WWF Climate Change Campaign
www.panda.org/climate

For more information:
Andrew Kerr, Public Affairs Manager
Tel: +31 6 5161 9462 or +49 160 8862163(mobile)
E-mail: akerr@wwfnet.org

Kyoto Without The U.S.
Costs and Benefits of EU Ratification of the Kyoto Protocol

by Mirjam Harmelink, Dian Phylipsen, David de Jager, Kornelis Blok

ECOFYS Energy and Environment, P.O. Box 8408, 3503 RK Utrecht, The Netherlands.
www.ecofys.com/climate, e-mail: m.harmelink@ecofys.nl

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1 Summary and overall conclusions

In 1997, the Parties to the United Nations Framework Convention on Climate Change adopted the Kyoto Protocol. The European Union agreed to reduce its emissions by 8 per cent in the period 2008-2012 compared to 1990 (or 1995 for other gases). The United States under the Bush administration has declared that it will not ratify the Kyoto Protocol and does not intend to force emission reduction measures upon the US economy. This paper shows that:

- if the European Union implements smart policy options, the costs to Europe of going ahead with the Kyoto Protocol without the US are limited;
- the majority of the implementation costs could well be compensated by the knock-on effect of climate change policies reducing investment that will otherwise be needed to achieve targets to reduce other pollutants that cause acidification;
- between 85 and 95 per cent of the EU's reduction target can be achieved without affecting the competitiveness of EU economies. Smart policies can offset the remaining effects on competitiveness.

1.1 Specific conclusions

- The annual cost of implementing the Kyoto Protocol in Europe ranges from 3-8 billion Euros (0.06 to 0.15 per cent of total gross domestic product (GDP) in 2010). The lower cost refers to a situation in which there is close European co-operation in implementing least-cost options.
- Assuming a least-cost approach for the European Union, the analysis shows that between 85 and 95 per cent of the Kyoto reduction target can be achieved without harming the EU's competitiveness. This is because at least 75 per cent of the reduction options can be implemented in sectors that are sheltered from international competition. Many of the - mainly energy-intensive - industries in sectors exposed to international competition have access to relatively cheap reduction options. The remainder, those most-affected by increases in production costs, generally face limited exposure to international competition.
- The competitiveness of the basic chemical industry in Europe, and to a lesser extent the glass industry, may be affected due to the implementation of climate change policies because they are exposed to international competition with the US. By implementing smart policies, however, these sectors can be compensated. Possible options are to achieve higher emission reductions in other sectors of the economy or to support implementation in the exposed sectors, for instance via tax incentives.
- Climate change policies have significant positive impacts on other environmental problems, meaning that other environmental targets will be easier to achieve. By implementing smart integrated climate policies, substantial cost reductions can be achieved in reaching targets set for tackling problems such as acidification.
- Unilateral implementation of the Kyoto Protocol by the EU could give European industry a head start in the development of innovative technologies for reducing emissions of greenhouse gases in the longer term.
- An 'early' start with climate change policies to reduce emissions could lead to substantial cost reductions for Europe in the future.

2 Background

In 1997, the Parties to the United Nations Framework Convention on Climate Change adopted the Kyoto Protocol. Under the protocol, industrialised countries committed to reduce their combined greenhouse gas emissions by 5.2 per cent below 1990[1] levels in the period 2008-2012. Under the Bush administration, the United States declared in March 2001 that they will not ratify Kyoto or force emission reduction measures upon the US economy. In the current negotiations, other governments

[1] With 1995 levels serving as the base year for emissions of PFCs, HFCs and SF6

are discussing two possible responses to the US decision: adjustment of the Kyoto Protocol to accommodate US objections, or ratification of the Protocol without the participation of the US. The first option could lead to substantial delay in the required emission reductions and, potentially, a weakened Protocol. The second option has led to discussion over the possible effects of climate policies on the competitiveness of EU industry compared to US companies that would not be subject to climate change policies.

This paper assesses the costs and benefits to the European Union of ratifying the Kyoto Protocol without the US. The costs and benefits of a 'unilateral' implementation of the Kyoto Protocol are assessed on the macro-economic level (in terms of changes in GDP) as well as the sectoral level (in terms of changes in production costs and the competitiveness of specific sectors in global markets). Furthermore, some additional benefits are addressed, such as the positive 'spill over' effect that an early start to the Kyoto Protocol could have on other environmental problems.

3 Compliance costs on a worldwide scale

The (macro) economic effects of climate change policies for different world regions and sectors have been analysed in considerable depth. According to most studies, the macro-economic effect of implementing the Kyoto Protocol is limited; between 0.3 and 1.9 per cent lower growth in gross domestic product (GDP) in 2010 compared to the reference case without additional climate change policies (see Bollen *et al* (2000), Burniaux (2000) and IPCC (2001)).

Bollen *et al* (2000) analysed the compliance cost of the worldwide implementation of the Kyoto Protocol, looking especially at the effects of emissions trading on total compliance costs. Two scenarios were assessed:

1) a scenario in which Annex B (industrialised) countries reduce their emissions through domestic measures;
2) a scenario with unrestricted emissions trading between Annex B countries.

They assumed that all reductions are to be reached by decreasing energy-related CO_2 emissions and that no use is made of the Clean Development Mechanism (CDM). Worldwide implementation of the Kyoto Protocol leads to a lowering of GDP by 0.5 per cent without, and 0.2 per cent with emissions trading schemes for Annex B countries, compared to the reference scenario. The effects on the EU are lower than the average effect on Annex B countries, and lower than the effect on the US (see **Table 1**). Note that this will on average lead to higher cost for implementing the Kyoto Protocol because relatively cheap options for reducing non-CO_2 greenhouse gases, as well as relatively cheap CO_2 credits from CDM projects, are not included.

Table 1: Effect of the Kyoto Protocol on the level of GDP in 2010 for scenarios with and without emissions trading, compared to a reference scenario. The absolute growth of GDP in the reference scenario is indicated. (Bollen et al, 2000)

	No emissions trading	With emissions trading	Absolute growth of GDP in the reference scenario
	% decrease in the absolute GDP level in 2010		% increase for the period 1995-2010
Annex B	-0.5%	-0.2%	
US	-0.9%	-0.3%	32%
EU	-0.3%	-0.1%	22%
Japan	-0.2%	-0.1%	20%

Bollen, *et al* (2000) also analysed the effect of a Kyoto Protocol without the US, however for 2020 instead of 2010. They concluded that Europe's GDP would be less affected in the case of American rejection of the Kyoto Protocol than in a situation in which the US ratifies. In the case of a Kyoto

Protocol with the US, Europe's GDP would drop between 1.1 and 1.3 per cent, whereas without the US in the Protocol this is limited to 1 per cent. In a scenario with emissions trading, Europe's GDP benefits from US non-participation (i.e. GDP is less affected) as a result of a lower price of emission credits that stems from lower demand.

Burniaux (2000) analysed the cost reductions that can be obtained when options for methane and N_2O as well as those for CO_2 are implemented to achieve the emission targets. They analysed a scenario in which all parties reach their Kyoto targets and no use was made of the Kyoto "flexible mechanisms"[2], such that all reductions had to be reached domestically. The main results, included in **Table 2,** show that the costs of the Kyoto Protocol are lower when reduction options for CH_4 and N_2O are considered as well. An additional conclusion was that the output of the coal, gas and oil sectors would be affected the most by implementation of the Protocol.

Table 2: Effect of the Kyoto Protocol on GDP in 2010 relative to a reference scenario where no use is made of the Kyoto mechanisms (Burniaux, 2000)

	Only CO_2	CO_2, CH_4 and N_2O
Annex B	-0.2%	-0.1%
US	-0.3%	-0.2%
EU	-0.2%	-0.1%
Japan	-0.1%	-0.1%

When judging the results of these models one should keep in mind that several factors are not taken into account which can either lead to over- or underestimation of the implementation costs. Further cost reductions could be obtained were emission reductions through sinks and the Clean Development Mechanism (CDM) to be taken into account as well.

4 Compliance costs for the European union

The Member States of the European Union jointly committed themselves to reduce their emissions by 8 per cent compared to 1990/1995 in the first commitment period 2008-2012. The Member States agreed to share the 8 per cent so that some Member States would commit to a higher reduction target while others would be allowed to increase their emissions. Studies show that the macro-economic effects of implementing the Kyoto Protocol are small for the European Union (Blok *et al* (2001).

Blok *et al* (2001) analysed the compliance cost for the European Union, incorporating emission reduction options for non-CO_2 greenhouse gases (N_2O, CH_4 and the fluorinated gases) and assuming no use was made of the Kyoto Mechanisms. They concluded that in the case of EU-wide implementation of the least-cost options the total annual costs of implementation in 2010 are 3.7 billion Euro, which is equal to 0.06 per cent of the projected GDP in the same year. In this case, reduction options with marginal cost up to 20 Euro per tonne CO_2 would have to be implemented. The annual compliance cost would double (7.5 billion Euro) if Member States fulfilled their targets individually, i.e. if each Member State implemented least-cost options available within its borders according to the Burden Sharing Agreement. In this case the average weighted marginal costs for the EU are 42 Euro per tonne CO_2 but for individual Member States marginal cost can rise to 100 Euro per tonne CO_2 (see **Table 3**). It can be concluded that close co-operation on the European level can bring savings in total compliance costs for a large number of Member States.

[2] emissions trading, the Clean Development Mechanism (CDM) and Joint Implementation (JI)

Table 3: Breakdown of emissions and marginal cost by Member state (Capros et al, 2001).

	Kyoto target	**Member State allocation (Burden Shar-ing case)**	**EU-wide allocation of least costs sectoral objectives**
	Reduction 1990-2010	Marginal Cost / ton CO2-eq	Marginal Cost / ton CO2-eq
Austria	-13.0%	53	20
Belgium	-8.0%	92	20
Denmark	-21.0%	53	20
Finland	0.0%	`	20
France	0.0%	1	20
Gemany	-21.0%	12	20
Greece	25.0%	11	20
Ireland	13.0%	32	20
Italy	-6.5%	35	20
Luxemburg	-28.0%	-	-
Netherland	-6.0%	106	20
Portugal	27.0%	23	20
Spain	15.0%	12	20
Sweden	4.0%	41	20
United Kingdom	-12.5%	12	20
EU-15	**-8.0%**	**42**	**20**

Note: 1) The ACEA agreement is included in the baseline
2) Data for Luxemburg are not available

Joint Implement and the Clean Development Mechanism could lower the compliance cost for the EU under the condition that the price of carbon credits on the global market is below 20 Euro/tonne of CO_2. If the price of credits is higher than 20 Euro per tonne it is cheaper for the EU to implement abatement measures within the EU. The current (limited) trade of carbon credits shows prices varying from 5-10 Euro per tonne CO_2. For example within the Dutch Emission Reduction Unit Procurement Tender (ERUPT) programme prices of 5-9 Euro per tonne of CO_2 are paid for credits from projects in central and eastern European countries (Senter, 2001). It is hard to predict what the prices will be in the future as this will very much depend on the pre-conditions for trade that will be laid down in international negotiations and on the number of parties active in the market. Assuming that the price for carbon credits remains at approximately 10 Euro per tonne of CO_2, 75 per cent of the reduction options that need to be implemented to reach the EU Kyoto target can be implemented without delay because they have costs below 10 Euro per tonne of CO_2 (Blok *et al*, 2000). This means that in case of close European co-operation, leading to the implementation of the least-cost options for Europe, the initial focus can be on domestic measures.

5 Compliance cost by sector: sheltered and exposed

5.1 Introduction

Assuming a least-cost approach for the European Union, this section reviews the reduction options and the costs of implementing the least-cost options by sector. **Table 4** summarises the emission reduction by sector within the EU under the least-cost approach.

Table 4: Summary of the EU-wide allocation of the least-cost reduction options in different sectors to reach the Kyoto target of -8 per cent (including options for CO_2 as well as non-CO_2 greenhouse gases) (Blok et al, 2001)

	Emissions in 1990/95 (Mt)	Baseline emissions in 2010 (Mt)	Cost-effective objective 2010 (Mt)	Change from 1990	Change from 1990 (Mt)	Change from baseline	Change from baseline (Mt)
Energy supply[1/2/]	1190	1206	1054	-11%	136	-13%	152
Non-CO_2 fossil fuel[3/]	95	61	51	-46%	44	-16%	10
Industry[2/]	*894*	*759*	*665*	*-26%*	*229*	*-12%*	*94*
Iron and steel	196	158	145	-26%	51	-8%	13
Non-ferrous metals	24	22	13	-46%	11	-41%	9
Chemical	243	121	81	-67%	162	-33%	40
Building materials	201	212	208	3%	-7	-2%	4
Paper, pulp and printing	29	22	20	-31%	9	-9%	2
Food, drink and tabacco	46	35	26	-43%	20	-26%	9
Other industries	155	189	172	11%	-17	-9%	17
Transport[4/]	753	984	946	26%	-193	-4%	39
Households	447	445	420	-6%	27	-6%	25
Services	176	200	170	-3%	6	-15%	30
Agriculture	417	398	382	-8%	35	-4%	16
Waste	166	137	119	-28%	47	-13%	18
Total	**4138**	**4190**	**3807**	**-8%**	**331**	**-9%**	**383**

Table 4 shows that approximately 40 per cent of the reduction can be achieved in the energy supply sector and 25 per cent in the industry sectors. An important reduction option in the energy supply sector is the further shift from coal to natural gas. For the industrial sector, the main reduction options involve further increases in energy efficiency and the implementation of abatement measures that reduce emissions of non-CO_2-greenhouse gases such as N_2O emissions from adipic acid and nitric acid production and emissions of PFCs from the aluminium industry.

Average production costs would increase as a result of greenhouse gas reductions. According to Capros *et al* (2001), the average production cost for electricity and steam would increase by 10 per cent, leading to an expected increase in the price for end-consumers of 5 per cent. This means that the costs for all household energy services and related equipment would increase by about 56 Euro per household in 2010. The average cost of industrial output in 2010 would increase by 0.8 to 5 per cent for energy-intensive sectors, i.e. iron and steel, building materials, non-ferrous metals, paper and pulp and chemical (see **Table 5)**. Further analysis shows that the iron and steel sector and the building materials sector are at the high end of the cost range for achieving emissions reductions, whereas the cost increase for the paper industry lies at the low end. The increase in the average cost for non-energy intensive sectors is in the range of 0.5 to 1 per cent.

Table 5: Increase in production costs compared to the baseline scenario for different energy-intensive industries due to the implementation of reduction measures to reach the Kyoto target of -8 per cent (Carpos et al, 2001)

Energy intensive industry	Increase in production costs compared to the baseline in 2010
	1% 2% 3% 4% 5% 5%
Chemical industry	
Iron and Steel	
Non ferro industry	
Building Material	
Paper	

Higher production costs can to some extent be passed on to end-consumers. However, this may cause problems in cases where competition occurs with companies from the US or from non-Annex I (developing) countries that do not have to increase their prices because of implementing climate change policies.

A distinction needs to be made between sheltered and exposed sectors. It is assumed that sheltered sectors do not have to compete significantly on the international level and that they can in principle pass the price increases resulting from climate change policies on to end-consumers. Exposed sectors are defined as sectors that have to compete with countries outside the EU and have, according to (KPMG, 2000)[3]:

a) an export ratio (share of total export in total domestic production) greater than 15 per cent and/or
b) an import penetration ratio (share of total competitive import in total final consumption) greater than 15 per cent.

In analysing the effect of the Kyoto Protocol without the US, additional criteria for exposed sectors are that they have to face:
c) a substantial increase in production costs due to investments in climate change reduction options (in principle these are the energy intensive sectors)
d) competition on the US market or with products coming from the US.

5.2 Sheltered sectors

Starting from this definition of sheltered and exposed sectors, initial analysis shows that only energy-intensive industry sectors can be considered exposed. This means that at least 75 per cent of the cost-effective reduction within the EU can be implemented without affecting the competitiveness of the EU economy. The energy sector, with the largest reduction potential, is a sheltered sector because electricity producers only compete in the European market. It is assumed that an increase in production costs for electricity and heat of approximately 10 per cent will be (partly) passed on to end-consumers. The non-energy intensive sector may have to compete on the global market but because production cost increases are very limited it is assumed this will not hurt their competitiveness. The same argument goes for other non-industry sectors like the service sector and the agriculture sector.

[3] The definition corresponds to the definition used by Eurostat for globalised EU industries (Eurostat, 1999)

5.3 Exposed sectors

Table 6 shows the export and import ratio for energy-intensive industries in the EU and shows the geographical breakdown of EU imports and exports. The light grey areas mark the import and export ratios between 10 and 20 per cent and the dark grey area indicate ratios above 20 per cent. Initial analysis of these two tables shows that production of basic chemicals, iron and steel, non-ferrous metals and to a lesser extent the manufacturing of pulp and paper can be considered exposed sectors. Of these sectors the production of basic chemicals has to face the most competition from the US.

Table 6: EU export and import ratios for energy-intensive sectors in the European Union in 1990, 1992 and 1995 (Eurostat, 1999)

E=Export ratio	**1990**		**1992**		**1995**	
I=Import Ratio	E	I	E	I	E	I
Chemical industry						
Basic chemical	17%	14%	19%	15%	***22%***	17%
Iron and steel industry						
Basic iron and steel production	11%	5%	12%	5%	14%	8%
Non-ferrous-metals	14%	***34%***	16%	***38%***	20%	***41%***
Building material						
Glass	11%	5%	11%	6%	13%	7%
Bricks	1%		0%		0%	
Cement	1%	0%	1%		3%	
Paper						
Manufacture of Paper & Pulp	13%	13%	13%	12%	15%	14%

Table 7: Geographical breakdown of EU imports and exports (from countries outside the EU) for energy-intensive sectors in 1999 (Eurostat, 2000). E= Export and I= Import). The figures represent the share of export to or import from a specific geographical area in the total export or imports of the EU.

	US		**Japan**		**CEEC**		**Remaining**	
	E	I	E	I	E	I	E	I
Organic chemicals	45%	30%	8%	11%	0%	5%	47%	54%
Rubber man.	25%	15%	4%	20%	18%	22%	53%	43%
Plastics	13%	33%	3%	10%	22%	13%	62%	44%
Iron and Steel	22%	5%	1%	4%	16%	25%	61%	66%
Non-ferro	23%	9%	6%	2%	16%	13%	55%	76%
Man. Paper and Pulp	14%	19%	2%	3%	19%	16%	65%	62%

CEEC=Central and Eastern European Countries

The chemical sector as a whole faces a fairly limited increase in production costs due to the implementation of reduction options (**Table 5**). The production of basic chemicals is the most energy-intensive part of the chemical industry, which faces substantial competition from countries outside the EU. Approximately 45 per cent of total exports go to the US, equal to approximately 10 per cent of total production. European producers of basic chemicals suffer from a deficit in price competition with the US; the EU suffers from a trade deficit in volume in the presence of higher prices (Eurostat (2000) and CEFIC (2000)). This could raise problems when the sector faces additional climate change policies, which further increase product prices. On the other hand, energy-related CO_2 emissions are expected to go down due to a shift to high value-added, low-energy chemicals production. This can already be observed in the breakdown of the chemical trade surplus for 1999, in which pharmaceuticals accounted for the largest share (see **Figure 1**).

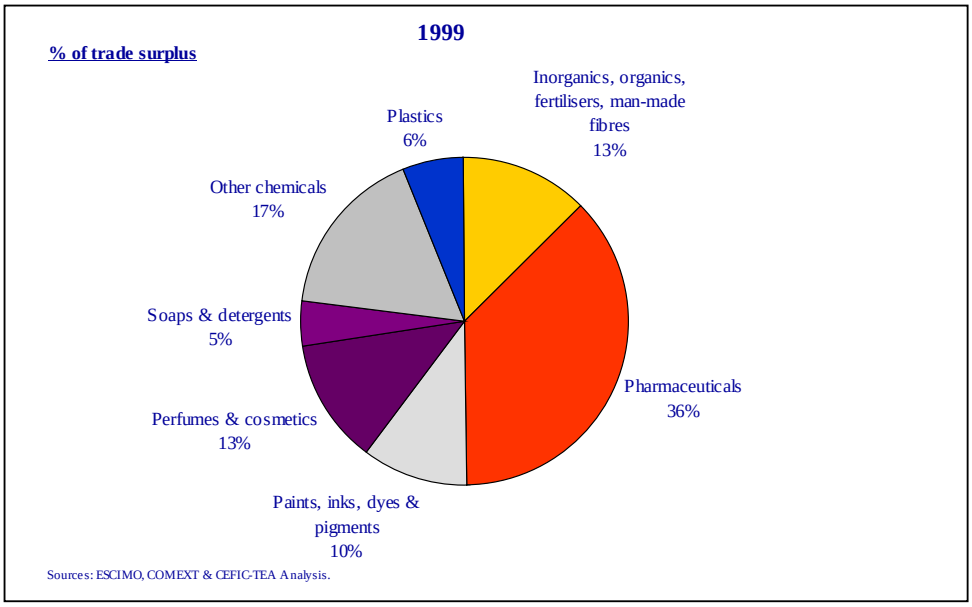

Figure 1: Breakdown of EU chemicals trade surplus (export minus import) (CEFIC, 2000)

The iron and steel industry faces the largest increase in production costs among the industrial sectors. This sector mainly faces import and export competition from other European countries: 70 per cent of steel exports go to other EU Member States and 10 per cent go to other European countries (see **Table 8**). This means that in principle there is a level playing field for the European steel industry if all companies face an increase in production costs. However, it must be noted that in theory there is a possibility that the share of imported steel in the EU would increase due to lower production costs in countries (like the US) that do not have to make investments in emission reductions.

Table 8: World trade in steel in 1999 (million metric tonnes) (IISI, 2000). The columns show the exporting regions; the rows show the destination of the exports. The grey diagonal figures from the upper left to the lower right represent the intra-regional export (i.e. the steel does not go outside the boundaries of the region) figures for the different regions.

Exporting Region>>> / *Destination*	**European Union (15)**	Other Europe	former USSR	North America	Latin America	Africa & Middle East	China	Japan	Other Asia	Oceania	Total Imports	Of which extra regional imports
European Union (15)	**70.4**	**12.6**	**3.8**	**0.2**	**1.4**	**1.3**	**0.4**	**0.7**	**3.4**	**0.6**	**94.8**	**24.3**
Other Europe	**10.9**	3.5	4.4	0.0	0.7	0.0	0.1	0.4	0.2	0.0	20.3	17.8
former USSR	**0.6**	0.1	3.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	4.6	0.9
North America	**7.0**	2.5	7.3	8.2	6.7	0.8	0.7	7.1	4.8	1.2	46.4	30.4
Latin America	**1.7**	0.8	1.0	1.6	4.2	0.2	0.0	1.1	0.5	0.1	11.3	6.2
Africa	**2.6**	1.5	1.6	0.1	0.0	0.7	0.3	0.4	0.3	0.0	7.6	7.4
Middle East	**2.1**	2.0	4.3	0.1	0.1	2.1	0.1	1.1	1.2	0.0	12.9	9.9
China	**0.4**	0.0	7.1	0.0	0.7	0.0	-	2.5	2.4	0.1	13.1	16.9
Japan	**0.1**	0.0	0.0	0.0	0.0	0.1	0.6	-	3.9	0.1	4.9	4.8
Other Asia	**2.0**	1.3	8.6	0.3	3.8	1.9	3.3	11.2	18.1	1.6	51.9	43.1
Oceania	**0.2**	1.2	0.0	0.0	0.0	0.1	0.0	0.4	0.4	0.4	2.8	1.6
Total Exports	**97.9**	25.4	42.0	10.5	17.8	7.3	5.6	25.0	35.2	4.1	270.7	163.4
of which: extra-regional expor	**25.6**	19.2	47.6	2.0	14.4	3.9	6.0	25.8	16.0	2.8	163.4	

The non-ferrous metals sector is dominated by the aluminium industry. In 1999, only 4.9 per cent of US exports of aluminium went to the European Union and 5.8 per cent of the US imports came from the EU (Al Ass, 2000). As the non-ferrous metals industry only faces a limited increase in production costs it is assumed that additional policies and measures will hardly affect the competitiveness of this sector.

The building materials industry has to face the second largest increase in production costs among the industrial sectors. The market for building materials is however mainly a European domestic market (with the possible exception of the glass sector) and does not face much competition from countries outside the EU. It can therefore be assumed that an increase in production costs due to additional climate change policies can be passed on to consumers.

The pulp and paper industry faces only a limited increase in production costs and competition from the US is limited. We therefore assume that the implementation of reduction options will not affects the competitiveness of this sector.

The above analysis shows that the competitiveness of the basic chemical industry and to a far lesser extent the iron and steel and glass industries may be affected if they have to implement reduction options according to the least-cost strategy of the European Union (i.e. in case of emission trading within Europe). This means that between 85 and 95 per cent of the reduction potential for the European Union can be implemented without harming the competitiveness of the EU economy.

It must be noted that in this section the competitiveness of European industry is analysed on a fairly aggregated sector level and that conclusions may not always hold when looking in more detail at specific small sub-sectors. It is very well possible that specific small sub-sectors or individual companies may face more competition than shown by the aggregated data used in this paper.

5.4 Smart policy options

Some industrial sectors may be affected because they are exposed to international competition from companies that are not subjected to climate change policies, i.e. US companies. There are, however, a number of possibilities to reduce the cost of implementation for these sectors through the implementation of smart policies.

One of the options for policymakers is to ensure that sheltered sectors implement a larger share of the overall emission reductions than foreseen in the least-cost approach, because competitiveness considerations play a smaller role in these sectors. On the one hand, this worsens the (direct) cost-effectiveness of the overall climate change strategy, but on the other hand it limits indirect effects on competitiveness. It can be compared to the approach taken in the past with regard to energy prices and energy taxes, with industry being partially exempted from energy taxes or price increases.

A second possibility is for sheltered sectors to implement a larger share of reduction options but with the possibility of trading between different sectors. This offers the possibility of having exposed sectors partly pay for measures in sheltered sectors.

A third option is that, via government sources, sheltered sectors contribute financially to the reduction options in the exposed sectors. A rule of thumb could be that measures with a limited payback period (e.g. 4 years) are implemented by the sectors themselves, possibly with some supporting measures such as low interest loans. If these measures are not sufficient to achieve the required emission reductions, compensation measures such as tax incentives could be employed.

Figure 2 shows what could happen to overall cost effectiveness if exposed sectors only implement measures with a payback period of less than 4 years. It is assumed that other sectors accept an additional burden to compensate for the reduction potential which industries should implement

following a least-cost approach; i.e. all measures with cost below 20 Euro/tonne. Shifting part of the burden means that the sheltered sectors now have to implement all measures with cost up to 29 Euro/tonne of CO_2.

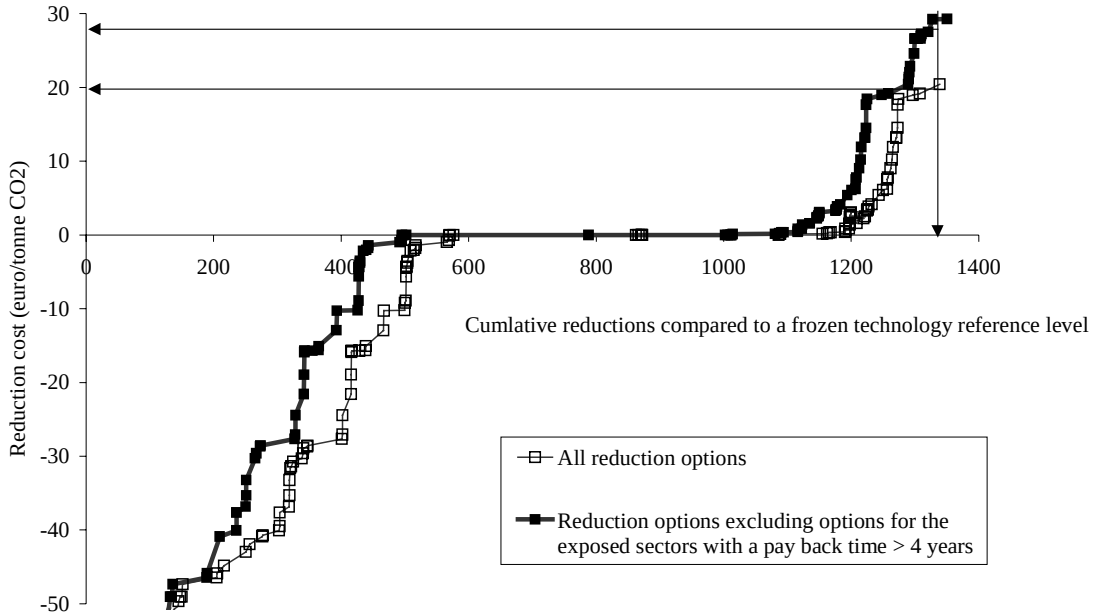

Figure 2: The specific costs of emission reductions as a function of the emission reduction in the European Union in 2010. The emission reduction is with reference to a level at which no emission reductions are implemented at all (frozen technology reference level)

6 Spill-over effects of climate change policies

Several studies show that climate change policies have significant spill-over effects on other environmental problems and can make it easier to achieve other environmental targets (ECN, RIVM (2000), RIVM et al (2000), Interlaboratory Working Group (2000)). **Figure 3** shows that climate change policies have significant spill over effects for acidification, particulate matter and heavy metals. A 15 per cent reduction in CO_2 emissions, compared to the baseline, leads to greater than 15 per cent reductions in other substances. The spill-over effects mainly arise in the energy sector due to the shift from coal to natural gas. RIVM *et al* (2000) concluded that if no additional climate change polices were implemented an additional investment in end-of-pipe technologies of 6 billion Euro per year would be needed to reduce the acidification emissions to a level that would ensure reaching the targets as set in the EU's National Emission Ceiling Directive (NEC) (Note this is in the case of a 15 per cent reduction in EU CO_2 emissions). Comparing this to the annual compliance cost for the EU to reach the Kyoto target of 3.7-7.5 billion Euro, this would mean that in a 'smart' policy scenario large parts of the greenhouse gas emission reductions can be obtained for 'free', assuming that other environmental targets have to be met without delay.

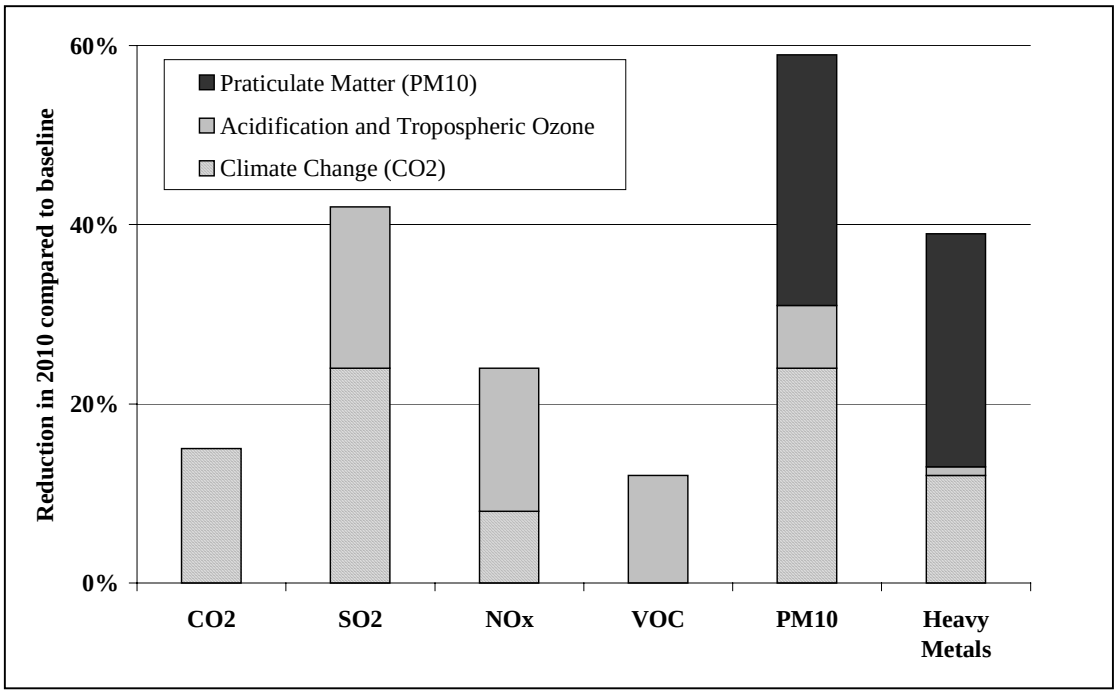

Figure 3: Spill-over effects from climate change policies; acidification and tropospheric ozone policies and primary particulate matter and heavy metals measures for the European Union (source RIVM et al, 2000)

Furthermore, climate change policies can contribute to the aims and objectives set out in the EU Green Paper on the security of energy supply (EC, 2000). The green paper sets out a strategy to ensure the energy supply of the European Union in the long-term. Expectations are that the European Union will become increasingly dependent on imported energy products; an increase from the current 50 per cent to about 70 per cent in 2030, a trend that will be reinforced by the enlargement of the European Union from 15 to 30 countries (see **Figure 4**). Implementation of climate change policies that lead to a reduction in energy demand could contribute to the aims of lowering the dependence of European Union on external sources.

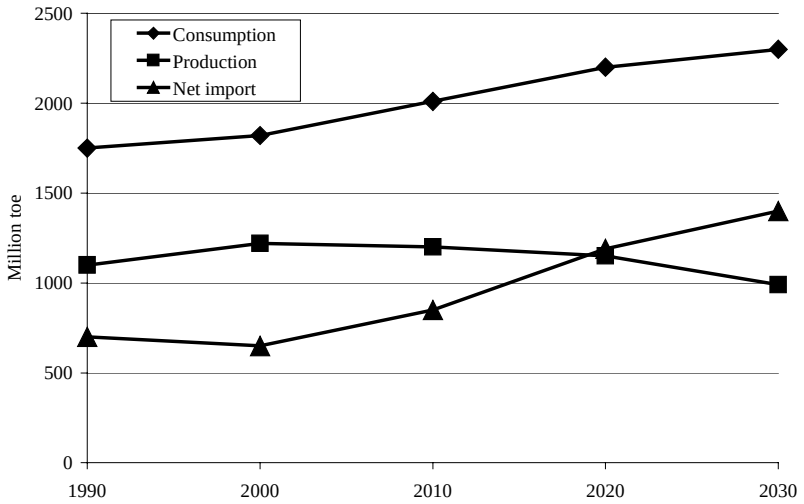

Figure 4: Projected baseline development of total energy consumption, production and import for Europe in the case of enlargement to 30 Member States (EC, 2000)

The Kyoto Protocol target can be achieved with well-known technologies. The shift from coal to natural gas, the further improvement of energy efficiency as well as the technologies to reduce emissions of non-CO_2 greenhouse gases are in most cases well developed. In the expectation of further emission reductions, it can be expected that new innovative technologies will emerge, as the potential to reduce emissions through well-known technologies is not boundless. For example, a shift from coal to natural gas is the most important option for the first commitment period (2008-2012) but will need to be superceded by more innovative technologies, such as renewable energy sources, to deliver further reductions in subsequent periods. A unilateral implementation of the Kyoto Protocol by the EU could give European industry a head start in the development of innovative technologies for the reduction of greenhouse gases in the longer term.

Not implementing the Kyoto Protocol may lead to substantial increases in mitigation costs on the longer term. It is generally accepted that a delay in the implementation of global climate change policies will limit the choices for reduction options in the future to meet the objective of the UN Climate Convention namely, stabilising greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous anthropogenic (human-induced) interference with the climate system (RIVM, 2001). An 'early' start with climate change policies could lead to substantial cost reductions for Europe in the future.

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