GREENHOUSE GAS EMISSION CONTROL STRATEGIES

GECS – Research Project N° EVK2-CT-1999-00010
Thematic Programme : Environment and Sustainable Development
DG Research Fifth Framework Programme

EXCERPTS FROM THE GECS FINAL REPORT

Prepared by P. Criqui, CNRS-IEPE (France)

from contributions of:

P. Tulkens, TFSD-FPB (Belgium)

D. Vanregemorter, CES-KUL (Belgium)

A. Kitous and Nguyen Anh Tuan, CNRS-IEPE (France)

N. Kouvaritakis, L. Paroussos, N. Stroblos and S. Tsallas, ICCS-NTUA (Greece)

C. Graveland, A.F. Bouwman, B. de Vries, B. Eickhout and B.J. Stengers, RIVM (Holland)

F. Eckermann and A. Löschel, ZEW (Germany)

P. Russ, JRC-IPTS (Spain)

D. Deybe and A. Fallot, CIRAD-amis Ecopol (France)

GECS: OBJECTIVES

The GECS project has been implemented in order to enhance the European capabilities for the economic analyses of long term (2030) Multi-Gas abatement strategies in the perspective of future climate negotiations. These analyses were only possible provided substantial improvements and enlargement in the modelling tools, of which the energy sector model POLES and the General Equilibrium model GEM-E3 that have already been extensively used by the Commission services. In order to provide the convenient analytical framework, it has been necessary to:

i Identify global cap and international emission permit endowment schemes that had to be consistent with the development in the on-going scientific assessment of climate change and international climate negotiation **(GECS Work Package 1.)**.

ii Develop a reference projections for non energy-related GHGs, bottom-up assessments of the different technological options to reduce these gases, and finally Marginal Abatement Cost curves for the different world region and time horizons **(GECS Work Package 2a.)**.

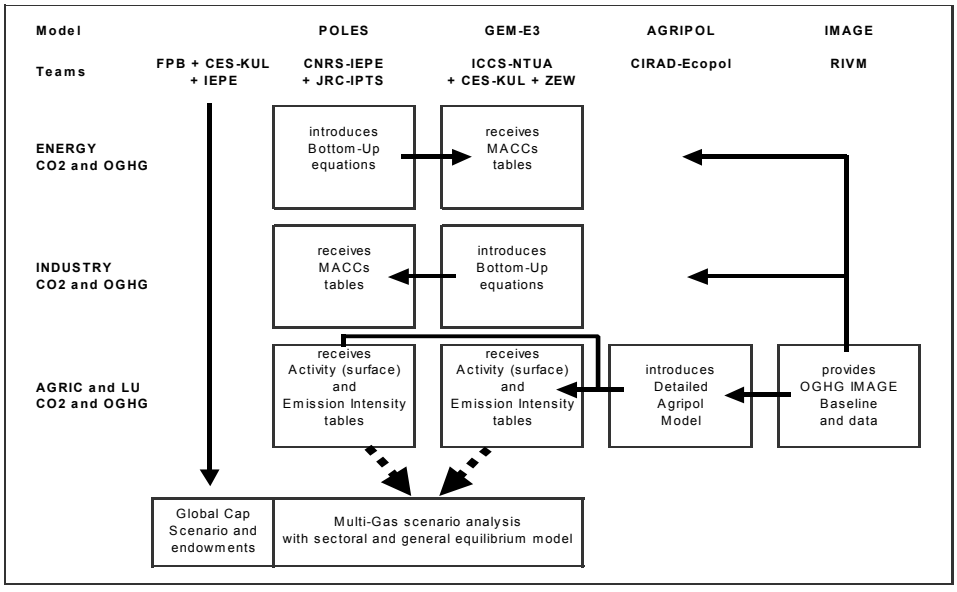
iii Build a new modelling framework for the simulation of the impacts of the introduction of a carbon value (CO_2 equivalent) in agricultural activities at the world regional level. This is based on the IMAGE model for the reference projections of agricultural activities and on the AGRIPOL model for the associated MAC curves **(GECS Work Package 2b.)**.

iv Improve and extend the POLES and GEM-E3 models in order to include all abatement options and MAC curves describing the potential abatement for the 6 Kyoto GHGs **(GECS Work Package 3.)**.

v Develop a full economic assessment of common global cap and endowment scenarios both with the POLES and with the GEM-E3 model, highlight the complementarity between the two modelling tools and explain – on the basis of sound economic analysis – the differences in results when they appear **(GECS Work Package 4.)**.

While Diagram 1 below illustrates the structure of the project and the circulation of information among the different teams/models, this Synthesis Report strictly follows the logic described above. *Section 2.* is dedicated to the analysis of global GHG emission trajectories and international permit endowment schemes. *Section 3.* presents the key technological information that has been gathered in order to prepare for the 6 GHG reference projection and MAC curves for energy, industry and wastes, while *Section 4.* concentrates on the modelling of the reference and MAC curves for agriculture. *Section 5.* briefly presents, without entering in full technical details, the improvements and extensions introduced in the POLES and GEM-E3 model in the framework of the GECS project. Finally *Section 6.* presents and analyses the detailed results of the Multi-Gas Emission Control Strategies, before *Section 7.* summarises the key findings of the project.

Diagram 1: Structure of the GECS project and corresponding information flows



GECS: CONCLUSIONS

The GECS project has demonstrated both the feasibility and usefulness of a research programme that proposed to combine different sources of information and expertise as well as different modelling approaches in order to produce coordinated economic assessments of policy scenarios. The key conclusions that came out of this process can be synthesised as follows:

- The abatement scenario that has been developed in the project, while taking into account the recent developments in the climate negotiation (including the US withdrawal as regards the First Commitment Period of the Kyoto Protocol) remains in line with the key targets of the UN-FCCC. The resulting abatement in world emissions of the 6 Kyoto GHGs corresponds to a reduction of about 15 % from the reference case in 2030.
- The international emission permit endowment scenarios associated to this "global cap", namely the Per Capita Convergence and the Soft Landing schemes, both respond to clear principles, respectively the "equality of rights in the future" and "the differentiated slowdown in emission growth for developing countries". When applied to the different world regions, they provide contrasted but consistent profiles. Both allow for endowments that largely benefit to the least developed regions of the world, these benefits being of course larger in the Per Capita Convergence.
- The detailed examination of the abatement options for other GHGs, whether in the energy and industry sectors or for waste, landfills and wastewater, has proved the importance of the corresponding potentials. The bottom-up analysis, confirmed by analysis of the global MAC curves produced by the models, show that the emissions of some activities are almost inelastic to the introduction of a GHG penalty, as in the case of CO_2 from cement production, while on the contrary other show an extreme sensitivity with reductions of more than 50 % for a high penalty level of about 50 €/tCO_2e (case of methane in gas transport, nitrous oxide in the chemical industry, PFC in aluminium and SF6 in semi-conductor industries). For the same level of penalty, most other activities show intermediate reduction levels, in the range of 20 to 40 %.
- As far as agricultural activities are concerned, the use of the IMAGE model has allowed for the development of an emission scenario that is consistent with the reference scenario in the project (the IMAGE scenario also provided the basis for the projection of emissions from waste, landfills and wastewater).
- Connected to this scenario, the development of the AGRIPOL model has introduced innovative treatments for simulating the impacts of a GHG penalty on emissions from agriculture, through changes in the basket of agricultural techniques. Given the hypothesis of a fixed demand for agricultural products that has been adopted in the project, the reaction of the agricultural sector has shown to be very limited, as the substitutions among techniques are either limited or entailing only a minor shift in the emission balance. This is all the more true when one considers that the margins for freedom in the choice of techniques will be substantially reduced to the 2030 horizon, when the pressure on available land and for higher productivity will strongly increase.
- This indicates that the contribution of agriculture to emission reduction abatement may be limited, unless significant changes in the structure of the demand for agricultural products occur. This issue remains to be explored as it implies a careful consideration of many complex economic factors, including international trade issues, and probably also sociological factors.
- Valuable information on two issues of fully different nature, carbon sinks and transaction costs, have been gathered in the project and are presented in the above report. However, for the sake of simplicity and consistency of the modelling exercises, these two items have not been included in the full economic analysis of the multi-gas scenarios with the partial and general equilibrium models.
- The analyses of the abatement scenarios – two multi-gas with Soft Landing or Per Capita Convergence endowments and two CO_2-only with different abatement targets – have been performed with two complementary modelling tools, POLES and GEM-E3. Their results provide useful insights for the design of global GHG abatement policies insofar as some of them are in full convergence, while other illustrate impacts that can only be seized by each

particular model, the former focusing on the sectoral/technological aspects and the latter on the macro-economic consequences of the abatement scenarios.

- Among the common statements to be drawn from the two families of exercises one can identify:
  - The demonstration of the relevance of the multi-gas strategies, as it appears that going from a CO_2-only to a multi-gas policy either allows to increase of about one fourth the total GHG abatement for the same Marginal Abatement Cost or to reduce of around 30 % the Marginal Abatement Cost for the same abatement in volume in 2030.
  - The level and profile of the GHG penalty induced by the emission constraint are highly consistent: in the POLES multi-gas exercise, the level of the penalty ends at 25 €/tCO_2e in 2030, while the corresponding value is of 18 €/tCO_2e in the GEM-E3 exercise. This is easily understandable as in the general equilibrium model, the macro-economic impacts of the abatement policy also result in changes in the level and structure of the economic activity, thus lowering the penalty that is necessary to meet the emission constraint.
  - As regards the comparative assessment of the two international endowment schemes under review, both models point to the fact that the Per Capita Convergence scheme, although globally more favourable to the least developed regions, may impose very high costs not only to the industrialised permit importing countries but also to regions such as the former Soviet Union and, to a lesser extent, China. On the contrary the Soft Landing scheme may be more acceptable for the developed regions of the world, while preserving net benefits and thus sufficient incentive for participation of the least developed regions.
- On top of these common statements, the main insights provided by the POLES model are related to the impacts of the abatement scenarios on the world energy system and list as follows:
  - All scenarios imply a significant restructuring both in the world primary energy supply and in the global demand for energy. In 2030, the latter is 7 to 10 % lower in the different abatement cases than in the reference. But the fuel mix in energy supply is of course also profoundly modified, with reductions in coal consumption of 27 to 37 % in 2030 and increases in nuclear and new renewable energy of respectively 19 to 32 % and 30 to 49 %, according to the case considered.
  - Not surprisingly indeed, the impacts on world demand and primary fuel mix are less pronounced in the multi-gas than in the CO_2-only cases. This phenomenon may be viewed as an adverse consequence of the multi-gas approach, but it is easily understandable as being the counterpart of introducing more margins of freedom in the abatement effort, with the corresponding gains in terms of total cost of the programme to be implemented.
- The results of the GEM-E3 model also provide rich insights in terms of understanding of the impacts of abatement policies on the activity of the different sectors and welfare of the world regions, with consequences for policy design:
  - The cost of achieving the abatement cases ranges between 0.65 and 0.85 percent of world GDP in 2030. The introduction of the multi-gas approach is particularly beneficial to the adjustment process of the most developed economies that have to face the bulk of the abatement costs.
  - However, the energy exporting regions, such as the Middle-East and to a lesser extent Former Soviet Union, may be severely affected in terms of welfare loss, principally due to the relative decrease in the price of their main exports. This might legitimate the fact that more attention has to be paid to the definition of the emission endowments for those particular regions.
  - Finally it appears from the endowment schemes comparison that the more egalitarian Per Capita Convergence rule clearly favours, as mentioned above, the developing world but that it also involves significantly stronger initial shocks and thus higher adjustment costs for the world economy as a whole. This demonstrates the nature of one of the key trade-offs that have to be carefully considered in the design of international climate policies.