OSTC (SSTC/DWTC)

Belgian Federal Office for Scientific, Technical and Cultural Affairs

"Climate Change, International Negotiations and Belgian Strategies" (CLIMNEG project)

Final Report 2001

Executive Summary

partners:

I. Center for Operations Research and Econometrics (CORE),
Université Catholique de Louvain

II. Institut d'Astronomie et de Géophysique Georges Lemaître (ASTR)
Université Catholique de Louvain

III. Centrum voor Economische Studiën (CES-ETE)
Katholieke Universiteit Leuven

IV. Federal Planning Bureau (FPB), Belgian Government

co-ordinator:

Professor Henry Tulkens
Université catholique de Louvain
.

C.O.R.E
34, voie du Roman Pays
B-1348 Louvain-la-Neuve
Belgium

Tel: + 32 10 47.43.32
Fax: + 32 10 47.43.01
e-mail: haas@core.ucl.ac.be

"Climate Change, International Negotiations and Belgian Strategies"

(CLIMNEG project)

Final Report 2001

Executive Summary

1. Objectives and research strategy

Conceived of in the early months of 1996 and created at the end of that year, the network has been devoted to the *interdisciplinary* study of decision making in matters relating to climate change.

The overall overall objective was to integrate what can be obtained from economic theory (CORE), climate sciences (ASTR), econometric simulation (CES), administrative and diplomatic experience (FPB) in the area, using simulation models as main research tool and common language.

The strategy was to structure the work into four parts, corresponding to four implemented projects:

Project CLIMNEG I : On the basis of existing economic-climatic models, the first purpose was to develop their economic components by searching for a characterization of the policies (scenarios) of greenhouse gases abatement in a multi-region world model, in terms of three alternative criteria (optimality, equity, strategic stability), by analyzing the ways to share the burden of those policies, and by examining the possibility of activities to be implemented jointly by different groups of countries.

Project CLIMNEG II had as purpose to look for enrichments of the climatic components of the basic models by integrating transfer functions that reflect the most recent state of the art, and thereby evaluating the effects on the global climate of the different scenarios studied in the economic component.

Project CLIMNEG III had as purpose to include, in an econometric component added to the basic models, the effects of these policies on economic equilibria at the world, European and Belgian levels.

Project CLIMNEG IV was to confront research activities with practice, by studying two fundamental aspects of the institutional implementation of policies, namely the international implementation of the instruments, and the coordination mechanisms between the decisions made by the concerned countries.

Using the methods of each of these disciplines involved in the network (physics, economics, econometrics), the purpose was to define, characterise and calculate policies of greenhouse gases abatement at the world, European and Belgian levels. The role of the simulation results was to serve as a reference for those who are in charge of participating, for our country, to the international negotiations.

2. Results

Although the results are presented below under four headings that approximately correspond to the four projects outlined above, it must be stressed that the interactions between the researchers has been so strong that all results must be considered common to the entire research group. A companion research project called CLIMBEL, started in 1998, on which it is reported separately, produced further joint results. Those of both CLIMNEG and CLIMBEL are collected together in the series *CLIMNEG-CLIMBEL Working Papers* whose titles are listed at the end of this report. It is referred to them by the acronym **CWP** followed by the number in the series.

Space constraints for this executive summary compels one to make a selection among the contributions made, a selection guided more by the necessity of homogeneity than by the intrinsic importance of some of the papers. The summary is therefore quite incomplete. A fuller appreciation of the contributions can be obtained by reading the final report or, better, the papers themselves.

I. At the ***economic theoretical*** level, the project has yielded the main following insights:

- Extending to *stock* externalities — an extension required by the nature of the climatic change problem — results that were available in the literature *on the strategic stability of cooperative agreements* in transfrontier (flow) pollution problems. The essence of the result obtained here (**CWP n° 1, 2, 6**) consists of an explicit formula to compute international resource transfers that induce the strategic

stability property. The fact that this extension was successful opened the way to the numerical simulations reported on under **II** and **III** below.

- Combining *equity considerations* with efficiency and strategic acceptability conditions in the design of abatement scenarios. The tool is again the one of international resource transfers, inspired by those reported on above, but corrected for equity purposes, and derived from alternative initial allocations of tradable emission permits. (**CWP n° 39**)

- An economic and game theoretic *interpretation of the Kyoto Protocol* (**CWP n° 12**). Based upon explicit modeling derived from the economic theory of competitive markets as well as from the theory of cooperative games the three following conclusions are established:

  (i) the quotas adopted in the Kyoto protocol are a step in the right direction, as far as overall international economic and environmental optimality is concerned;

  (ii) trading mechanisms for emission permits allow for an efficient and strategically stable allocation across countries of the overall abatement effort just mentioned;

  (iii) as far as future commitment periods are concerned, the "Kyoto scheme" of quotas — properly assigned — together with tradable permits constitutes an appropriate instrument for eventually reaching an international optimum, characterised by strategic stability.

II. At the ***climate modeling*** level, the project's main results are as follows:

- An improved climate module has been developed, from a starting model by Kverndokk, and validated on the basis of other two-dimensional models (**CWP n°21**).

- Extension of this improved model, whereby emission trajectories are translated into *regional* temperature changes, aimed at being fed back into the economic model through climate change damage functions.

- Introduction of *sulphate aerosols*: sulphate aerosols represent one of the main reasons for which regionalisation of impacts is important in economic studies. A

simplified way to represent the regional effect of aerosols was needed, however. A first attempt was made using results from the ASTR-UCL two-dimensional model, which includes the effect of aerosols (**CWP n°7**). Additional geographical information came from existing three-dimensional simulations made with coupled atmosphere-ocean general circulation models forced with both greenhouse gases and aerosols.

These improvements to the climate module (regionalisation and treatment of sulphate aerosols) allow the coupled climate-economy models mentioned in **I** above and **III** below to be one step ahead of the models existing in the literature. The first simulations using this improved climate module are described in **CWP n°32** and in **CWP n°44.**

III. As far as ***economic modeling and econometric simulations*** are concerned, the project's main results are the following:

- at the *world* level:

- A six regions integrated assessment model called *"Climneg World Simulation" (CWS)* has been constructed, derived from the Nordhaus and Yang model published in 1996. For this CWS model, the stability inducing transfers identified in **I** above have been computed and efficient stable cooperative emission trajectories determined. These appear to be quite more demanding than Nash equilibrium ones, although the economic gain they induce is only moderate. This sheds some light on the issue of the relative importance of national *vs.* global policies. Another remarkable finding from these simulations is that while world consumption is steadily increasing in the long run under the efficient (and stable) emissions scenarios, world consumption is not sustainable under Nash as well as business as usual scenarios in the sense that it is bound to decrease from the middle of the next century on (**CWP n° 18** and **19**).

- An extension of the CWS model has been subsequently formulated (**CWP n° 32**) to account for *sulphate aerosols,* which dampen the effects of CO2 concentrations on temperature. While this appears to be indeed the case in the early periods, later periods (beyond 2100) exhibit an overwhelming domination of the CO2 effects, rendering irrational sulphur emissions reduction.

- Finally, the *stability* of alternative forms of *international cooperation* has been tested using the CWS model in **CWP n° 40**, based on the theory of endogenous formation of coalitions. The analysis concludes with a strong stability of the "Kyoto coalition", in spite of credible possible deviations on the part of the countries that formerly belonged to the Soviet Union

- at the *European* level:

  - the EU "bubble" Burden sharing agreement on the distribution of the Kyoto emission reduction target over the EU member states was investigated using an "inverse opptimum" approach and marginal abatement cost curves. The simulations reveal that the EU bubble improves in terms of cost efficiency upon a uniform reduction assignment, but that substantial differences in marginal costs persist. (**CWP n°33**).

  - using the (pre-existing) GEM-E3 medium term general equilibrium model, marginal abatement cost functions have been estimated for the European countries as well as for 6 to 8 other regions of the world. This was done in order to compare the global costs of emissions reduction under alternative settings, an efficient one and a uniform one across countries. For the EU countries, the difference shows as follows: for a same tax of $100/ton of CO2, efficient allocation of the effort reaches 31% whereas uniformity of effort (that is, if no account is taken of cost differences between countries) allows only for 17%.

- at the *Belgian* level

  - using the (pre-existing) MARKAL partial equilibrium model of the energy system in Belgium, *marginal abatement costs* of greenhouse gases emissions abatement in 2010 for the country have been estimated. A figure of about BEF 2000/ton is obtained for reductions corresponding to Belgium's commitment under the Kyoto Protocol (**CWP n° 41**).

  - *Macroeconomic impacts for Belgium* of alternative domestic policies to meet the Kyoto targets are also reported on in **CWP n° 41**.

IV. At the ***interface between research and policy design***, an essential part of the CLIMNEG project (one fourth of the resources were devoted to it) was the inclusion in the researchers' team of members of the federal administration of the Belgian government, who are involved in the preparation, the attendance and the follow up of the international climate negotiations.

The specific tasks assigned to these persons and their activities in the network resulted in four categories of contributions:

- The preparation of *pedagogical documents* destined to political decision makers and high administration officials not directly involved as well as to the public at large, on various aspects of climate change issues, namely: the history and evaluation of international collaboration on climate change over the last ten years (**CWP n°28**); the theory and evaluation of tradable emission permits (**CWP n°29**); the fiscal instruments of climate policies (**CWP n°30**); the regulatory instruments of climate policies (**CWP n°31**); the communication instruments in national and international climate policies (**CWP n°38**); the voluntary agreements on emission abatement (types, characteristics, implementation, examples) (**CWP n°37**). All six documents have been re-issued in French as **CWP n°47.**

- Through the CLIMNEG coordination meetings, continuous *exchanges of information* and ideas between academics and practitioners, which led the former to be regularly briefed by the latter on the most recent developments (*e.g.* after the Kyoto, Berlin, Buenos Ayres, The Hague Conferences of the Parties and other meetings in Bonn). Reciprocally, practitioners have been offered ample exposure to conceptual and methodological results as they were developing, both in climate science and in economics (*e.g.* on alternative climatic models, on tradable permits, on cooperation issues, on simulation techniques, etc.)

- Increased motivation for academic members of the network to take part, when invited to, in several of the key events that occurred over the years in climatic change affairs, both internationally and in Belgian circles.

- Finally, diffusion of knowledge for the public at large, through public seminars, lectures, publishing of vulgarisation articles, and interviews given to the printed and audio-visual press.

3. Assessment

With the financial means set at the disposal of the research team, not only pre-existing research on climate affairs was allowed to be pursued in Belgium, but new research has been developed.

Interdisciplinarity is probably the most prominent characteristic of this new stage; it may also be considered as the most important as it was non existant beforehand. Obvious results of that are the greater attention attached by scientists in Belgium to the socio-economic implications of climate change policies, as well as the greater concern by Belgian social and economic scientists for the climate change problem.

A further result, specific to the CLIMNEG project, is that a team of increasingly competent persons has been formed, many of which are outside of CLIMNEG today but exert usefully their competence in a variety of institutions. Building this kind of capacity is probably a major and long lasting benefit of the project, for the community at large.

Last but not least, the scientific contributions themselves should have lasting effects. Those, to be judged by the publication record, cannot be seriously ascertained at this stage, given the long delays prevailing.

CLIMNEG & CLIMNEG-CLIMBEL WORKING PAPERS

List of Titles - Liste des Titres - Titellijst

Paper copies of CLIMNEG/CLIMBEL Working Papers can be obtained free of charge by ordering them at the CLIMNEG Secretariat, c/o CORE-UCL, Voie du Roman Pays 34, 1348 Louvain-la-Neuve, Belgium. - Phone +32 10 47 43 44 - Fax +32 10 47 43 01
E-mail: climneg@core.ucl.ac.be
Please also visit our website at http://www.core.ucl.ac.be/climneg

CLIMNEG WORKING PAPERS

N°1: GERMAIN M., TOINT Ph. and TULKENS H., 1997, "Financial Transfers to Ensure Cooperative International Optimality in Stock Pollutant Abatement" , published as chapter 11 in Faucheux S., Gowdy J. and Nicolai I. (eds), *Sustainability and Firms: Technological Change and the Changing Regulatory Environment*, Edward Elgar, Cheltenham, 205-219, 1998.

N°2: GERMAIN M., TULKENS H. and DE ZEEUW A., 1996, "Stabilité Stratégique en Matière de Pollution Internationale avec Effet de Stock: le Cas Linéaire", published in la *Revue Economique*, Paris, 49 (6), 1435-1454, 1998.

N°3: CURRARINI S. and TULKENS H., 1998, "Core-Theoretic and Political Stability of International Agreements on Transfrontier Pollution". (Also available as *CORE Discussion Paper* n° 9793)

N°4: TULKENS, H., 1997, "Cooperation vs. Free Riding in International Environmental Affairs: Two Approaches", published as chapter 2 in Hanley, N. and Folmer, H. (eds), *Game Theory and the Environment*, Edward Elgar, London, 30-44, 1998.

N°5: CHANDER, P., 1998, "International Treaties on Global Pollution: a Dynamic Time-Path Analysis", appeared in Ranis, G. and Raut, L. K. (eds), *Festschrift in Honor of T.N. Srinivasan*, Elsevier Science, Amsterdam. (Also available as *CORE Discussion Paper* n° 9854)

N°6: GERMAIN M., TOINT Ph., TULKENS H. and DE ZEEUW, A., 1998, "Transfers to Sustain Core-Theoretic Cooperation in International Stock Pollutant Control". (Also available as *CORE Discussion Paper* n° 9832)

N°7: BERTRAND, C., 1998, "A Short Description of the LLN-2D Global Climate Model", mimeo.

N°8: TULKENS, H. and VAN YPERSELE, J.-P., 1997, "Some Economic Principles for Guiding International Cooperation on the Issues Raised by Climate Change", handout for a lecture delivered at the "Global Change Workshop MIT-UCL", Petrofina, Brussels.

N°9: VAN YPERSELE, J.-P., 1998, "La Contrainte Climatique et le Protocole de Kyoto", communication au Symposium "Le Protocole de Kyoto: contrainte ou opportunité? Le défi des changements climatiques", Conseil Fédéral du Développement Durable, Bruxelles.

N°10: EYCKMANS, J., 1999, "Strategy Proof Uniform Effort Sharing Schemes for Transfrontier Pollution Problems", published in *Environmental and Resource Economics*, 14, 165-189.

N°11: CHANDER, P. and KHAN, M.A., 1998, "International Treaties on Trade and Global Pollution". (Also available as *CORE Discussion Paper* n° 9903)

N°12: CHANDER, P., TULKENS, H., VAN YPERSELE, J.-P. and WILLEMS, S., 1998, "The Kyoto Protocol: An Economic and Game Theoretic Interpretation", to be published in Dasgupta P., Kriström, B. and Löfgren K.-G. (eds), *Environmental Economics – Theoretical and Empirical Inquiries: Festschrift in Honor of Karl-Göran Mäler*, forthcoming Edward Elgar. (Also available as *CORE Discussion Paper* n° 9925)

N°13: BERTRAND, C., VAN YPERSELE, J.-P. and BERGER, A., 1998, "Volcanic and Solar Impacts on Climate since 1700", published in *Climate Dynamics*, Springer-Verlag, 15, 355-367, 1999.

N°14: EYCKMANS, J. en PROOST, St., 1998, "Klimaatonderhandelingen in Rio en Kyoto: een Successverhaal of een Maat voor Niets?" (Also available as *Leuvens Economisch Standpunt* n° 1998/91, Centrum voor Economische Studiën, Katholieke Universiteit Leuven, 1998)

N°15: D'ASPREMONT, Cl. and GERARD-VARET, L.-A., 1997, "Linear Inequality Methods to Enforce Partnerships under Uncertainty: An Overview", published in *Games and Economic Behavior* 25, 311-336 (1998).

N°16: BERTRAND, C. and VAN YPERSELE, J.-P., 1999, "Potential Role of Solar Variability as an Agent for Climate Change". *Climatic Change*, 43, 387-411, 1999.

N°17: D'ASPREMONT, Cl., 1998, "La Justice entre les Générations", published in *Reflets et Perspectives de la Vie Economique* (Brussels), 38 (1), 11-14, 1999.

N°18: EYCKMANS, J. and TULKENS, H., 1999, "Simulating with RICE Coalitionnaly Stable Burden Sharing Agreements for the Climate Change Problem". (Also available as *CORE Discussion Paper* n° 9926)
N°19: GERMAIN, M. and VAN YPERSELE, J.-P., 1999, "Financial Transfers to Sustain International Cooperation in the Climate Change Framework". (Also available as *CORE Discussion Paper* n° 9936)

Overleaf: CLIMNEG-CLIMBEL Working Papers

CLIMNEG-CLIMBEL WORKING PAPERS

N°20: VAN STEENBERGHE, V., 1999, "La Conception d'un Marché Domestique de Droits d'Emission de Gaz à Effet de Serre : Aspects Economiques", miméo.

N°21: BERTRAND, C. and VAN YPERSELE, J.-P., 1999, "Development of a New Climate Module for the RICE/DICE Model".

N°22: MILCHTAICH, Igal, 1999, "How Does Selfishness Affect Welfare?" (Also available as *CORE Discussion Paper* n° 9954)

N°23: BOUCQUEY, N., 1999, "L'Organisation d'un Marché de Permis Négociables: Notions Pertinentes en Droit Privé" (version provisoire – draft).

N°24: GERMAIN, M., LOVO, S. et VAN STEENBERGHE, V., 2000, "De l'Importance de la Microstructure d'un Marché de Permis de polluer".

N°25: BERNHEIM, Th. and GOUZEE, N., 1999, "A Sustainable Development Approach to Climate Change: Why and How?"

N°26: GERMAIN, M., TOINT Ph. et TULKENS H., 1999, "Transferts Financiers et Optimum Coopératif International en Matière de Pollutions-Stocks", publié dans *L'Actualité Economique. Revue d'Analyse Economique*, 75 (1-2-3), 427-446, 1999. (Version en langue française du CLIMNEG Working Paper N° 1.)

N°27: RAY, I., 2000, "Game Theory and the Environment: Old Models, New Solution Concepts".

N°28: BERNHEIM, Th., 2000, "Voortgang in de Internationale Samenwerking voor de Beheersing van de Klimaatproblematiek. Een Stand van Zaken." (Pedagogisch Fiche n° 1)

N°29: BERNHEIM, Th., 2000, "Verhandelbare Emissierechten en Geografische Flexibiliteit voor Reducties in Broeikasgassen: De Kyoto-Mechanismen." (Pedagogisch Fiche n° 2)

N°30: BERNHEIM, Th., 2000, "De Inzet van Fiscale Instrumenten in het Klimaatbeleid: Theoretische Concepten en Praktische Uitvoering." (Pedagogisch Fiche n° 3)

N°31: BERNHEIM, Th., 2000, "Het Gebruik van Regulerende Instrumenten in het Nationale en het Internationale Klimaatbeleid." (Pedagogisch Fiche n° 4)

N°32: EYCKMANS, J. and BERTRAND, C., 2000, "Integrated Assessment of Carbon and Sulphur Emissions, Simulations with the CLIMNEG Model." (Also available as *ETE Working Paper* n° 2000-08, Centrum voor Economische Studiën, Katholieke Universiteit Leuven, 2000)

N°33: EYCKMANS, J. and CORNILLIE, J., 2000, "Efficiency and Equity in the EU Burden Sharing Agreement." (Also available as *ETE Working Paper* n° 2000-02, Centrum voor Economische Studiën, Katholieke Universiteit Leuven, 2000)

N°34: BOUCQUEY, N., 2000, "L'Organisation du Marché des Permis Négociables. L'Emergence de Marchés et les Problèmes de Concurrence."

N°35: DELCOURT, R., 2000, "L'Organisation du Marché des Permis Négociables. Développement des Aspects de Droit Bancaire et Financier pour le Permis Négociable."

N°36: VAN YPERSELE, J.-P., 1999, "Modélisation des Changements Climatiques Futurs au Carrefour d'une Recherche Fondamentale en Environnement et d'une Recherche Socio-Economique en Appui à la Décision", publié dans les Actes du Symposium "A la Recherche d'un Dialogue Durable entre Science et Politique" des 24 et 25 novembre 1999, Services Fédéraux des Affaires Scientifiques, Techniques et Culturelles (SSTC), Bruxelles.

N°37: BERNHEIM, Th., 2001, "Vrijwillige Overeenkomsten als Instrument in het Klimaatbeleid, Mogelijkheden en Beperkingen." (Pedagogisch Fiche n° 5)

N°38: BERNHEIM, Th., 2000, "Communicatieve Instrumenten in het Nationale en Internationale Klimaatbeleid, Uitvoering aan de Hand van de Overdracht van Technologie en Capaciteitsopbouw." (Pedagogisch Fiche n° 6)

N°39: GERMAIN, M. and VAN STEENBERGHE, V., 2001, "Constraining Equitable Allocations of Tradable Greenhouse Gases Emission Quotas by Acceptability."

N°40: EYCKMANS, J., 2001, "On the Farsighted Stability of the Kyoto Protocol".

N°41: PROOST, St. and VAN REGEMORTER D., 2000, "How to achieve the Kyoto Target in Belgium – Modelling Methodology and Some Results".

N°42: CHANDER, P. and TULKENS, H., 2001, "Limits to Climate Change", paper presented at the Sixth CORE – FEEM - GREQAM – CODE Coalition Formation Workshop held at Louvain-la-Neuve, January 26-27, 2001.

N°43: GERMAIN, M. and VAN STEENBERGHE, V., 2001, "Optimal Policy with Tradable and Bankable Pollution Permits: Taking the Market Microstructure into Account".

N°44: GERMAIN, M., TULKENS H., TULKENS Ph. and VAN YPERSELE, J.-P., 2001, "Side Payments to Ensure International Cooperation in a Regionalised Integrated Assessment Model of Climate Change" (forthcoming).

N°45: VAN IERLAND, W., 2001, "Insights in the Economics of Climate Change and its Solution" (forthcoming).
N°46: VAN IERLAND, W., 2001, "Emissiehandel Binnen het Belgische Klimaatbeleid: een Analyse van de Mogelijkheden en de Beperkingen" (forthcoming).
N°47: BERNHEIM, Th, 2001, "Coopération Internationale et Instruments pour la Prise de Décision dans le Cadre de la Politique Climatique", version française des "fiches pédagogiques" contenues dans les CLIMNEG-CLIMBEL Working Papers nos 28, 29, 30, 31, 37 et 38, publié dans *Planing Papers* Nº 89, Bureau Fédéral du Plan, Bruxelles, août 2001.