

# GREENHOUSE GASES AND NATIONAL ENERGY OPTIONS: Technologies and Costs for Reducing Emissions of Greenhouse Gases

## *Annex 4*

to the Implementing Agreement of the International Energy Agency  
for a PROGRAMME OF ENERGY TECHNOLOGY SYSTEMS ANALYSIS

### 1. PREAMBLE

This proposal for Annex IV of the IEA Energy Technology Systems Analysis Programme (ETSAP) comes at a time of intense international activity on the greenhouse effect, which is focused primarily in the United Nations Intergovernmental Panel on Climate Change (IPCC). An overview of national studies of carbon dioxide emissions conducted during ETSAP Annex III has already been presented to the Energy and Industry Subgroup of the Response Strategies Working Group of the IPCC, which met in Tokyo in July 1989.

The successful incorporation of environmental parameters into MARKAL during Annex III has put ETSAP into a strong position to address the major new challenge of responding to the issue of climatic change. In Annex IV, ETSAP can develop substantive and timely advice for the IPCC, the International Energy Agency, Member countries, and other governments concerned with strategies for responding to climatic change and related environmental issues. The purpose of this proposal is to define the work that should be conducted in Annex IV to build on and extend the existing capacity of ETSAP to address these issues.

### 2. GUIDANCE FROM THE INTERNATIONAL ENERGY AGENCY

#### *(a) Commitments of the IEA Governing Board*

At its 30 May 1989 meeting, the International Energy Agency Governing Board at Ministerial Level "called sharp attention ... to two aspects of the current energy situation to which they attach particular importance and view with deep concern:

- "growing worldwide oil consumption, particularly for transportation ... and
- "the environmental aspects of energy supply and consumption, including both the more conventional and better-known pollutants and the growing atmospheric concentration of CO<sub>2</sub> and other 'greenhouse' gases and its long-term consequences for global warming and climate change."

The Ministers also pledged a "re-examination of priorities ... with a view to determining whether reorientations or new programmes are needed to strengthen the contribution which developing countries can make to the global response to climate change issues, and agreed that progress achieved in these areas will be closely monitored and assessed within the IEA's country review process."

They agreed that there "will be a long and on-going process in which the IEA and its Member countries can show leadership within the overall international process which is developing for addressing climate change issues, with a view to integrating energy security and environmental policies in both the short and long term. They agreed that for this purpose the IEA will continue its cooperation with the OECD and will participate in the activities of the Intergovernmental Panel on Climate Change as a focal point ..."

#### *(b) Linkage Between Technology Assessments and Energy Projection / Modelling*

In a Note by the IEA Secretariat to the Committee on Energy Research and Development (IEA/CRD(89)39), it was "recommended that careful attention be devoted to the linkage between energy technology assessments on the one hand, and energy environmental modelling on the other. In a response strategy for climate change, the ultimate variable is improved or new technology; systems analysis can identify where improvements and innovations would pay."

The Secretariat noted that a systems approach to anthropogenic emissions of greenhouse gases from energy technologies and activities has been proposed under the Energy Technology Systems Analysis programme: "A grid of national and compatible energy systems models would allow assessment of energy technology options ... The understanding is that from the standpoint of technology implementation, final implementation must be at the national level; international negotiations on emissions reduction will be facilitated if realistic and specific estimates of ramifications at the national level are available."

During the discussion of Note IEA/CRD(89)39 at the CRD, it was recommended that the Secretariat should consider the feasibility, desirability, and appropriate terms of cooperation for making available to selected non-IEA countries the tools developed in the Energy Technology Systems Analysis Programme (ETSAP) for energy - environment - technology analyses and trade-offs. This would allow these countries to weigh environmental factors (including those of regional or global nature) along with the usual commercial factors in formulating their respective energy supply options and approaches. By providing such a tool to energy planners and modellers, it should be possible to draw them into the evolving environmental issues, particularly global climate change, and have a consistent basis for discussing and encouraging energy policy options that take domestic as well as international considerations into account.

#### *(c) Country and Programme Monitoring*

The Secretariat also noted that "it might be of great use to perform special (greenhouse-oriented) thematic surveys, including case studies. These studies would consist of the analysis of specific energy sectors or geographical regions. Surveys and studies would allow to gain better understanding of trends in emission data, strategies which could be adopted to implement energy technologies. A relatively small number of well-focused thematic surveys and technology-oriented case studies could have great value in providing more solid ground to response strategies."

### **3. ETSAP CAPABILITIES**

In response to this guidance from the International Energy Agency, this proposal for Annex IV of the ETSAP is offered with the goal of addressing the greenhouse gas issue through analytical studies with a set of national energy system models.

At the IPCC Expert Group Meeting on Methodologies and Analytical Tools held in Paris in April 1989, it was determined that no single approach is adequate to the present purposes of the IPCC, and that a hybrid of "bottom-up" national analyses combined with a "top-down" global analysis is needed. This proposal would extend the "bottom-up" approach to a set of directly comparable national models, the results of which can be correlated to interface with a "top-down" global model.

ETSAP using the MARKAL model is one of two international organizations that can provide the nucleus for such a development, the other being the Commission of the European Communities (CEC) using the EFOM model. With the CEC represented on the ETSAP Executive Committee it is anticipated that the work of the two organizations will be coordinated and mutually supportive.

MARKAL is a standard software package used to represent national energy systems. It has been used by more than twenty nations. In Annex III of ETSAP, eight countries used their national models to evaluate measures for controlling emissions of sulphur dioxide, nitrogen oxides, and, in five countries, carbon dioxide. In April 1989, results of the work on carbon dioxide emissions were reported both to the IEA/OECD Expert Seminar on Energy Technologies for Reducing Emissions of Greenhouse Gases and to the IPCC Expert Group Meeting on Methodologies and Analytical Tools.

The ETSAP Participants provide a cadre of energy systems analysts that can be expanded to provide a larger and more diverse sample of national energy system models for analysing the global greenhouse problem. They have worked cooperatively for over a decade developing and applying the MARKAL model to their own countries, and some have assisted countries in the developing world in energy planning using the MARKAL model.

#### 4. OBJECTIVES

The overall goal of Annex IV of ETSAP is to further develop and apply systems analysis of national energy systems in order to develop insight for the development of policy options to deal simultaneously with energy and environmental requirements, in particular to minimize the emission of greenhouse gases and global climatic change. The purpose of this goal is to render service to the IPCC, to the IEA and its Member countries, and to other countries.

The specific objectives of Annex IV are:

- (a) *Analysis of national energy systems:*  
To identify the most cost-effective blends of technological options to reduce national or regional emissions of greenhouse gases and secure other energy and environmental objectives, including energy security.
- (b) *Examination of global consequences:*  
To understand and explain any differences among national results} and to integrate --or collaborate in the integration of --the results of national energy models in the context of global climatic change in order to better inform national and intergovernmental analysis of policies to reduce the emission of greenhouse gases.
- (c) *Outreach:*  
To design and effect processes to reach out beyond the current ETSAP membership to relevant energy-environment actors in both IEA/OECD countries and centrally-planned and developing countries, and to share MARKAL as an analytical tool that will allow a broad range of countries to bring consistent and compatible analyses of national energy systems to various international fora.

#### 5. METHOD

In general, the analysis will be performed using the set of MARKAL or EFOM energy system models to represent a "reference energy system" developed for each country and designed to allow a wide range of responses for greenhouse gas emission control. Starting from the economic output of a global model (e.g., the Edmonds-Reilly Long-Term Global Energy-CO<sub>2</sub> Model) and with a consistent set of technology characterizations, the national models will be optimised with appropriate objective functions taking into account cost and emission constraints.

Objective A will be achieved by using the models to determine the relative importance of each technology and appropriate groupings of technologies. Importance will be determined by the extent of greenhouse gas emission reduction, effect on energy security, and other suitable measures. For each country, cost-emission tradeoff curves will be calculated with a range of constraints applied. Technologies introduced at each step of increasing control can be shown indexed to the curves.

Experience has shown that the MARKAL and EFOM models are particularly well suited for communication with policy analysts and decision makers. National reference groups will be set up to foster exchanges between the systems analysts and their clients.

Contacts will be established with the appropriate IEA Collaborative RD&D Projects through the IEA Working Parties to develop authoritative data for technology characterization. It is anticipated that this will be a two-way process. It is very difficult to obtain fully agreed data for energy technology

characterization. On the other hand, data for the techno-economic performance of speculative new energy technologies can be tested in MARKAL and be translated into R&D priorities.

ETSAP will cooperate with the IEA Secretariat in identifying types of technology, specific energy sectors, and geographical regions of interest, and using the MARKAL/EFOM systems models to obtain better understanding of trends in emission data, strategies that could be adopted to implement energy technologies} and more solid ground for response strategies.

Objective B will be achieved by seeking a large and representative coverage of countries. This will consist initially of the ETSAP Annex IV signatories but will be expanded through the outreach programme to include centrally-planned and developing countries. An in-depth comprehension and presentation of national differences will be needed. A method will be developed for integrating the grid of national models in a manner that permits their combined use while preserving national "analytical sovereignty".

Objective C will be achieved by designing during the first year of Annex IV a programme to involve other countries to expand in number and variety the international sample on which global emission decisions can be based. The context within which ETSAP is conducted will be widened through the use of "national reference groups" for the development and analysis of the models, through joint meetings with other related international projects, through a concerted effort to communicate with the wider professional community, and by otherwise involving decision makers.

## 6. ACTIVITIES

The principal activities of Annex IV will be of four types:

- National programmes of work, appropriate to the individual Participants, aimed at supporting the objectives of Annex IV, with guidance from national reference groups.
- A common programme of work in which the national analyses will be integrated to draw conclusions regarding greenhouse gas emission control in IEA and other countries.
- An Outreach Programme and a MARKAL Users Network intended to develop the capability for using the MARKAL model for national greenhouse gas emission control in non-IEA countries.
- A standard version of MARKAL for personal computers will be adopted.

### Common Programme of Work

The common programme of work will be designed to complement and if possible support other international greenhouse gas studies. In particular, it will be coordinated with the JOULE project on energy systems analysis of the CEC so that EFOM applications under JOULE will be a fully acceptable alternative to MARKAL in order to avoid duplication. The common programme of work will consist of the following activities:

- (a) Identify greenhouse gases to be included in the common analysis. and, as far as possible, their relative effectiveness as greenhouse gases.
- (b) Prepare characterizations of technologies that can limit the emissions of these greenhouse gases with particular attention to the demand side, including energy conservation and efficiency improvements. Other technologies may include biogas, hydrogen production and use, carbon dioxide removal, recycling materials (e.g., plastics, wood, metals), and material substitution options
- (c) Agree on common assumptions for a few scenarios using the national MARKAL models, possibly on the basis of a global greenhouse model.

- (d) For each common scenario, calculate the appropriate emission-control trade-off curves, making a distinction as appropriate between CO<sub>2</sub> and other greenhouse gases. An important question to be answered in a sensitivity analysis is whether the addition of other greenhouse gas emissions, their respective control technologies, and their fringe costs and benefits will significantly change the identified trade-off curves.
- (e) Subject national results to multinational review and comparison, in particular through the use of a group of experts.
- (f) Develop a model or a procedure for integrating the national model results.
- (g) Using this procedure, integrate these national results to draw international conclusions on energy technology.
- (h) In cooperation with the IEA Secretariat, greenhouse-oriented thematic surveys, e.g., of specific types of technology, will be made. These studies will consist of the analysis of specific energy sectors or geographical regions aimed at obtaining a better understanding of trends in emission data and strategies that could be adopted to implement energy technologies.

These activities will be undertaken in international meetings as well as in separate national work and review or ad hoc groups. It is anticipated that there will be about two workshops per year to share reports on progress of the project. Consideration will be given to the desirability of stationing a representative of each Participant with the Operating Agent for a period of several months at the beginning of the project and again at its conclusion for the purpose of developing a consensus on plans and preparing a comprehensive final report, respectively. Joint meetings with other international organizations doing related work will be sought to foster the international usefulness of the ETSAP work.

It is anticipated that this common programme of work will draw upon related national energy systems analysis work that may be reported to the project.

### Outreach Programme

The Outreach Programme will be designed during the first year of Annex IV, drawing upon the experience of the Participants in energy planning in developing and centrally planned countries using the MARKAL model. To support this programme a personal computer version of MARKAL will be used; it will be necessary to establish whether or not this PC version of MARKAL may require proprietary software. During the first year, it is intended to hold a workshop in association with the International Institute for Applied Systems Analysis to begin a programme of outreach to Eastern European countries. Outreach plans, e.g., the possibility of "twinning" IEA with non-IEA countries) will be developed in conjunction with national foreign aid organizations and international research and development organizations. The development of a MARKAL Users Network, to promote the exchange of programmes) procedures, and data, will be addressed.

## **7. ORGANIZATION**

### *(a) Executive Committee*

Annex IV will be directed by an Executive Committee consisting of representatives of the participating International Energy Agency countries and international organizations as voting members. Representatives of non-IEA countries that may participate will be nonvoting members of the Executive Committee.

### *(b) Specific Responsibilities of the Operating Agent*

- (i) Project Staff

For the purpose of carrying out the above objectives the Operating Agent shall establish} within sixty days after the Annex has entered into force} a Project Staff composed of a project head and such additional assistance as may be required} including external staff, to fulfill the Task.

(ii) Executive Responsibilities

The Operating Agent shall be responsible for overall coordination of the project. The main responsibilities will be:

- to manage the common tasks
- to assure appropriate communication among the Participants,
- with the approval of the Executive Committee, to represent ETSAP in various international conferences, bodies, and groups, and
- to prepare and distribute a newsletter on the project activities for outside distribution.

In addition to the Project Head, additional staff will be used by the Operating Agent to meet the common objectives of the project. Activities requiring common work may include quality assurance review, development of the procedure for comparing and integrating the national models, preparing the final conclusions and report of the project, and other activities that may be decided upon by the Operating Agent or the Executive Committee.

The common work may be performed by the Project Head, by other Operating Agent staff, or by organizations or professionals from the participating countries.

(iii) Meetings and seminars

At the request of the Executive Committee, the Operating Agent shall organize workshops and seminars.

(iv) Validation

At the request of the Executive Committee, the Operating Agent shall coordinate the work of a small group of experts charged with reviewing the consistency and accuracy of national models and the main results.

(v) Preparation of Draft Programme of Work and Reports

The Operating Agent shall prepare and submit to the Executive Committee, prior to its first meeting, a draft programme of work for the three-year period of the Project. The Operating Agent shall report to the Executive Committee at least once a year on the progress of the activities under this Project. Upon termination of this Annex, the Operating Agent shall prepare and submit to the Executive Committee for approval, a draft final report on the activities carried out during the period of this Annex. Following approval, the Operating Agent shall transmit the report to the Agency and to the members of the TEA Committee on Energy Research and Development.

The Committee on Energy Research and Development may, during this Annex, propose additions to the Programme of Work. The Executive Committee shall decide whether these proposals will be added to the Programme, provided such additional work can be carried out within the resource levels set out in paragraphs 7(b)(i) above and 8(a) below.

*(c) Specific Responsibilities of Each Participant*

Participants shall carry out to the extent possible the following activities and communicate the results to the Operating Agent in the form of computer printouts and country reports:

- (i) Collection of national data on emission release and emissions control technologies:
- (ii) Collection of information on energy system structure and related data:
- (iii) Establishment of data on technology characterization and related data:
- (iv) Performance of scenario analysis using an energy system model;

- (v) Discussion of the data base, assumption, methodology, and results with the national reference group in their respective country.

*(d) National reference groups*

Establishment of national reference groups will be encouraged, the members of which may include representatives of the national sponsoring organization, the national financing organization (if different), the organization supporting the outreach programme, and in the case of members of the European Community the EC representative.

## 8. FUNDING

*(a) Common Financial Obligations*

Common project activities will be funded through the Operating Agent. The actual costs of the Operating Agent's activities during this Annex will be divided equally among all participants. If the number of Participants changes, the shares of contribution to the costs will be adjusted proportionally. New Participants will pay a full share of the costs beginning in the project year in which they become Participants.

The designated Operating Agent (paragraph 10, below) estimates the annual cost of the core programme, not including bilateral outreach activities, to be about Dfl 420,000. The Executive Committee will decide an annual budget based on this estimate each year, taking inflation into account.

*(b) Individual Financial Obligations*

In addition to the contributions set out in subparagraph (a) above, each Participant shall bear all costs it incurs in carrying out this Task, including the costs of participation in workshops and seminars.

*(c) Funding for the Outreach Programme*

Funding for the Outreach Programme will be determined during the first year of Annex IV. It is anticipated that this will require support from national or international bodies responsible for foreign aid.

## 9. TIME SCHEDULE

This Annex will enter into force on January 1, 1990 and will remain in force for a period of three years. It may be extended by agreement of two or more Participants acting in the Executive Committee and taking into account any recommendation of the Agency's Committee on Energy Research and Development concerning the term of this Annex, which shall thereafter apply only to these Participants.

## 10. OPERATING AGENT

The Netherlands Energy Research Foundation will serve as Operating Agent, acting through the Energy Study Centre (ESC), Petten. Ir. Tom Kram will serve as Project Head and devote two-thirds of his time to the Project. Any change in this arrangement during the period of this Annex will be agreed between the ESC and the Executive Committee.

## 11. INFORMATION AND INTELLECTUAL PROPERTY

### (a) Executive Committee Powers

The publication, distribution, handling, protection and ownership of information and intellectual property arising from this Annex shall be determined by the Executive Committee in conformity with this Agreement.

### (b) Right to Publish

Subject only to copyright restrictions, the Participants in this Annex (referred to in this Annex as the "Participants") shall have the right to publish all information provided to or arising from this Annex except proprietary information, but they shall not publish it with a view to profit, except as agreed by the Executive Committee.

### (c) Proprietary Information

The Operating Agent and the Participants shall take all necessary measures in accordance with this Annex, the laws of their respective countries, and international law to protect proprietary information. For the purposes of this Annex proprietary information shall mean information of a confidential nature such as trade secrets and know-how (for example, computer programmes, design procedures and techniques, chemical composition of materials, or manufacturing methods, processes, or treatments) that is appropriately marked, provided such information:

- (1) Is not generally known or publically available from other sources;
- (2) Has not previously been made available by the owners to others without obligation concerning its confidentiality; and
- (3) Is not already in the possession of the recipient Participant without obligation concerning its confidentiality.

It shall be the responsibility of each Participant supplying proprietary information to identify the information as such and to ensure that it is appropriately marked.

### (d) Production of Relevant Information by Governments

The Operating Agent should encourage the governments of all Agency Participating Countries to make available or to identify to the Operating Agent all published or otherwise freely available information known to them that is relevant to the Project. The Participants should notify the Operating Agent of all pre-existing information, and information developed independently of the Project known to them which is relevant to the Project and which can be made available to the Project without contractual or legal limitations.

### (e) Production of Available Information by Participants

Each Participant agrees to provide to the Operating Agent all previously existing information and information developed independently of the Annex which is needed by the Operating Agent to carry out its function in this Project and which is freely at the disposal of the Participant and the transmission of which is not subject to any contractual and/or legal limitations:

- (1) If no substantial cost is incurred by the Participant in making such information available, at no charge to the Project;
- (2) If substantial costs must be incurred by the Participant to make such information available, at such charge to the Project as shall be agreed between the Operating Agent and the Participant with the approval of the Executive Committee.

### (f) Use of Proprietary Information

If a Participant has access to proprietary information which would be useful to the Operating Agent in conducting studies, assessments, analyses, or evaluations, such information may be communicated to the Operating Agent in accordance with an agreement between the Operating Agent and the specific Participant setting forth the terms and conditions for such acceptance, but the proprietary information shall not become



part of reports, handbooks, or other documentation, nor be communicated to the other Participants except as may be agreed in writing between the Operating Agent and the Participant which supplied such information.

(g) Acquisition of Information for the Project

Each participant shall inform the Operating Agent of the existence of information known to the Participant that can be of value to the Project, but which is not freely available, and the Participant shall endeavour to make the information available to the Project under reasonable conditions, in which event the Executive Committee may acting unanimously, decide to acquire such information. '

(h) Reports on Work Performed under the Project

The Operating Agent shall provide reports on all work performed under the Project and the results thereof, including studies, assessments, analyses, evaluations and other documentation, but excluding proprietary information, to the Participants.

(i) Authors

Each Participant shall, without prejudice to any rights or authors under its national law, take necessary steps to provide the cooperation with its authors required to carry out the provisions of this paragraph. Each Participant will assume the responsibility to pay awards or compensation required to be paid to its employees according to the laws of its country.

## 12. RESULTS

The results of this project shall be:

- (a) Maintenance and improvement of an international capability for the analysis of energy technologies and their future prospects and extension of such a capability within the context of energy and the environment, and in particular climatic change;
- (b) Periodic reports on workshops or seminars and on analytical studies undertaken in connection with the Project; and
- (c) A final report on the activities carried out under this Annex

## 13. PARTICIPANTS

The Contracting Parties that are Participants in the Project are the following: