END OF TERM REPORT
(1999 – 2004)

1. Objectives and Strategy

The Contracting Parties of this Implementing Agreement carry out a Programme consisting of co-operative Energy Technology Systems Analysis (ETSAP)[1]. The objective of ETSAP is to assist decision-makers in the assessment of new energy technologies and policies in meeting the challenges of energy needs, environmental concerns, and economic development.

ETSAP's strategy in achieving the objectives is twofold. Through a common research programme, ETSAP established, maintains and enhances the flexibility of consistent multi-country energy/economy/environment analytical tools and capability (the MARKAL family of models). ETSAP members also assist and support government officials and decision-makers by applying these tools for energy technology assessment and analyses of other energy and environment related policy issues.

ETSAP thereby contributes directly to the mission of the IEA Committee on Energy Research and Technology, which is to "promote the development and deployment of clean and advanced energy technologies through international networking, cooperation, collaboration, analysis and policy advice". In particular, the work of ETSAP fulfils objective 2 of the current CERT Strategic Plan (April 2002) "to more clearly define and analyze energy technology issues and opportunities, and to enhance the development of analytical tools that inform and support policy and program development in Member countries" as well as contributing to the other objectives of the CERT.

Since the IEA approved the shared goals (1993), ETSAP has increased the capabilities of its tools in order to model *free and open energy markets*, where the impact of long term *energy security and environmental protection policies* can be evaluated. The original bottom-up engineering least cost modelling tools have been merged with bottom-up economic approaches to provide full computable economic equilibrium tools, with explicit treatment of hundreds of energy technologies.

2. Tasks and participation

ETSAP tools are developed through cost sharing annexes. Annex VII "Contributing to the Kyoto Protocol" started in 1999 and was completed by June 2002[2]. Annex VIII "Exploring Energy Technology Perspectives" entered into force on January 1, 2002 and is due to expire at the end of 2004, if the mandate is extended. In October 2003 the Executive Committee approved Annex IX "Energy Models Users' Group", the first task-sharing annex of ETSAP. These Annexes envisaged the following program of work:

- the development, demonstration and deployment of new methods, with increased flexibility to depict more complex energy systems, in particular multi-regional models with endogenous trade in order to evaluate common or joint actions implemented by groups of countries and the endogenous treatment of evolution in the costs of new technologies (technology learning);
- the use of ETSAP tools, data services and analytical capacity to support the IEA Energy Technology Perspectives Project [IEA/CERT(2001)25];
- the widespread and successful use of ETSAP tools, methodologies, data services and knowledge by the governments of the ETSAP Contracting Parties, other member and non-member countries, as well as international organizations, in multi-lateral collaboration, discussions, and negotiations;

[1] See Article 1 (Objectives), paragraph (a) (Scope of Activity) of the Implementing Agreement (the full text of the IA is downloadable from www.etsap.org).
[2] The text of the Annex and the final report, which illustrates its achievements, are downloadable from www.etsap.org.

- the establishment of linkages with economic and environmental models and approaches that complement the work of ETSAP;
- the maintenance and ongoing use of ETSAP networks for continuous analytical support;

21 Contracting Parties have signed the ETSAP Implementing Agreement on behalf of Austria, Australia, Belgium, Canada, Denmark, European Commission), Finland, Germany, Greece, Ireland, Italy, Japan, Korea, Netherlands, Norway, Spain, Sweden, Switzerland, Turkey, UK, DOE US. Delegates of the Contracting Parties meet twice a year for the Executive Committee, where budgets, annual reports, strategies and program of work are discussed and approved. The invitation is extended to relevant experts, IEA delegates and representative from countries interested in joining.

The following organizations contracting parties have actively participated to date in either or both of Annex VII and Annex VIII on behalf of the contracting parties: ABARE (Australia), VITO and Uni-Leuven (Belgium), NRCan (Canada), DG RTD (EC), TEKES and VTT (Finland), IER (Germany), CRES (Greece), ENEA (Italy), JAERI (Japan), KEMCO and KIER (Korea), ECN (Netherlands), Uni-Chalmers (Sweden), PSI (Switzerland), DTI (UK), BNL and EIA (US). The participation of Austria, Denmark, Ireland, Norway, Spain and Turkey is pending. Users of ETSAP tools, such as China, New Zealand and South Africa, have also expressed keen interest in participating in ETSAP and have been invited to join by the Executive Committee.

3. The work Programme and Nature of Work

In order to analyse the development of energy systems over the medium to long term and to explore synergies and competition between energy supply technologies and end-use devices on a 'level playing field', ETSAP has developed original tools: the MARKet ALlocation computer model generator (MARKAL), the Integrated MARKAL EFOM System (TIMES) and their advanced user interfaces (collectively known as the MARKAL family of models).

The leading role that technology has in affecting changes in energy consumption and production patterns and emission profiles is represented in the models by rich (hundreds of technologies) and country-specific databases. Full-scale models represent all aspects of detailed energy balances as separate markets. They allow policy analysts and decision-makers to identify and explore feasible energy technology scenarios that balance energy budgets and meet a range of environmental requirements at economic equilibrium over extended periods of time.

ETSAP Members and their partners cooperate to establish, maintain and expand a consistent multi-country energy/economy/environment analytical capability. Key features of the approach are a combination of individual national teams and a common, comparable and combinable methodology.

In Annex VII, ETSAP continued to extend its repertoire of models and methods for analysing energy systems, with particular emphasis on supporting on-going international cooperation in reducing greenhouse gas emissions. Using a suite of MARKAL models as an expert system, a set of recommendations were made as to how best to meet the requirements of the Kyoto Protocol.

Annex VIII focuses on analysing the role of technologies in meeting the long-term challenges of energy, environment protection, and economic growth. The core of participants' activity is devoted to the use of the tools for domestic analyses and projects. To exchange their findings and results researchers meet twice a year. They hold small group sessions to develop particular aspects of the tools, plenary session to share techniques, compare results of their analyses and participate in larger workshops organised jointly to other groups working in ETSAP related fields. Back to back with the regular workshops, in the last five years ETSAP has held joint workshops with:

- the International Energy Workshop to compare energy modelling approaches with the International Institute for Applied Systems Analyses, the International Modelling Forum, the IEA secretariat and other notable modelling groups from around the world;
- the IEA secretariat to discuss base assumptions for the Energy Technology Perspective Project;
- ABB for the presentation of the China Energy Technology Program;
- the Energy Research Institute of National Development and Reform Commission of China, to compare IEA and ERI approach to energy modelling and statistics;
- the US-DOE for discussing Technologies to Reduce Greenhouse Gas Emissions: Engineering – Economic Analysis of Conserved Energy and Carbon
- the Australian Bureau of Agricultural and Resource Economics (ABARE) to consider perspectives of "Integrating top-down and bottom-up modelling";
- the Industrial Association of Venice (Italy) and its Kyoto club to deliberate implications of the Third Assessment Report of IPCC;
- the Energy Branch of the Poli-Technical University of Torino and members of the Advanced Local Energy Planning task of the Energy Conservation in Buildings and Community Systems Implementing Agreement;

The greatest attention is devoted to the maintenance of the tools, which is sub-contracted to experts of member countries, to ensure a continuous check on the quality of the analyses. In the last five years resources have been spent on the development of the new TIMES model generator and its new VEDA interfaces.

4. Co-ordination with other Bodies

ETSAP members work closely with users of its analytical tool. Benefits are mutual. Model Users learn to understand the capability of the model in answering issues related to energy, environment, and economy. ETSAP experts learn from model users specific energy and environmental issues that need to be addressed in a way that is tractable analytically. ETSAP members have been working with the following organizations over the past several years:

- the International Energy Agency (IEA), for its Energy Technology Perspective (ETP) project:
- the U.S. Energy Information Administration (EIA), for its publication "International Energy Outlook";
- the Asia-Pacific Economic Cooperation (APEC), where MARKAL models are used or under development in no less than 15 of the 21 member economies;
- user's groups in Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand and Vietnam, for a multi-year capability building undertaking in energy modelling and policy assessment, for the Association of South East Asian Nations (ASEAN), supported by the Australian Agency for International Development AusAID;
- government officials in Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, and Bolivia, for the development of capabilities in analysing energy technologies and markets and preparing emissions baseline, with the support of the U.S. Brookhaven National Laboratory and US-Environmental Protection Agency;
- the Swiss branch of ABB Asea Brown Boveri for its China Energy Technology Program;
- the European Commission, where several contracting parties participate to different research and policy studies, such as ACROPOLIS, SAPIENT;
- some EURATOM associations for the assessment of new power plant concepts;
- the IEA implementing agreement on Energy Conservation in Buildings and Community Systems, in Annex 33 "Advanced Local Energy Planning", where teams of local planners and modelling experts from German, Italy, the Netherlands and Sweden have performed a MARKAL study for several municipalities and regional planning offices;

- the Energy Research Institute of National Development and Reform Commission of China, the Tsinghua University and other Institutes for the development of China energy models with ETSAP tools;
- the Indian Institute of Management, Ahmedabad (prof. Shukla) for the development of long-term Indian Energy Models with ETSAP tools;
- the Department of Operation Research and Energy Policy Analysis of the Stanford University (prof. Alan Manne), for the development of hard-links between ETSAP tools and macro-economic models;
- the International Institute for Applied Systems Analysis (IIASA, Vienna), for the extension of MARKAL to assess the effects of technological "learning" across several geographical regions.

5. Information Dissemination

In the last five years ETSAP members published tens of papers on the improvement and the application of ETSAP tools in international scientific journal (see list reported in attachment 2, which is largely incomplete). The two semi-annual workshops organized by ETSAP, where tens of MARKAL / TIMES presentations are given, are another opportunity to disseminate the results to researchers and policy makers. ETSAP members present their work to several other major international and national conferences (World Energy Conference, UNFCCC related conferences, etc.). The main results of Annex VII have been diffused through the final report (2002). ETSAP activities and achievements are disseminated in non-technical terms with the NEWS Letter, which is issued twice a year.

The direct organization of workshops, the publication of the newsletter, the presentation of the achievements to several other conferences and seminars is not sufficient to ensure a satisfactory dissemination in this field. The problem is the intrinsic conceptual and practical difficulty of the tools. To overcome this, the concept of outreach has been adopted, which compares more to capacity building than to technology transfer and has been conducted for both it member and non-member countries. Training courses of variable lengths and complexity are offered regularly (at Brookhaven National Laboratory, at Policy Study Unit of the Netherlands Energy Research Foundation, at Institute for Energy Economics and the Rational Energy Use of Energy of the University of Stuttgart and the Chalmers University) or on demand for particular projects (recently at the US Environment Protection Agency, at ISIS in Roma for the NEEDS and EFDA projects). Most important are all forms of "on the job training", where experts with some knowledge of energy technologies and markets, economy, applied mathematics and computing are brought to understand energy related policy problems and to use the tools for their analyses.

In return from this dissemination activity, ETSAP members receive several request for additional information. The web site of ETSAP hosted by ECN has received an average of 4000 page hits per month. This is the target for the new independent web site, which is under construction. A search with Google of the words ETSAP + MARKAL returns about 5000 entries. This number gives an idea of the importance of the "grey literature" generated by ETSAP experts.

6. Scale of Activities

The Contracting Parties share scarce domestic R&D funds and join intellectual capabilities from different background to implement the base common program. The total yearly budget is around 250-300k€. The direct research and analyses of participants is achieved by means of additional countries commitments to the participating institutions, which far exceeds their direct contribution to the project. In addition, during this term, all have also benefited from substantive resources invested in tailoring ETSAP tools. Particularly worth noting are two important high-profile projects that have advanced the state of multi-regional global models

with the technical support of ETSAP: the "Energy Technology Perspective Project" of the IEA secretariat and the "Systems for Analysis of Global Energy markets" of the US Energy Information Administration.

The joint organization of workshops reduces common, as well as participants, expenses, concentrates the time devoted to communication to a couple of weeks per year, and widens the chances of contacts with researcher in related fields. The attendance ranges between 50 and 150. The proceedings of the workshops and a non-technical synthesis reported in the newsletter are downloadable from the ETSAP web site, or may be obtained by following links from said website.

There are now over a hundred groups in over 50 countries across the world, which are licensed users of ETSAP tools (see attachment 1). The list includes important international and national organizations, local government and municipalities, energy industries, universities and consultants.

7. Major Achievements

Five years ago the publication "International Collaboration in Energy Technology: a Sampling of Success Stories" (IEA, 1999) described ETSAP as one of the success stories of the 25-year history of Agency: "ETSAP has contributed to policy development in many countries". After recognizing MARKAL as a tool to assess possible impacts of mitigation technologies and policies (IPCC, "*Second Assessment Report*", 1995), the Special Report on Emission Scenarios (IPCC, 2000) includes scenarios built with MARKAL generated models. Three of ETSAP's regular contributors had key roles in the preparation of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001).

In the last five years the following major International Projects utilizing the ETSAP tools, and experts, add to the previous success stories.

- The Energy Technology Perspective (ETP) project being developed by the IEA secretariat has adopted ETSAP tools. For the analysis of energy research and technology policies, the IEA secretariat has developed a global MARKAL model, representing 15 linked world-regions, each with a detailed representation of both current and future technology options for supply and end-use of energy, including endogenous technology learning and emission permits trade. It will provide technology detail for the World Energy Outlook (WEO) scenarios.
- The "Systems for Analysis of Global Energy (SAGE) markets" of the US Energy Information Administration, also a 15-region global model, is now being used as the modelling framework underlying the annual publication of the International Energy Outlook. Innovations introduced to ETSAP tools include the ability to run the model in a myopic, time-stepped manner (rather than strictly clairvoyant), a market share algorithm that employs the marginal values associated with user-identified technology clusters to redistribute shares to said technologies, and an endogenous technology learning representation that includes knowledge "spillage" between regions.
- Capacity building undertakings in the field of energy – environment modelling and policy assessment are using ETSAP tools. The Energy Policy and Systems Analysis Project (EPSAP) is a multi-year capability building undertaking for the Association of South East Asian Nations (ASEAN), supported by the Australian Agency for International Development AusAID; it supports the implementation of national MARKAL models in Indonesia, Malaysia, Philippines, Thailand and Vietnam for domestic and regional policy analyses. Similar goals are pursued in Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, and Bolivia by the Central America project.
- Analysts of Scandinavian countries joined forces and national MARKAL models to analyse risks and benefits from a trans-Nordic gas grid, an extension of domestic tradable green certificates to Scandinavia and the extension of the Nordic energy market.
- In a joint project, the "International Institute for Applied Systems Analyses" (Austria) and the "Paul Scherrer Institut" (Switzerland) have extended the capabilities of ETSAP tools to assess the effects of technological "learning spill-overs" across several geographical regions.

- In projects financed by the European Commission (DG RTD), such as ACROPOLIS, SAPIENT, European ETSAP members have participated with their MARKAL / TIMES global, regional and national models.
- Within the IEA Annex 33 "Advanced Local Energy Planning" of the IEA implementing agreement on Energy Conservation in Buildings and Community Systems, ETSAP experts from Germany, Italy, the Netherlands and Sweden have carried out local planning studies with ETSAP tools and have drafted an important "Guidebook for Advanced Local Energy Planning" (2000).

Each participant has contributed with *National Assessments* to the success of ETSAP. Only a few of them are well known internationally, such as the contribution of the AEA Technologies with the UK MARKAL model to the White paper "Our energy future – creating a low carbon economy" (2003), the contribution of the Canadian ETSAP team to the "Canadian National Climate Change Implementation Process" (2000) and Second National Communication of Italy for the United Nation Framework Convention on Climate Change, prepared by ENEA for Italy. Participants' studies have contributed to the preparation of domestic energy R&D strategies, climate change mitigation strategies and in general impact evaluations of energy – environment policy measures. These numerous contributions are reported in non-technical terms by the semi-annual issues of the ETSAP News Letter and with technical details by the proceedings of the semi-annual workshops. Both are downloadable from www.etsap.org; older issues are downloadable from the previous ETSAP website www.ecn.nl/unit_bs/etsap/markal/main.html.

The recent developments make ETSAP tools quite unique[3] and advantageous for building consistent long-term energy – environment – economic scenarios, evaluating dynamic costs and benefits of new energy technologies and policies, assessing energy R&D programs, quantifying the impact of mitigation and environment protection policies. From the technical point of view ETSAP tools offer several advantages.

- The same MARKAL / TIMES toolkit is used to create models of systems
  - extended to regions interlinked together in multi-regional models with endogenous trade,
  - with few to thousands of energy commodities, materials, emissions and technologies,
  - including all energy sectors from primary resources (in PJ) to delivered energy services (expressed in specific units such as pass.km) and materials / wastes (expressed in tons),
  - limited to the energy sector (partial equilibrium) or extended to the full economy (general equilibrium, MARKAL-MACRO versions),
  - at increasing level of economic equilibrium: from nearly simulation modes with smooth market shares to intra-temporal equilibria and myopic view, to inter-temporal perfectly foresight allocation of capital investments and decisions;
  - with full representation of technological dynamics, from exogenous time dependent cost / efficiency improvements, to endogenous technology learning depending on cumulative markets, to research – market two factors learning, to global "trade / spill–over" learning.
- Since each step of supply/demand curves represents a technology or a fuel source, further to equilibrium quantities and prices, each solution ranks technologies or resources according to the policy objective that is pursued.
- The same toolkit has maintained the original capacity of running the same model in simpler optimisation models, where it is minimized in turn the total discounted system cost, cumulative emissions or their external damage, the total import of un-secure energy sources, or whatever combination of Objective Functions, in order to provide trade-offs among different policy objectives.
- Since the code of the model generators is open, researchers can experiment theoretical improvements; ETSAP validates them and makes them available to all users. Networking extends to the support in the development of data, approaches to modelling common subsystems, interpretation

[3] The Long-range Energy Alternatives Planning system, developed by the Stockholm Environment Institute (LEAP, SEI Boston) seems the only energy-modelling tool comparable to ETSAP tools, as to flexibility, diffusion and international recognition. However, from the methodological point of view, ETSAP tools are a step forward since they generate models ranging from pure simulation (as LEAP) to full economic equilibrium models, multi-regional models, stochastic, endogenous learning, etc. They contain much more information and provide greater insight into the problems through the employment of more sophisticated analytical techniques, while avoiding economic inconsistencies.

of results and sharing analyses. Workshops and external common projects are further opportunities to communicate results, while maintaining independent conclusions.

TIMES has advantages over MARKAL: simpler code, fully flexible time periods from one to one hundred years, fully flexible representation of load duration curves for electricity heat traffic etc., more accurate yearly based cost representation, time dependent discount rates, more accurate representation of results, more flexible representation of technologies and vintages, more flexible users' constraints, fully flexible units of energy emissions materials and currencies. In the last two years several features of TIMES / VEDA also found their way into the more established MARKAL / ANSWER platform. Ultimately ETSAP offers a network of experienced analysts who understand and recognize their national energy systems, issues and concerns, sharing said expertise for the benefit of all.

The third party software used to run the models generated with MARKAL/TIMES has been improved. Version 5 of the ANSWER shell fully supports multi-regional models. Version 4 of the VEDA-BE (Back End, producing tables with drag and drop functions across existing model dimensions) has improved grouping capabilities across scenarios and runs through an extended use of sets. It is now used outside the circle of ETSAP tools users and it is offered to all users of the Generalized Algebraic Modelling System (GAMS has about ten thousand users) as a generalized reporting tool. The beta version of the VEDA-FE (Front End) shell has been recently distributed to interested users. The GAMS modelling environment, increasingly paired with a power optimiser (CPLEX or XPRESS), continues to advance, enabling larger models to be solved faster and thereby permitting the order of magnitude increase in model size needed to support the large multi-region models increasingly being built.

8. Issues

Further to updating continuously the tools and the network of experts, important developments are expected in the tools and in the analyses. As in the past, two types of activities are foreseen.

The first line of activity foresees enhanced support to existing and new international multi-regional projects. Two new projects have received the financial support of the European Commission in the 6th Framework Research Programme. The four years project on "New Energy Externalities Development for Sustainability" (NEEDS) will develop a 25 member states pan-European energy model using TIMES, which merges energy bottom-up modelling with externalities and life cycle assessment techniques. On a smaller scale, the European Fusion Development Agreement has started the implementation of a global multi-regional TIMES model extending to 2100, in order to evaluate the benefits of developing future energy supply concepts taking into account security and climate change concerns.

These international and national projects require more in depth analyses of direct and indirect impacts of energy technologies related policies, carried out independently or concurrently by different decision makers. It is planned to improve the tools along the following lines.

- The Integrated MARKAL – EFOM System will be developed to exploit fully its potential. By adding better representation of infrastructures, stochastic treatment of exogenous events, general equilibrium and damage function versions, more solid impact evaluations are expected.
- VEDA front-end and back-end interfaces TIMES and MARKAL models will be optimised in order to shorten the time for analysis – from model conception to data entry, to runs and result syntheses – also if the size and details of the models increase.
- It will be explored the feasibility of increasing the working efficiency of MARKAL / TIMES users by combining them with international databases. Tests are underway to hard-link ETSAP tools with the CO2DB technology database developed by the Environmental Compatible Energy Strategies Project of IIASA and with energy balances and statistics of the statistical office of the IEA.

- Simpler energy models are linked to complementary approaches, such as Graphical Information Systems, reliability / security packages, integrated medium scale climate models and Input Output economic models. It will be studied the possibility to establish generalized links of ETSAP tools with packages implementing those approaches.

The above improvements should foster a larger diffusion of the methodology and a higher quality of the analyses. Furthermore, it is foreseen to improve the website, to complete the documentation of the tools, to develop new training material, to support new projects involving non-member countries (for instance a multi-province China model), to enhance the presence to international conferences (for instance WEC2004 and the conferences of the IAEE) and scientific journals (for instance Energy Policy).

It has been observed that the main hurdle to use ETSAP tools is the difficulty of having a group of experts. The full participation to ETSAP has the additional difficulty of maintaining a tight connection between experts and decision-makers. This may result difficult in situations where decisions are taken based upon criteria that escape quantitative modelling, such as social issues, consumer preferences, general domestic or international policies. In some cases, non-members countries find difficult to pay the participation fee of 20-25k€ or even the purchase of the base third party software (from USD5k for universities to USD20k for commercial companies) needed to work with ETSAP tools.

An extension of this Implementing Agreement could be used to explore better long-term frameworks capable of ensuring a stable maintenance and use of the tools. One possibility to take the best advantage of the achievements reached so far, may be to link the activity of this IA to the core activities of the IEA secretariat, making it less dependent on fluctuating domestic fund rising mechanisms. With the ETP project and the developments to be pursued in the next extension term, the activities and fruits of ETSAP might come to play an increasing core role for the IEA secretariat, as it is now at the statistical office. Such a link may foster a greater independence of research and a higher visibility of analyses and results.

Attachment 1

Licensed users of ETSAP tools, i.e. the MARKet ALlocation model generator – MARKAL, The Integrated MARKAL EFOM System – TIMES, and their users' interfaces: MUSS, ANSWER, VEDA. Institutions may have changed, and the status of use columns (Active or Inactive/ Unknown) indicates ETSAP's best understanding of the current situation [March 2004].

Country	*Institution*	*Active*	*In-active/ Unknown*
Australia	Australian Bureau of Agricultural and Resource Economics	x	
	Intelligent Energy Systems	x	
	Key Economics	x	
	Noble-Soft	x	
	Queensland University of Technology	x	
	SMEC International	x	
	SRC International		x
	University of Technology, Sydney	x	
Bangladesh	Ministry of Environment and Forest		x
Belgium	Ecolas NV	x	
	Institut Wallon	x	
	Tractabel		x
	University of Leuven	x	
	Vlaamse Instelling vor Technologisch Onderzoek	x	
Bolivia	Programa Nacional de Cambious Climaticos	x	
Brazil	Universidade Federal do Rio de Janerio		x
	University of North Carolina (PhD)		x
Bulgaria	Energoproekt		x
Cambodia	Ministry of Industry, Mines and Energy	x	
Canada	Alberta Research Council	x	
	Groupe d'Etudes et de Recherche en Analyses des Décisions	x	
	HALOA	x	
	Hydro Quebec		x
	KanORS	x	
	Natural Resources Canada, Energy Policy Branch	x	
	Saskatchewan Energy & Mines	x	
	Univeristy of Regina	x	
China	Beijing University of Technology/Energy Research Institute		x
	China Institute for Nuclear Industry Economics	x	
	China University of Mining and Technology	x	
	EMSD, Hong Kong		x
	Environmental Protection Department, Hong Kong	x	
	GRIEP, Guangzhang	x	
	Guangdong Energy Economic Research Centre	x	
	Shanghai Academy of Environmental Sciences	x	
	Tianjin University		x
	Tsinghua University	x	
Colombia	Ministry of Energy & Mines		x
	National University of Medellin	x	
	University of Los Andes	x	
Croatia	Energy Institute "Hrvoje Pozar"	x	
Czech Republic	Energy Efficiency Center (SEVEn)		x
	Ministry of Industry and Trade		x
	SRC International, Prague		x
El Salvador	Universidad Centroamericana	x	
Estonia	Tallinn Technical Institute	x	
Ethiopia	Agency Energy Agency		x
	National Meteorological Services		x
Finland	Helsinki University of Technology	x	
	VTT Energy	x	

Country	*Institution*	*Active*	*In-active/ Unknown*
France	Ecole des Mines de Nantes	x	
	Ecole des Mines de Paris	x	
	Ingénieur de Recherche CNRS Secrétaire Général du CIRED	x	
	International Energy Agency	x	
Germany	Bremen Energy Institute	x	
	Energy Research Center (STE/KFA)	x	
	Institute for Energy Economics & the Rational Use of Energy (IER)	x	
	KEA Klimaschutz und Energieagentur Baden-Wuerttemberg		x
	Max-Planck-Institut für Plasmaphysik	x	
	Municipality of Mannheim (+MVV, ICC)	x	
	University of Essen	x	
Greece	Center for Renewable Energy Sources (CRES)	x	
Honduras	Universidad Nacional Autónoma de Honduras	x	
Indonesia	ASEAN Centre for Energy	x	
	Badan Pengkajian Dan PenerapanTeknoiogi (BPPT)	x	
	BPMIGAS	x	
India	Indian Institute of Management, Ahmedabad	x	
	India Institute of Technology		x
	Tata Energy Research Institute	x	
Iran	Isfahan University	x	
Italy	Agenzia per la Protezione dell'Ambiente e Territorio	x	
	CESI (Milano)	x	
	Ente per la Nuove Technologie l'Energia e l'Ambiente	x	
	Environment Park SpA (Torino)	x	
	Istituto di Metodologie per l'Analisi Ambientale (CNR, Potenza)	x	
	Istituto Nazionale per la Fisica della Materia (Napoli)	x	
	International Association of Energy Economists, Italian branch	x	
	Politecnico di Torino, Dipartimento di Energetica	x	
	University of Pavia	x	
Japan	Hokkaido University	x	
	Japan Atomic Energy Research Institute	x	
	Osaka Gas Company		x
	Tohoku University	x	
	University of Tokyo	x	
Kuwait	Institute for Scientific Research	x	
Laos	Department of Electricity, Ministry of industry and Handicrafts	x	
Latvia	Department of Energy	x	
Malaysia	PTM Malaysia Energy Centre	x	
Mexico	Instituto Mexicano del Petróleo	x	
	National University of Mexico	x	
Myanmar	Ministry of Energy	x	
Nepal	Dept. of Hydrology and Meteorology		x
New Zealand	Victoria University of Wellington	x	
Nigeria	Centre for Energy Research & Development		x
Norway	Institute for Energy Technology	x	
	Norwegian Water Resources & Energy Admin.		x
Panama	Universidad Tecnológica De Panamá	x	
Poland	Gdansk University of Technology	x	
Puerto Rico	Metropolitan University		x
Slovak Republic	Ministry of the Economy		x
Slovenia	Institute for Power Economy & Electric Industry		x
South Africa	CSIR	x	
	University of Cape Town	x	
South Korea	Institute of Energy Research	x	
	KEMCO	x	

Country	*Institution*	*Active*	*In-active/ Unknown*
Spain	CIEMAT	x	
Sri Lanka	University of Peradeniya		x
Sweden	Chalmers University of Technology	x	
	Goetenborg University	x	
	Lund University	x	
	Profu AB	x	
	Royal Institute of Technology	x	
	STEM	x	
	Vattenfall Utveckling AB		x
Switzerland	Paul Scherrer Institute	x	
	Swiss Federal Institute of Technology Lausanne	x	
	University of Geneva	x	
Taiwan	Energy / Resources Lab., Industrial Technology Research Institute	x	
	Environmental Protection Agency		x
	Excel Technology Consulting Inc		x
The Netherlands	G3/NOVEM (for City of Delft)	x	
	IGWR	x	
	DWA	x	
	KEMA, BV		x
	Netherlands Energy Research Foundation	x	
The Philippines	Department of Energy	x	
Thailand	Asian Institute of Technology	x	
	National Energy Policy Office	x	
Tunisia	Agence pour la Maitrise de l'Energie		x
Turkey	Kocaeli University	x	
	Mamara University	x	
Ukraine	Odessa Regional State Administration		x
United Kingdom	Harwell Laboratory (ETSU), now AEA Technologies	x	
United States	Brookhaven National Laboratory	x	
	Clean Energy Commercialization	x	
	East-West Center		x
	Hagler Bailly		x
	International Resources Group	x	
	Johns Hopkins University	x	
	Lawrence Berkeley Laboratory		x
	Lorna Greening	x	
	Los Alamos National Laboratory		x
	National Energy Technology Laboratory	x	
	National Renewable Energy Laboratory	x	
	Northeast States for Coordinated Air Use Management-NESCAUM	x	
	New York State Energy Office		x
	OnLocation	x	
	Penn State University		x
	Princeton University	x	
	Rutgers University	x	
	Stanford University	x	
	University of South Carolina	x	
	US Department of Energy (EERE)	x	
	US Energy Information Administration	x	
	US Environmental Protection Agency (ORD)	x	
Vietnam	Ministry of Industry	x	
Zambia	Department of Energy		x
57	***TOTAL***	***118***	***39***

Attachment 2

List of major ETSAP related papers published in the last five years by international scientific journals (list produced by the "ISI Web of Knowledge" search engine, searching the topic MARKAL in titles, keywords and abstracts)

Denault M, Goffin JL
Solving variational inequalities with a quadratic cut method: a primal-dual, Jacobian-free approach
COMPUT OPER RES 31 (5): 721-743 APR 2004

Unger T, Ekvall T
Benefits from increased cooperation and energy trade under CO2 commitments - The Nordic case
CLIM POLICY 3 (3): 279-294 SEP 2003

Labriet M, Loulou R
Coupling climate damages and GHG abatement costs in a linear programming framework
ENVIRON MODEL ASSESS 8 (3): 261-274 SEP 2003

Larson ED, Wu ZX, DeLaquil P, et al.
Future implications of China's energy-technology choices
ENERG POLICY 31 (12): 1189-1204 SEP 2003

Mathur J, Bansal NK, Wagner HJ
Investigation of greenhouse gas reduction potential and change in technological selection in Indian power sector
ENERG POLICY 31 (12): 1235-1244 SEP 2003

Kagiannas AG, Didis T, Askounis DT, et al.
Strategic appraisal of energy models for Mozambique
INT J ENERG RES 27 (2): 173-186 FEB 2003

Cosmi C, Macchiato M, Mangiamele L, et al.
Environmental and economic effects of renewable energy sources use on a local case study
ENERG POLICY 31 (5): 443-457 APR 2003

Jaccard M, Loulou R, Kanudia A, et al.
Methodological contrasts in costing greenhouse gas abatement policies: Optimization and simulation modeling of micro-economic effects in Canada
EUR J OPER RES 145 (1): 148-164 FEB 16 2003

Naughten B
Economic assessment of combined cycle gas turbines in Australia - Some effects of microeconomic reform and technological change
ENERG POLICY 31 (3): 225-245 FEB 2003

Morris SC, Goldstein GA, Fthenakis VM
NEMS and MARKAL-MACRO models for energy-environmental-economic analysis: A comparison of the electricity and carbon reduction projections
ENVIRON MODEL ASSESS 7 (3): 207-216 SEP 2002

Rohatgi US, Jo JH, Lee JC, et al.
Impact of the nuclear option on the environment and the economy
NUCL TECHNOL 137 (3): 252-264 MAR 2002

Salvia M, Cosmi C, Macchiato M, et al.
Waste management system optimisation for Southern Italy with MARKAL model
RESOUR CONSERV RECY 34 (2): 91-106 JAN 2002

Hamacher T, Lako P, Ybema JR, et al.
Can fusion help to mitigate greenhouse gas emissions?

FUSION ENG DES 58-9: 1087-1090 NOV 2001

Gielen D, Chen CH
The CO2 emission reduction benefits of Chinese energy policies and environmental policies: A case study for Shanghai, period 1995-2020
ECOL ECON 39 (2): 257-270 NOV 2001

Bahn O, Barreto L, Kypreos S
Modelling and assessing inter-regional trade Of CO2 emission reduction units
ENVIRON MODEL ASSESS 6 (3): 173-182 2001

Gielen DJ, de Feber MAPC, Bos AJM, et al.
Biomass for energy or materials? A Western European systems engineering perspective
ENERG POLICY 29 (4): 291-302 MAR 2001

Sato O, Shimoda M, Tatematsu K, et al.
Roles of nuclear energy in Japan's future energy systems
PROG NUCL ENERG 37 (1-4): 95-100 2000

Condevaux-Lanloy C, Fragniere E
An approach to deal with uncertainty in energy and environmental planning: the MARKAL case
ENVIRON MODEL ASSESS 5 (3): 145-155 2000

Kanudia A, Loulou R
Advanced bottom-up modelling for national and regional energy planning in response to climate change
INT J ENVIRON POLLUT 12 (2-3): 191-216 1999

Bahn O, Cadena A, Kypreos S
Joint implementation of CO2 emission reduction measures between Switzerland and Colombia
INT J ENVIRON POLLUT 12 (2-3): 308-322 1999

Nystrom I, Wene CO
Energy-economy linking in MARKAL-MACRO: interplay of nuclear, conservation and CO2 policies in Sweden
INT J ENVIRON POLLUT 12 (2-3): 323-342 1999

Shipkovs P, Kashkarova G, Shipkovs M
Renewable energy utilization in Latvia
RENEW ENERG 16 (1-4): 1241-1244 JAN-APR 1999