ECONOMIC EVALUATION OF SECTORAL EMISSION REDUCTION OBJECTIVES FOR CLIMATE CHANGE: SUMMARY REPORT FOR POLICY MAKERS

EXECUTIVE SUMMARY

Background

This report summarises the results of a two year study to identify a least-cost allocation of objectives for different sectors and greenhouse gases that allows the European Union to reduce its greenhouse gas emissions by 8% by 2008 – 2012 compared to 1990 emissions. This is the level stipulated by the commitments in the Kyoto Protocol. This approach will fully maintain the environmental integrity of the Kyoto Protocol, while identifying those policies and measures that achieve the Kyoto target in a manner that minimises the cost. Simply, the intention is to identify a least-cost allocation so that the cost of production of energy and other goods would increase as little as possible.

An important back-drop to this study is the fact that often, a reduction target is allocated uniformly to different sectors (i.e. an –8% reduction is allocated to all sectors). This is done because the regulator has no information on the reduction potential in the individual sectors and is consequently forced to use a "one-size-fits-all" approach. However, this approach can prove to be very costly. In a recent European Commission study[1] it was shown that the cost of reaching the Kyoto target would more than double if each sector had to attain the same percentage emission reductions. In short, following a least-cost route, the EU Member States could make annual savings of € 11.5 billion compared to a situation where each sector has a uniform objective. There are different pathways to reach the Kyoto target and the objective of this study is to identify the cheapest one.

Caveats and coverage of the study

Even if the potentially cheapest allocation is identified, it does not automatically mean it should be adopted. Two of the most important reasons for deviating from an identified least cost allocation are that: *i)* some options may not be politically or otherwise feasible e.g. due to strong lobby group pressure or due to technical or social difficulties; and *ii)* choosing a longer time horizon than used in this study (2008-2012) could give rise to a different allocation, since the longer-term potential of technological progress is taken into account. Such consideration of allocations was beyond the scope of this study.

Some options, such as fuel cells, have not been included in this study because of their technological limitations and expected development up to 2010. Thus, deviations from the least-cost objectives set out in this study may be reasonable, if there is evidence that setting tougher objectives for a particular sector would induce further technological development that would pay off in the subsequent commitment periods.

While the results of this study are based on a state-of-the-art methodology and the input data was extensively examined, it is possible that some mitigation options have been omitted, or that the potential of some measures has been over or under-

[1] See "The Economic Effects of EU-wide Industry-Level Emission Trading to Reduce Greenhouse Gases - Results from PRIMES model", available at: http://europa.eu.int/comm/environment/enveco/.

estimated. Thus, the results presented should be used with care. This caveat applies even more when considering the results for separate Member States. This is because, for instance, it has not been possible to take into account all local circumstances when mitigation options have been defined. However, it is felt that the results by Member State are an important additional input to the EU endeavours to reach the Kyoto target most cost-effectively.

Due to the extensive coverage of all gases and due to the unavailability of detailed data in some sectors (e.g. aviation) it has not been possible to cover all sectors equally deeply. Thus, due to such information constraints it is possible that some reduction opportunities are missed. This would introduce a bias which would lead to an overestimation of total compliance costs and to a lower reduction objective for the sector where data is not available.

As the coverage of this study is wide there are more uncertainties attached to the results of this study than if the scope had only been for e.g. energy related CO_2 emissions. However, due to a rigorous and consistent analytical treatment of all greenhouse gases, it is believed that this study is relatively unbiased and thus an important contribution to understanding the costs of mitigation options of greenhouse gases.

This report is the first time that all greenhouse gases have been included in an EU wide study. However, due to paucity of data, land-use change and the corresponding changes in biological sinks have not been included. Furthermore, for the purposes of this study, it was assumed that the EU would reach its target without using the flexible mechanisms[2].

Methodologies and examination of input data

The study combines a "top-down" and a "bottom-up" methodological approach and compares them as far as possible. As both approaches have their strengths and weaknesses, they complement each other, and increase understanding of different cost-effective greenhouse gas mitigation options.

1. In the "top-down" approach, the PRIMES model is used in which all options are analysed simultaneously. Here, it is more difficult to separate distinct options from one another. Thus, it is unclear what exactly the results imply from a policy point of view. Also, the "top-down" approach is less detailed compared to the "bottom-up" approach. However, the advantage of the top-down approach is that the results are 100% consistent within the model. The "top-down" approach and the detailed results of the analysis are described in a separate report, prepared by the National Technical University of Athens[3].

2. In the "bottom-up" approach, different technological options for the reduction of greenhouse gas emissions were identified, their investment and operation costs

[2] These flexible mechanism are International Emissions Trading, Joint Implementation and Clean Development Mechanism. The EU would most likely pay other Parties of the Kyoto Protocol so that they would take action to reduce their greenhouse gas emissions and correspondingly, the EU would need to mitigate less within its area. In such a case the least-cost allocation would change to some extent. It was beyond the scope of this study to analyse such cases.

[3] P. Capros, N. Kouvaritakis, L. Mantzos (2001): Top-down analysis of greenhouse gas emission reduction possibilities in the EU, National Technical University of Athens, Athens, March 2001

calculated and, finally, the cost per ton of CO_2 equivalent determined. The "bottom-up" approach and the results of the analysis are described in a separate report[4] and in several sector reports, which were prepared by Ecofys Energy and Environment and AEA Technology Environment. The advantage of the "bottom-up" approach is that the options for reducing greenhouse gas emissions are clear and easy to understand. However, it can not dynamically analyse simultaneous or behavioural changes[5] in demand and supply of energy, as is the case in the PRIMES model.

The assumptions and the data used in this study were examined in detail by industry and NGO experts as well as the European Commission staff. The examination was carried out in seven workshops, four of which were held in November 1999 and three in March 2000, as well as with bilateral contacts. Given the extensive coverage of this study, it has not been possible to include all suggestions arising from the workshops in the final analysis. Where this has not been possible, or in cases where differences of opinion have ensued (e.g. concerning forecasts of sector growth), the issues have been highlighted in a transparent manner in the sector specific reports to allow possible follow-up work.

EU-wide results

For non-CO_2 greenhouse gases and process emissions of CO_2 only the bottom-up approach was used. This study reports the base year emissions for 1990 or 1995 (the latter is used for the fluorinated gases - HFCs, PFCs and SF_6), the baseline emissions in 2010 and identifies available mitigation options. These options were combined with the top-down analysis for energy related CO_2 emissions, resulting in the main findings of the study (Table A, full details in Annex 1). The marginal cost for emission reduction would be €$_{99}$ 20 per tCO_2 eq., taking a successful implementation of the ACEA agreement into account[6].

Instead of each sector having to reduce its greenhouse gas emissions by 8% from 1990 emission levels, the least cost allocation methodology implies that some sectors need to reduce their emissions by more than 8%. These sectors are energy supply (11%), fossil fuel extraction (46%), industry (26%), agriculture (8%) and waste (28%). It should be noted that since the projected growth of greenhouse gas emissions in these sectors is negative (with the exception of energy supply), the real effort needed to make the required reductions is less than it appears. Taking this into account, the real reductions that these sectors would need to make from their projected 2010 emissions are much lower: for fossil fuel extraction (16%), industry (12%), agriculture (4%) and waste (13%). Emissions in the remaining sectors would need to be reduced from their projected levels in 2010 as follows: transport (4%) (this includes the full implementation of the ACEA agreement), households (6%), commercial and public services (15%). The overall weighted reduction remains at 8% from 1990.

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[4] C. Hendriks, D. de Jager, K. Blok et al. (2001): Bottom-up Analysis of Emission Reduction Potentials and Costs for Greenhouse Gases in the EU, Ecofys and AEA Technology, Utrecht, March 2001

[5] For instance, if the price of oil increased, renewable energy would become more attractive, and power generators would shift towards renewables. The larger the increase in the price of oil, the more there would be a shift towards substituting energy sources. In a top-down approach based on an energy systems model like PRIMES, these changes can be analysed but a detailed "bottom-up" approach can handle such changes only partially.

[6] See footnote 7 in the main text.

Table A Summary of the EU-wide allocation of least-cost objectives for different sectors to reach the Kyoto target of –8% in 2010

EU-15 **Emission breakdown per sector *(top-down)***	**Direct emissions (Mt CO2 eq.)**				
	Emissions in 1990/95	*Baseline emissions in 2010*	***Cost-effective objective 2010***	*Change from 1990*	*Change from 2010 baseline*
Energy supply[1/2/]	1190	1206	**1054**	-11%	-13%
Non-CO_2 fossil fuel[3/]	95	61	**51**	-46%	-16%
Industry[2/]	894	759	**665**	-26%	-12%
Transport[4/]	753	984	**946**	26%	-4%
Households	447	445	**420**	-6%	-6%
Services	176	200	**170**	-3%	-15%
Agriculture	417	398	**382**	-8%	-4%
Waste	166	137	**119**	-28%	-13%
Total	**4138**	**4190**	**3807**	**-8%**	**-9%**

Note: The ACEA agreement is included in the baseline, the marginal cost is €$_{99}$ 20 per tCO_2 eq.

[1/] Energy supply comprises power and steam production and refineries.

[2/] Eurostat definition of sectors: Industrial boilers are allocated to industrial sectors.

[3/] Non-CO_2 greenhouse gas emissions from fossil fuel extraction, transport and distribution.

[4/] Due to data inavailability, emission data for the transport sector include international aviation, which is excluded in the IPCC inventory methodology.

Source: This study

According to the least-cost allocation of sectoral objectives EU-wide, the compliance costs for the EU would be €$_{99}$ 3.7 billion per annum for the period 2008-2012 (0.06% of EU GDP in 2010)[7]. Compared to the baseline, the cost increase will be limited for most sectors: the average electricity and steam generation costs would increase by 10%, energy costs for most energy demand sectors would increase by 5% at most. For example, costs for all household energy services and related equipment will increase by about €$_{99}$ 56 per household, per year.

The six most important ways for the EU to reach the Kyoto target in the most cost-effective manner are identified as being:

- Decarbonisation of energy supply
  - Further switching from coal to gas.
  - More efficient generation of power (e.g. increasing the share of Combined Heat and Power).
  - Increase in the use of renewable energy (notably biomass and wind energy).
- Improvement of energy efficiency, particularly in industry, households (retrofitting) and the services sector.
- Further reduction of nitrous oxide from the adipic acid industry and implementation of reduction options in the nitric acid industry.

[7] With the ACEA/JAMA/KAMA agreement incorporated in the baseline; full flexibility scenario, i.e. a European-wide allocation of least-cost objectives for different sectors. If the ACEA agreement was excluded from the baseline, the compliance costs would be €$_{99}$ 2.9 billion higher.

- Reduction of methane emission in coal mining, the oil and natural gas system as well as waste and agriculture sectors.
- Reduction of fluorinated gases in specific applications, e.g. industrial processes, mobile air conditioning and commercial refrigeration.
- Energy efficiency improvement measures in the transport system.

Results per Member State

Table A shows an EU-wide allocation of least-cost objectives for different sectors. If each Member State fulfils their target individually according to the Burden Sharing Agreement, the least-cost allocation changes by coincidence so little, that the percentages in Table A would not be altered significantly. However, the marginal abatement costs would increase from €$_{99}$ 20/tCO_2 eq. to €$_{99}$ 42/tCO_2 eq. (weighted EU average). Thus, the total compliance cost of all EU Member States would increase from €$_{99}$ 3.7 billion to €$_{99}$ 7.5 billion per annum. The marginal abatement cost in each Member State would range from €$_{99}$ 1/tCO_2 eq. to over €$_{99}$ 100/tCO_2 eq. Annex 2 disaggregates the results to each Member State, taking into account the Burden Sharing Agreement.

One way of interpreting the difference between the EU-wide allocation and the Member State based allocation approach is to identify this as a potential for EU-wide emission trading[8]. An alternative way to interpreted the difference is a recommendation for the allocation of a specific number of permits to those sectors that would be given the possibility to participate in emission trading and specific objectives to those sectors that are subject to other policies and measures. These interpretations are useful to keep in mind when using this study to identify policies and measures either at the EU level, i.e. in the Working Groups of the European Climate Change Programme, or in Member States.

Table B summarises the results:

Table B Marginal abatement and total compliance costs for both an EU-wide and a Member State allocation of least-cost objectives to reach the EU Kyoto target of –8% in 2010

	Marginal abatement cost in 2010	Total compliance cost in 2010
EU-wide allocation of least cost sectoral objectives ('full flexibility case')	€$_{99}$ 20/tCO_2 eq.	€$_{99}$ 3.7 billion/yr
Allocation of least cost sectoral objectives in each Member State ('burden sharing case')	€$_{99}$ 42/tCO_2 eq.	€$_{99}$ 7.5 billion/yr

Note: in both cases the amount of greenhouse gases reduced is exactly the same (331 Mt of CO_2 eq from 1990)

[8] In this case it would be (unrealistically) assumed that emission trading would be possible across all sectors and all greenhouse gases. Thus, EU-wide emission trade could save as much as half of EU Member States total compliance costs.

Recommendations

The objective of this study was not only to identify the least cost allocation of sector specific objectives but also to define which policies and measures would be most appropriate to realise such an allocation. In the context of this study, it was not possible or meaningful, to give recommendations on policies and measures to be undertaken to realise each reduction option identified. An attempt has been made in this summary for policy makers to suggest relevant policies and measures when appropriate. They are given in some cases in the sector specific chapters but mainly collected at the end of this summary. The highlights of the recommendations are:

1. Emission trading among all Member States in well defined sectors holds the potential for significant cost reductions (up to half of total compliance costs) in reducing greenhouse gas emissions to 8% less than 1990/1995 emissions levels. It is recommended to include not only energy related CO_2 emissions but also, when measurable, other greenhouse gases. Such gases would be process emissions of CO_2 in the cement, iron and steel, and chemical industries, PFC emissions from aluminium production, N_2O emissions from adipic and nitric acid production, HFC emissions from chemical industry (by-product of HCFC22 production) and process emissions of CH_4 in the oil and natural gas industry.
2. It is vital to fully implement all policies and measures, both at EU and Member State level, that are assumed to reduce greenhouse gas emissions. Examples are the ACEA agreement to reduce the average CO_2 emissions of new cars, the reductions of methane due to the implementation of the Landfill Directive and the action plan of the White Paper on Renewable Energy Sources. For combined heat and power, specific policies would need to be designed, preferably at the EU level, in order to increase its share option and to limit the possible negative impacts of the liberalisation on the European energy markets.
3. As the energy markets in the EU are currently undergoing liberalisation this may render more difficult the implementation of some CO_2 emission reduction options, in particular in combined heat and power. Therefore, the European Commission and the Member States should ensure that the transition period towards liberalised energy markets is as short as possible and, if required, additional policies and measures are designed to reduce possible negative impacts on emission reduction of greenhouse gases.
4. As energy consumption in public, commercial and residential buildings in the EU is still relatively high in comparison to attainable consumption levels, an EU-wide approach to reduce energy consumption is recommended. Such an approach might include the dissemination of information about successful policy instruments, further labelling of equipment and materials (e.g. for lighting and glazing) and research and development (e.g. concerning integrated approaches to low-energy and zero-energy buildings for the various climate zones in the EU). Retrofitting existing buildings for increased efficiency of energy use, better management of energy use in office buildings, carrying out energy audits of dwellings when they are handed over to new owners/tenants and building more energy efficient (both in terms of cooling and heating) new buildings are some options which offer significant reduction potentials.
5. The low cost options identified in the non-CO_2 gases in energy supply, industry, transport, agriculture and waste sectors should be fully exploited.

6. While beyond the remit of this study, it is clear that further reductions in the cost of compliance are possible thanks to research and development. Thus, research and development of emission reduction technologies should be further supported both at the EU and Member State levels. Such technologies could be made available before, during or after the first Kyoto commitment period. Examples include, fuel cells, renewable energy sources, CO_2 storage and catalysts for nitrous oxide emission reduction in the nitric acid industry and the transport sectors as well as reductions of HFC emission in cooling applications.

Reference :

Kornelis Blok, David de Jager and Chris Hendriks. 2001. 'Economic Evaluation of Sectoral Emission Reduction Objectives for Climate Change – **Summary Report for Policy Makers**, ECOFYS Energy and Environment, AEA Technology, National Technical University of Athens, Utrecht, March 2001.

http://europa.eu.int/comm/environment/enveco/climate_change/sectoral_objectives.htm