost estimates mentioned above neglect the positive economic primary and secondary benefits from reduced damage due to less air pollution. Estimates of the primary (climate) benefits depend on the assumptions made on discount rates, climate sensitivity, the reference point for the emissions and the weight attached to damage in developing countries. Accounting for all these factors suggests that the global benefits of a 15% reduction in CO₂ emissions in the EU would be between 0.3bn and 101 bn Ecu /yr.

These estimated benefits are for the world as a whole and only part of them will benefit the EU. The large range of estimates for the benefits mainly depends on the value attached to damage occurring in the distant future. If this value is very high (the discount rate is zero) damage in the future is worth as much as damage now. If the value is low (e.g. a discount rate of 10 %) the value of 100 Mecu of damages in 50 years ahead would be worth less than 1 MEcu now. The choice is basically political.

The above estimate does not yet reflect the avoided damage costs (secondary benefits) due to the reduction in other pollutants. The strategy would not only reduce greenhouse gases but would also reduce sulphur dioxide, nitrogen oxides sulphur and particulate emissions compared to current legislation by 15% to 25% if not more. The associated benefits (on mainly human health, agriculture and infrastructure damages) can be estimated to be at least 11bn to 32 bn Ecu. In addition, the reduction in CO₂ emissions

would also cut the annual compliance costs from the Commission's proposed acidification strategy by at least 4 bn Ecu each year.

The total (primary and secondary) benefits related to the reduction in greenhouse gases are difficult to express and quantify in monetary terms. Available estimates suggest that these might range from 15 to 137 bn Ecu per year. This estimate taken together with the direct compliance costs, would imply that the proposed emission reduction could on balance bring net benefits if one attaches a high value to damage in the far future.

Improving overall the allocation of resources, e.g. through a better restructuring of tax systems will tend to have, positive overall effects on employment. CO₂ emission reductions are often linked to the more labour intensive solutions, i.e. imported fuels could be replaced by domestically-produced mitigation technologies. Although this is difficult to quantify in general terms, it has to be an important element in the detailed elaboration of a climate change strategy after Kyoto.

Finally, it is necessary to emphasise the strong case for collective action, first and foremost by the industrialised countries. Unilateral action would imply that the EU would carry the full costs of the policy alone. At the same time other countries would benefit without having contributed to the solution. Coordinated action ensures that environmental costs and benefits for the EU would be better balanced. Joint action with other industrialized countries is therefore essential to overcome the imbalance that would be created by unilateral action and is the only way that the parties can arrive at an effective climate policy.

Conclusion

Although the overall costs might look to be relatively manageable at the aggregate level, costs could be substantially higher at the disaggregated level, e.g. for specific sectors and could have a significant impact on their international competitiveness if other industrialised countries do not take on comparable commitments. The extent to which the costs are politically and socially acceptable depends on the willingness of society to invest in a European policy that addresses global warming. This will crucially depend on the commitments of other industrialized countries described in chapter 7. Joint action is a condition for a proper balance of costs and benefits for all countries concerned.

Mitigation costs differ between economies, regions, sectors and firms, and also between greenhouse gases. These differences and the numerous leverage points and policy measures for reducing greenhouse gas emissions make the choice of the policy mix and the geographical coverage of a comprehensive climate policy a crucial issue. Policy makers should struggle for implementing a policy mix which achieves the aimed-at emission reduction at least cost. This holds both domestically and internationally. The more instruments and measures are available and the broader the geographical coverage the cheaper and the more politically acceptable a cost-effective strategy will turn out to be. Moreover, common and co-ordinated policies and measures could open a new and less costly vector of cost-effective policies, inter alia because it would make policies globally more environmental efficient, e.g. through limiting the risk of carbon leakage.

6. Other Greenhouse Gases

Methane is the second most important greenhouse gas in the EU basket. In 1990 agriculture accounted for 45 %, waste 32 % and energy 23 % of EU methane emissions. Calculations, referred to in the Commission's Communication on methane (COM (96) 557), indicate that in 2010 compared to 1990 a reduction of methane emissions of up to 13% to 15% is feasible with current policies. A reduction of 40% over the same period is estimated to be the maximum technically feasible assuming that significant policy changes are made.

The costs of this extra 25% reduction of CH_4 (from around 15% to around 40%), equivalent to around 100 Mtonnes of CO_2 , can be estimated at around 20 to 30 Ecu/tonne of CO_2 equivalent reduced which gives an annual cost of around 2bn Ecu to 3bn Ecu. However, this additional 25% methane reduction may allow CO_2 to be reduced by 12% instead of 15%. It should be noted that this additional 25% reduction assumes a 60% reduction of methane emissions in the waste sector and reductions of 34% in agriculture and energy. As far as agriculture is concerned, further analysis is required to ensure that only such measures are pursued that are technically feasible, politically acceptable and consistent with other policy objectives. It is therefore uncertain, how much of the reduction potential of methane above 15 % will actually take place.

Policy measures aiming at improved treatment of waste, methane recovery in new and existing landfills, best available recovery techniques in coal mines, minimising emissions in the production on-shore and off-shore of oil and natural gas and minimum leakage standards and more frequent control of gas pipelines need to be pursued. For agriculture, a better storage and treatment of animal manure is a promising option and there is a need for analysing how the Common Agriculture Policy (CAP) and Rural Development policies can assist such a development, for example, in the form of incentives or investment aid for covered manure storage combined with biogas utilisation, notably at larger intensive animal production units. Research into the possibilities for improved feeding of animals should also be encouraged in the Community's agricultural research programme.

Emissions of Nitrous oxide, N_2O , in 1990 amounted to 0.9 Mtonnes, equivalent to around 300 Mtonnes of CO_2 . Reductions in N_2O emissions from industry, in particular the nylon producing sector, which accounts for a third of total N_2O emissions can lead to a reduction of 30% in N_2O emissions in the year 2010. N_2O emissions from energy use (power stations) are expected to remain stable up to 2010 since most new power plants are likely to be gas fired and the lower N_2O emissions will more than offset growth in electricity production. N_2O emissions from agriculture are estimated to fall due to reduced fertilizer use and this trend should be further assisted by enhancing the agricultural component of the CAP in the context of Agenda 2000. The reductions in these sectors will more than offset increases from transport due to catalytic converters. Consequently, estimated reductions in N_2O could be between 70 to 95 Mtonnes of CO_2 (equivalent).

The reduction of N_2O (0.285 Mtonnes) could cost around 120 Ecu/ton of N_2O or 0.36 Ecu/ton of CO_2 equivalent , in total 0.03 bn Ecu. As regards policy instruments, steps can be taken to ensure that as regards emissions from industry agreements cover all producers. In agriculture, increased support should be given to environmentally friendly farming practices, such as best practice in fertilizer use. In the energy sector intensified research to reduce N_2O emissions from fluidised bed combustion of fossil fuels needs to be pursued and improved catalytic technology is required in the transport sector.

7. All industrialized countries must be committed to comparable action

Implementing reductions in greenhouse gas emissions that will imply significant changes in production and consumption pattern, is not possible for individual countries or groups of countries such as the European Community. Many industries operate in an environment with increasing global competition where relatively small cost margins are important. More and more economic sectors compete for capital in a global market where short term profit is important. And several important industrial sectors in Europe have faced or are facing overcapacity that make changes difficult to achieve.

Experience with the implementation of the Climate Convention since Rio makes it evident that only in a global regime of shared responsibility and comparable commitment will it be possible to change the trend in emissions which is necessary. This is why the EU proposal is a negotiation position and not a unilateral commitment. It is based on the assumption that other industrialized countries must and can act in the same way and it is linked to the proposal to identify common and co-ordinated policies and measures to achieve the targets. It has been argued that agreed common and co-ordinated policies and measures will reduce the flexibility for parties to the protocol in implementing their commitments. The EU position is based on the belief that in some cases : global co-ordination of policies and measures makes it easier to pursue cost-effective solutions and it reduces the political resistance to take action that will easily be seen as applying to only some parties to the protocol.

It is important to underline that the potential for CO_2 emission reductions identified in the EU for achieving the proposed EU target by 2010 are available to other industrialized countries as well. Significant improvement in fuel efficiency in cars and electricity consumption in appliances can be achieved throughout the world. Higher performance of fossil fueled power plants or accelerating the use of renewables can also be achieved as well as improved energy efficiency in industry.

It is also clear that many of these measures can also apply in developing countries. There is reason to believe that even without legal commitment by developing countries, a significant carry-over effect is likely to be observed. Fuel efficiency of cars is basically decided by international producers based in Europe, US and Japan and cars exported to or produced in countries outside these countries will not continue with higher specific fuel consumption. The same will hold true in several other areas.

8. Developing Countries

The Climate Convention, as well as the Berlin Mandate, recognise that industrialised countries must take the lead in reducing greenhouse gas emissions. Industrialised countries emission accounted for 75 % of global emissions in the base year 1990 and on a per capita basis CO₂ emissions in industrialised countries are on average 10 times as high as in developing countries.

It is also generally true that the ongoing and expected development in developing countries is likely to lead in future to much higher emissions from these countries, although on a per capita basis most developing countries will remain well below emission levels in industrialised countries.

The answer to the challenge is three fold. The first answer is a reinforcement of the obligation on industrialised countries to act now. Only through political and technological leadership will it be possible to create a situation that will bring developing countries closer into the global process.

The second answer. Both greenhouse gas emissions and the economic capability to limit or reduce greenhouse gas emissions vary enormously among developing countries. It is important, therefore, that the more developed among the developing countries gradually assume bigger responsibilities when their level of development justifies it. There is no room for free riders on this issue. This reflects the fact that both greenhouse gas emissions and the economic capability to limit or reduce greenhouse gas emissions vary enormously among developing countries.

Finally, if the industrialised countries apply and develop technologies that have low greenhouse gas emissions in order to meet their emission reduction commitments many of these are also likely to be applied in the developing countries in reducing their emissions. The Commission recognises that to facilitate this technology transfer the Community will need to focus and to expand its technical and financial cooperation with the developing countries.

9. Conclusions

In conclusion the Commission underlines:

- that the potential future damage and cost resulting from anthropogenic climate change makes it imperative to urgently reduce greenhouse gas emissions
- that industrialised countries must continue to take the lead
- that the emission reduction targets are technically feasible and economically manageable in the EU only if all industrialised countries make comparable reduction efforts
- that many of the measures identified within this Communication for a cost-effective strategy, are equally applicable to other industrialised countries

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- that the choice of the right mixture of instruments is essential for a cost-effective climate strategy.
- that given the political challenge and the need for action, the involvement of all parts of society will be needed.
- that the Commission will develop a more detailed Climate Change strategy after the emission reduction commitments have been agreed in Kyoto

EU proposal analyses

EU Delegation

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Annex

Analysis of Costs

I. Introduction

1. Total costs of environmental policy to society consist of compliance costs, welfare costs and pollution damage costs. Compliance costs (or direct resource costs) are the material costs incurred in the form of investments, fuel cost and savings and other operating and maintenance expenses. Welfare costs consist of the changes in utility caused by the impact of the policy on consumption patterns. These are usually approximated by looking at impacts on GDP. Avoided pollution damage costs are the positive impact on welfare from reduced damage due to air pollution (from both greenhouse gas emissions and associated reduction in other pollutants). This annex provides more detail on the indicative estimate of the costs as they have been used in the Communication. More details can be found in the references. This annex first describes compliance costs, then welfare or macro-economic costs and finally avoided damage costs.

II. Compliance costs (direct resource costs)

2. Table 1 shows that according to analysis in progress the direct annual resource costs might range from 13 bn to around 34 bn Ecu for a reduction of CO₂ emissions by 2010 of 15% compared to 1990. This analysis assumes a 15% CO₂ reduction for illustrative purposes. As set out in the working paper it might be more cost effective to achieve the overall 15% reduction for the basket of three gases through reducing CO₂ by less than 15% which is compensated by decreases in the other greenhouse gases by more than 15%. Both CRASH91 and CRASH94 calculate the direct resource costs for the energy system in the form of additional investments, fuel costs and operating expenses. Both studies arrive at similar, relatively low estimates of 13 bn to 15 bn Ecu (in 1990 prices) of the least costs for meeting the EU target as a whole.¹ If less efficient burden sharing agreements are incorporated, costs may be around 70% higher and amount to 23 bn Ecu. CRASH94 looks at 2020 and includes energy efficiency measures on the demand side in industry and the tertiary sector which were not included in CRASH91. One has to be careful in interpreting the differences between the models. GDP growth rates are more or less comparable (around 2.5% per year) but the CRASH studies assume future oil and coal price levels which are higher than the PRIMES model. Moreover, unlike POLES and PRIMES, the Crash exercise used a cost minimization model for the whole energy system rather than simulating energy markets.
3. The POLES model arrives at costs of around 30 bn Ecu if the 15% target would be met at least cost.² If the target were to be met with a burden sharing formula, costs are expected to be somewhat higher and might amount to 34 bn Ecu/yr. Costs are high since the baseline forecast for the emissions (+15% compared to 1990) is higher than the baseline

¹ Coherence (1991) Cost-effectiveness analysis of CO₂ reduction options. May 1991. CEC, DGXII, Brussels. Coherence/ECN (1994) Up-date of the Crash Program. March 1994. CEC, DGXII, Brussels.

² Calculated on the basis of IEPE - ECOSIM (1997), Climate Change Technology Strategy Study, CEC DG XII-F, preliminary POLES results supplied by Mr. Thonet and Mr. Kouvaritakis (DGXII).

(around 10% more in 2010) in the other studies. This implies that a more substantial emission reduction would thus be needed to reduce emissions by 15% compared to 1990. .

Table 1. Costs of substantial reductions of CO₂ in the EU in 2010 compared to 1990 (d)

Study	Reduction 1990	Policy	Annual Costs bn Ecu90	Average Costs Ecu/tCO ₂	Marginal Costs Ecu/tCO ₂
CRASH91	15	least-cost EU	15	19	52
	15	sub-optimal	23 c)	28	
CRASH94	15	least-cost EU	13	16	53
	15	sub-optimal	23 c)	30	
POLES	15	least-cost EU	29	30	68
	15	sub-optimal	34 c)	33	79
POLES	10	least-cost EU	19	22	51
	10	sub-optimal	24	28	79
PRIMES	10	least-cost EU	2 b)	3.5	
	10	least-cost without transport	11	19	
	10	policies and measures	8 a)	15	
	10	policies and measures without transport	15	26	

a) with the model using sector specific discount rate (between 8 and 30%), costs would be 14 bn Ecu

b) with the model's discount rates costs are around 6 bn Ecu

c) given certain burden sharing arrangements across countries but still assuming least-cost within individual countries.

d) all model calculations use discount rates of 8% (Crash91 uses 5% for some countries)

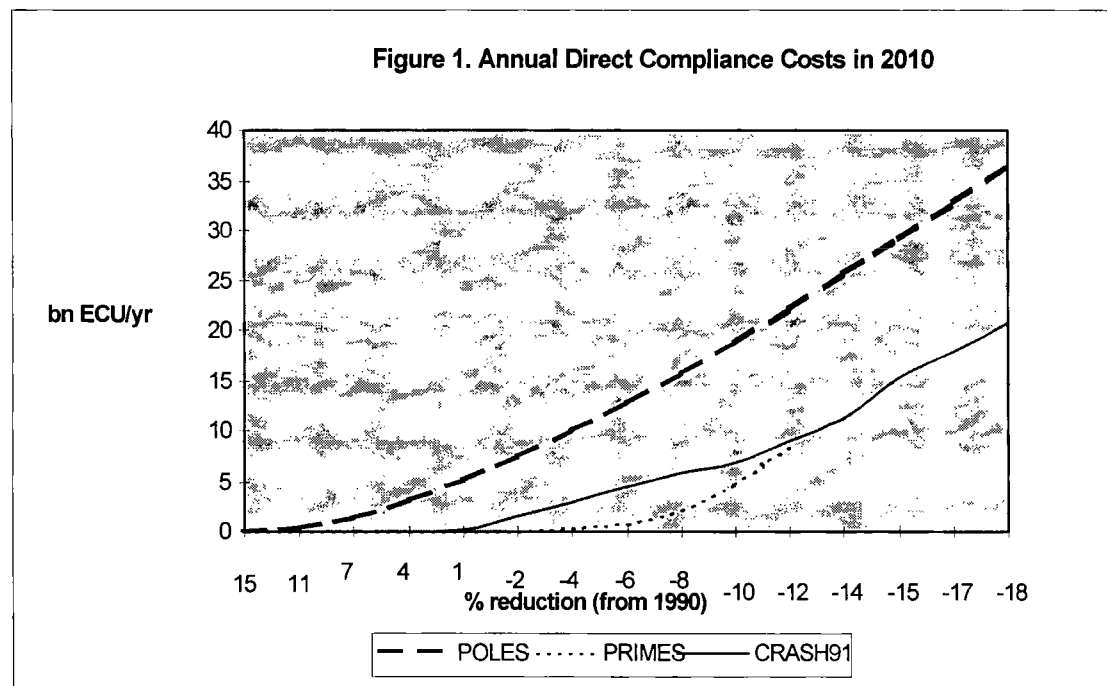
4. The PRIMES model was originally designed to analyse energy market behaviour in response to economic incentives to reduce CO₂ emissions. Table 1 shows that according to preliminary results of PRIMES, derived on the basis of eight Member States, the annual costs for a reduction of 10% (for the EU15) compared to 1990 can vary between 2 and 15 bn Ecu.³ The lowest costs occur when the target is met at least costs across the EU. A higher cost estimate applies when policies and measures are implemented that are not distributed in a cost-effective way across (sectors and) countries. In that case costs can amount to 8 bn Ecu per year. In general the costs are fairly low compared to the other models for this reduction since the costs of reducing emissions in the transport sector are expected to be negative. The compliance costs are negative since the fuel costs savings of 40% are expected to outweigh the additional investments for more fuel-efficient cars. These negative costs in transport do not take account of the possible need to compensate the substantial losses in tax revenues stemming from lower fuel consumption. Without these special fuel efficiency effects the PRIMES model gives

³

The 8 countries are Belgium, France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom. See P. Capros, L. Mantzos, E. Kokkolakis et al. (1997) Evaluation of policies and measures and their costs for the EU to meet the Kyoto target of -15% CO₂ emissions, Draft of 5 Oct. National Technical University Athens.

estimates of the annual costs of between 11 bn and 15bn ECU (see without transport). The lower cost estimate applies in case of a cost-effective distribution of reductions across sectors and countries.

5. Figure 1 depicts the annual direct compliance costs (in 2010) as a function of the emission reduction compared to 1990. A reduction of 15% compared to 1990, when effected in a least-cost way, might cost between 15 bn and 30 bn Ecu (in 1990 prices), depending on the model. Extrapolating the results of PRIMES, which are only available for reductions of up to 12%, suggest a similar range, depending on the function used to extrapolate.



6. In conclusion, a 15% reduction in CO₂ emissions compared to 1990 might cost between 15 bn and around 35 bn Ecu. The lower estimate applies if substantial reductions are available at zero costs, energy prices are favorable and policies and measures are implemented across sectors and Member States in a least-cost way. The higher cost estimate would be valid if there is no efficiency gap (no cost free options), reference emissions are relatively high or the burden is shared between countries and sectors in a suboptimal way from a pure cost effectiveness point of view.
7. The compliance costs can both be under as well as over-estimated. They can be underestimated since the bottom-up type of engineering analysis ignores so called hidden costs in the form of transaction costs (costs for finding and implementing options) and administration costs (public expenditures for implementation). Constraints that may limit the actual uptake of the measures are also ignored. Costs can also be underestimated since any rebound effects are not taken into account. These are the indirect impacts of reduced energy use on energy prices (reduction) which partially might undo the fuel costs savings through increasing demand. Furthermore, some of the energy efficiency improvements might lead to a loss of comfort and choices and could

increase welfare costs which are not captured in the engineering cost estimates. Others maintain that there is little convincing empirical evidence for this statement.⁴

8. There are also reasons to believe that the compliance costs are overstated since the estimates:
 1. do not account for the joint implementation of emission reductions with non EU countries⁵;
 2. may not fully capture the economies of scale possible in moving from small to large scale implementation of less energy- and/or carbon intensive technology at a higher rate than was implied in the model specifications;
 3. omit no-regret options such as subsidy removal and tax shifts that are economically advantageous.
9. Evidence on the potential cost savings of joint implementation is abundant and shows that these cost savings might perhaps range from 10 to 50 %, depending on the reduction strived for, the reference point and which countries are assumed to jointly implement reductions and specific implementation features chosen. ⁶ The empirical evidence on tax shifts is reported in the next section of this annex.

III. Macro-economic impacts

- 10 Macro-economic costs used as a proxy for welfare costs have been estimated on the basis of different macro-economic models. These models usually estimate the impact of energy/carbon taxation and sometimes tradable permits on macro-economic indicators such as GDP, consumption and employment. Table 2 and Figure 2 summarise the results of these studies. (The key to the studies used is in Table 2).

⁴ See Krause, F. (1997) European studies on the costs of mitigating carbon emissions a review of methods and findings. Energy Policy (forthcoming).

⁵ Compare Repetto, R. and D. Austin (1997). The costs of climate protection: a guide for the perplexed. World Resources Institute, Washington.

⁶ Klaassen, G. (1996) Acid rain and environmental degradation, the economics of emissions trading. Edward Elgar, Cheltenham, UK

Figure 2. Macroeconomic impacts

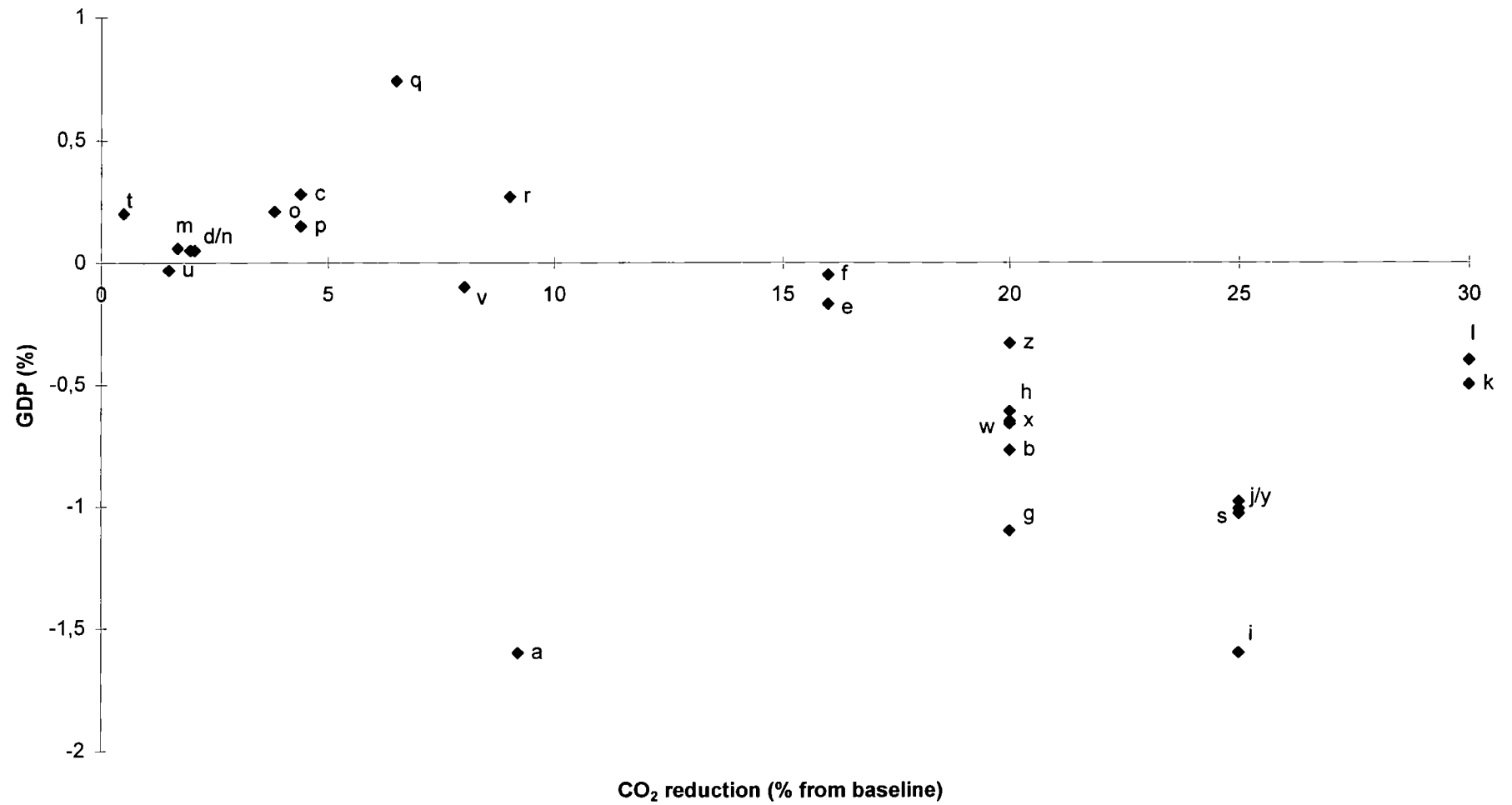


Table 2. Macro-economic impacts

CO ₂ (% baseline)	GDP (% points)	Study	Key	Policy
9,2	-1,6	BdP97	a	no recycling of tax revenues
20	-0,77	Capros97b	b	no recycling, endogenous energy savings
4,4	0,28	Capros97a	c	no recycling: budget deficit
2,08	0,05	Capros97a	d	no recycling: budget deficit
16	-0,17	Boehringer	e	no recycling: uniform reduction, no trading
16	-0,05	Boehringer	f	no recycling: differentiated reduction, no trading
20	-1,1	Capros97b	g	no recycling of tax revenues
20	-0,61	Capros97b	h	no recycling: EU wide trading
25	-1,6	Capros97b	i	no recycling of tax revenues
25	-0,98	Capros97b	j	no recycling: EU wide trading
30	-0,5	Boehringer	k	no recycling: uniform reductions, no trading
30	-0,4	Boehringer	l	no recycling: differentiated reduction, no trading
1,7	0,06	BdP97	m	recycling, tax exempt industry
1,98	0,05	Capros97a	n	recycling: social security contributions
3,83	0,21	Capros97a	o	recycling: social security contributions
4,4	0,15	BdP93	p	recycling: social security contributions
6,48	0,74	BdP97	q	recycling: social security contributions
9,01	0,27	BdP95	r	recycling: social security contributions
25	-1,03	Capros97b	s	recycling: cut labour taxes
0,5	0,2	E3ME97	t	recycling: social security contributions
1,5	-0,03	BdP95	u	recycling: soft loans
8	-0,1	BdP95	v	recycling: subsidies energy
20	-0,66	Capros97b	w	recycling: capital (interest rates)
20	-0,65	Capros97b	x	recycling: cut labour taxes
25	-1,01	Capros97b	y	recycling: cut labour taxes
20	-0,33	Capros97b	z	recycling: labour tax+endogenous energy savings

11. Figure 2 depicts the impacts on GDP (% difference in GDP level in 2010 compared to what would have happened without policy) as a function of the CO₂ reduction compared to the baseline (reference emission in 2010). This impact can be either positive or negative. This mainly depends on the level of applied tax rates and on how carbon/energy tax revenues are used. Positive impacts in terms of increases in GDP of up to 0.75% compared to the baseline (GDP growth without tax) are reported for reductions of up to 10% over the reference scenario for the emissions. Negative impacts on GDP of up to around 1.5% GDP are quoted in the literature as well for a range of up to 30 % of CO₂ emission reduction from the baseline. These ranges are broadly in line with other studies for OECD countries⁷.

12. Table 2 shows that, in general, those studies⁸ report negative impacts on GDP, and consequently on employment, where the revenue from energy or carbon taxes are not recycled. That is the tax revenues, or the proceeds of auctioned permits, are being used to reduce governments budget deficits. This is confirmed by previous work in this arena.⁹ An exception to this rule is the general equilibrium work by Capros for those cases where it is assumed that the reductions in budget deficits lead to a reduction in the long-term interest rate without simultaneously having negative impacts on the balance of payments (exports minus imports).
13. If tax revenues or the revenues from selling tradable permits are re-used to reduce the social security contributions paid by employers positive impacts on GDP and employment can be expected under certain circumstances. This is confirmed by other studies for which no CO₂ impacts were available¹⁰. These results depend on the initial economic situation and more specifically on the existence of inefficiencies in the form of involuntary unemployment. Table 2 shows that other forms of using tax revenues such as financing soft loans or giving subsidies for energy efficiency improvements may be less successful in stimulating GDP. National studies for Austria contradict the latter finding however.¹¹ Older studies confirm that if tax revenues are used to reduce other taxes such as VAT or personal income taxes, negative rather than positive impacts on GDP can be expected.¹²
14. The underlying assumption for EU policy is that other industrialised countries undertake comparable commitments. With unilateral action the changes in industrial structure can be expected to be larger than with coordination. With unilateral action the production of

⁸ BDP97=Bossier, F., L. Lemiale, S. Mertens, E. Meyermans, P van Brusselen and P. Zagame (1997). *Evaluation of fiscal measures for energy products: results from the HERMES-Link System*. Report submitted to the European Commission, April 1997, Federal Planning Bureau/Erasmus, Brussels/Paris. CAPROS97a=Capros, P and T. Georgakopoulos (1997) *Evaluation of fiscal measures for energy products:*

results from the GEM-E3 and MIDAS models, May 23, 1997, report submitted to the European Commission, DGXII, National Technical University Athens. E3ME97= Cambridge Econometrics and Chambre de Commerce et d'Industrie de Paris (1997) *Evaluation of fiscal measures for energy products: results from the E3ME model*, Draft May 1997, report submitted to the European Commission, DGXII, Cambridge. BDP93= Bureau du Plan-Erasmus (1993) *Un redéploiement fiscal au service de l'emploi*. Rapport à la DGXI, Brussels/Paris. Bdp95=Bossier J.F. et al. (1995) *Efficience énergétique et nouvelles technologies*. Dans "Le progrès technologique pour la compétitivité et l'emploi." Commission Européenne., Joule II Programme, pp. 87-111. Capros97b=Capros, P., T. Georgakopoulos, S. Kostomiti and A. Filippoupolitis. (1997) *Macroeconomic Implications of the "Kyoto" CO₂ target for the European Union*, October 3, 1997, NTUA, Athens. Boehringer=Boehringer, C., J. Jensen and T. Rutherford (1997) *The costs of carbon abatement in six EU countries: implications of alternative baseline projections*. Paper for the IPPC workshop on Economic Impacts of Annex I actions on all Countries, Oslo, August 18-20.

⁹ European Commission (1992b) *European Economy*, Special edition No. 1. The economics of limiting CO₂ emissions. CEC; Brussels.

¹⁰ CEC (1994) *Besteuerung, Beschäftigung, und Umwelt: Steuerreform zur Abbau der Arbeitslosigkeit*. In: *Jahreswirtschaftsbericht 1994*; Europäische Kommission, Generaldirektion Wirtschaft und Finanzen, pp. 111-144.

¹¹ Koepl, A., Kratena, K., C. Pichl, F. Schebeck, S. Schleicher and M. Wueger. (1995) *Macroeconomic and sectoral effects of environmentally motivated energy taxation in Austria*. WIFO, Vienna.

¹² European Commission (1992b) *European Economy*, Special edition No. 1. The economics of limiting CO₂ emissions. CEC; Brussels.

energy-intensive industries goods will be relocated to outside the EU. Moreover, energy consumption might fall in the EU but rise elsewhere (since global energy prices would fall). As a result carbon dioxide emissions in the rest of the world would increase (carbon leakage) which would partially undo the efforts of the EU to reduce global emissions. Evidence suggests that this carbon leakage (change in energy consumption in the rest of the world relative in relation to the change in energy consumption in Europe) could be substantial¹³. Exempting the energy-intensive industry from climate measures would reduce this leakage but also would imply that the reduction of real national income in Western Europe (compared to business-as-usual) would be higher since more expensive measures would need to be taken in the non-energy intensive sectors.

IV Avoided damage costs

a) Introduction

15. Avoided damage costs (or benefits) can consist of primary damage costs (directly related to the reduction in greenhouse gases) or secondary damage costs or benefits (related to the indirect reductions in the emissions of non-greenhouse gases such as sulphur dioxide). For climate change such benefits are difficult to quantify in monetary terms because of its inter-generational and global character. It is also difficult to put a value on some damage categories such as human health and sensitive ecosystems.

b) Primary benefits

16. Earlier studies estimated the aggregated damage due to a doubling of CO₂ concentrations at 1.5 to 2% of world GNP while the OECD would lose 1.0 to 1.5% of GDP and developing countries 2.0 to 9.0%. The estimates ranged from 0.3 to 221 \$/ton C (in 1990\$)¹⁴ These first estimates are now being updated to better reflect: damages in developing countries, non-market losses, variability and extreme events, adaptation and uncertainty. Table 3 contains provisional numbers from the Model FUND.¹⁵

Table 3. Marginal damages for CO₂, CH₄ and N₂O emissions

Discount rate	0%	1%	3%	5%	10%
CO ₂ (\$/tC)	317	171	60	26	6
CH ₄ (\$/tCH ₄)	660	517	295	170	52
N ₂ O (\$/tN ₂ O)	32,735	16,862	5,459	2,217	434

¹³ Tang, P., R de Mooij, R. Nahuys (1997) An economic evaluation of alternative approaches for limiting the costs of unilateral regional action to slow down global climate change, simulations with Worldscan, 1997, CPB, the Netherlands (Study for DGII, CEC),

¹⁴ See IPCC (1996) Climate Change 1995, economic and social dimension, Cambridge . Fankhauser and Tol (1996) Climate Change Costs: Energy Policy, 24(7), pp.65-673

¹⁵ Personal communication N. Eyre to Mr. Valette. For a description of FUND see Tol, R. (1995). The damage costs of climate change toward more comprehensive calculations. Environmental and Resource Economics 5, pp. 353-374.

17. Those preliminary numbers are assessed under the "base case" assumptions of the ExternE global warming assessment which have been used in the MODEL FUND, that is
- * future damages are discounted back to 1990;
 - * impacts are assessed over the period from the emission date to 2100;
 - * emissions are incremental to IPCC emission scenario IS92d;
 - * damage allow to include that damage in developing countries is independent of income but worth as much as elsewhere;
 - * no secondary benefits.

Table 4 Sensitivity analysis of marginal damages of CO₂ emissions (in \$/tC)

Case/discount rate	0%	1%	3%	5%	10%
Base case	317	171	60	26	6
Impact horizon: 2200	243	172	62	26	6
No equity correction	142	73	23	9	2
Climate sensitivity: 1.5°C	186	101	35	15	3
Climate sensitivity: 4.5°C	590	318	112	49	11
IS92d scenario	288	156	56	25	6

18. Table 4 presents a sensitivity analysis around the base case. The base case represents the damage per ton carbon relative to the baseline for the emissions. Extending the horizon from 2100 to 2200 (including damage beyond 2100) makes little difference, except for the zero discount rate. No equity weights implies that damage to poorer countries counts less since the value attached to the damage would depend on the level of income per capita. If the climate is more sensitive (a more significant impact of 4.5 °C instead of 2.5°C) this leads obviously to higher marginal damages. If the climate is less sensitive (1.5°C) damages are lower. If the baseline emissions are lower (IS92d), marginal damage costs are lower as well. In conclusion-

CO₂ 170\$/tC

CH₄ 520 \$/tCH₄

N₂O 17,000 \$/tN₂O

damages due to climate change depend very strongly on the assumptions used in assessment. Reasonable parameter values in sensitivity tests allow damages to be assessed in the range 2 - 600 \$/tC¹⁶. The most important parameter is the discount rate: the value society attaches to damage occurring in the distant future.

19. A 15% reduction in the EU emissions in 2010 implies a emission reduction of around 740 Mton CO₂ (compared to the pre-Kyoto scenario of 8%). A reduction of 740 Mton in the EU would than imply (global) benefits (reduction in damage) of between 0.3 and 101 bn ECU. With higher reference emissions in the EU in 2010 (POLES expects +15%) emissions reductions in the EU would have to be higher to meet a 15% reduction compared to 1990. As a result benefits and costs would be higher.

c) Secondary benefits

20. The following evidence is available on the avoided damage costs due to reduced externalities. A 10% reduction in CO₂ emissions by 2010 would cut the costs from the Commissions proposed, but not yet implemented acidification strategy (COM(97) 88 final 12/3/97) by 4.1 billion Ecu each year¹⁷. This approach is based on the avoided pollution abatement control costs.
21. One can also look at the avoided damage costs. A 15% reduction in CO₂ emissions compared to 1990 represents a reduction of around 23% compared to the baseline. Modelling work in progress with GEM-E3 suggest that this can be translated in a reduction of some 25% in SO₂ emissions compared to the reference scenario and a reduction of around 20% in NO_x emissions in 2010¹⁸. Looking at the absolute levels in the reference case¹⁹ with current policies this implies a reduction of SO₂ emissions by roughly 1400 kton and of NO_x by 1700 kton. On a European scale SO₂ damage avoided can be estimated at around 4000-7000 Ecu/ton- and NO_x at 3000 to 5000 Ecu per ton NO_x²⁰. This implies avoided damage costs of 5 bn to 9 bn Ecu for SO₂ and 5 bn to 8 bn Ecu for NO_x. This gives a total of 10 bn to 17 bn Ecu/yr. Analysis being developed to implement the 5th Environment Action Programme in respect of CO₂, CH₄, N₂O, SO₂ and NO_x will look in more detail at these benefits and costs.
22. The proposed reduction of CO₂ emissions of 15% would also have other secondary benefits since it might cut PM10 emissions by some 15%²¹. This equals around 200 to 250 kton less PM10 than expected with current legislation in 2010²². The reduced damage costs (mortality and morbidity) might be estimated at 3000 to 60000 Ecu/ton²³ implying avoided damage costs of at least 0.6 bn to 15 bn Ecu each year. Adding up the secondary benefits compared to current policy (excluding the not yet agreed acidification strategy) would imply avoided damage costs of 11 bn to 32 bn Ecu each year.

¹⁷ See Amann et.al. (1997) Cost-effective control of acidification and ground level ozone. Second Interim report to the European Commission, DGXI.

¹⁸ Recent analysis suggest higher reductions (Capros, Macroeconomic Implications of the "Kyoto" CO₂ target for the European Union, Sept. 1997).

¹⁹ See footnote 17.

²⁰ Coopers and Lybrand (1996) Cost-Benefit Analysis of the Different Municipal Solid Waste management systems: Objectives and Instruments for the year 2000. European Commission, DGXI, Brussels. Also compare Holland, M, and Krewig, W (1996). The benefits of an acidification strategy for the EU, ExternE, case study 3, DG XII.

²¹ Recent analysis suggest higher reductions (Capros et al, Macroeconomic Implications of the "Kyoto" CO₂ target for the European Union, 5 Oct. 1997)

²² See IVM et al (1997) Economic evaluation of air quality targets for sulphur dioxide, nitrogen dioxide, fine and suspended particulate matter and lead. IVM, Amsterdam, Second interim report to the CEC, DG XI.

²³ See Ozdemiroglu, E. and D. Pearce (1995). Economic Evaluation of Benefits of abating nitrogen oxides and other related substances. United Nations, Economic Commission for Europe, EB.AIR/WG.5/R56, June 1995