Volume 7, No. 7 January 2002

IEA OECD ETSAP news

ANNEX VII CONTRIBUTING TO THE KYOTO PROTOCOL

Is Kyoto Fatally Flawed? - An Analysis with MacGEM

A report, *Is Kyoto Fatally Flawed? - An Analysis with MacGEM*, was presented at the ETSAP workshop in Paris, 9-11 October 2001, by Denise Van Regemorter. The report, which examines the effect on the Kyoto Protocol of the US withdrawal and the Bonn agreement, was prepared by Johan Eyckmans and Denise Van Regemorter of the Center for Economic Studies (CES) at the Katholieke Universiteit of Leuven, Belgium and Vincent van Steenberghe of the Center for Operations Research and Econometrics, at the Université Catholique de Louvain, Belgium.

Under the 1997 Kyoto Protocol, global emissions of carbon dioxide would rise by 15.6 percent, compared to a 30 percent rise under business as usual, according to the model results. With the USA out, the rise is expected to reach 25 percent. Under the Bonn agreement - depending upon the actions of Eastern European countries and the former Soviet Union, and the possible use of carbon sinks - the rise may range between 23.8 and 26.4 percent.

The MacGEM model used for the projections consists of a set of marginal abatement cost functions for carbon emissions originating from fossil fuel use. The model aims to evaluate compliance costs and permit trading equilibria in the first commitment period of the UN Framework Convention on Climate Change. The marginal abatement cost functions, shown in Figure 1, are estimated from data generated for 15 regions or countries in the world by the GEM-E3-World general equilibrium model.

The USA is the major emitter of greenhouse gases among the industrialized countries that signed the Kyoto Protocol (Annex B countries), accounting for more than one-third of their total emissions. The nonparticipation of the USA therefore changes things significantly. The global emission reduction objective is drastically weakened. Consequently, as summarized in Table 1, the price of the emission permits decreases by more than half (10 versus 22 US$$_{1995}$ton/$CO_2$) because an important share of permit demand falls out. As the total emissions objective of the world falls, it is not surprising that the world's cost also falls, from 0.058 percent to 0.008 percent of 2010 GDP.

Compliance costs for most of the industrialized countries are cut by more than half. However, the biggest losers are Eastern Europe and the former Soviet Union. By exactly the same amount as the drop in compliance costs in the other countries, their benefits drop from 2.1 percent to 0.8 percent of GDP in 2010 because of the sharp reduction in the permit price.

The Bonn agreement reached in July 2001 covers mainly four topics:

- Use of flexible mechanisms
- Use of carbon sinks
- Funding provisions
- Compliance issues.

Flexible mechanisms

The Parties agreed to put no cap on the use of flexible mechanisms, but domestic actions should constitute "a significant element" of the emission reductions. Under the Commitment Period Reserve, each party must keep some specified amount of Assigned Amount Units in its greenhouse gases account. The effect is similar to putting a ceiling on permit exports.

The goal of the Commitment Period Reserve is to prevent the risk of over-selling emission permits by Parties by requiring them to maintain a certain amount of permits in their account. This must be at least (a) 90 percent of the Party's assigned amount, or (b) five times its most recently reviewed inventory, whichever is lower.

The model can easily represent the first constraint (a), which allows 10 percent of the assigned amount of emissions to be exported. However, the second constraint (b) requires knowledge of future emissions. In the model, this constraint is represented by the 2005 business-as-usual emissions from the GEM-E3-World model. This is about 22 percent of the assigned amount. This level should be interpreted as an upper limit of the actual 2005 emissions, inasmuch as countries may reduce their emissions early and thus stay below the business-as-usual projection.

The model is unable to simulate shifting abatement within the first commitment period, which is the only period modeled.

Actions by the countries of Eastern Europe and the former Soviet Union

The trajectory of business-as-usual emissions from the countries of Eastern Europe and the former Soviet Union is shown in Figure 2. The historical sharp drop in emissions from 1990 to 1995 is followed by a projection of emissions under the Kyoto Protocol without the USA.

Visit ETSAP on the www: http://www.ecn.nl/unit_bs/etsap/

Information on ETSAP, its activities and members is also provided on the Internet. The home page contains the latest news, general information on ETSAP, and links to: ETSAP members; ETSAP 'outreach' activities; description of the MARKAL model and its users; archives of new items; selected publications and the ETSAP Newsletter.

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"Hot air, " the difference in emissions from the assigned amount under the Kyoto Protocol and that projected for business as usual, amounts to 0.68 $GtCO_2$, as shown in the figure. This represents 15.3 percent of the assigned amount of these countries.

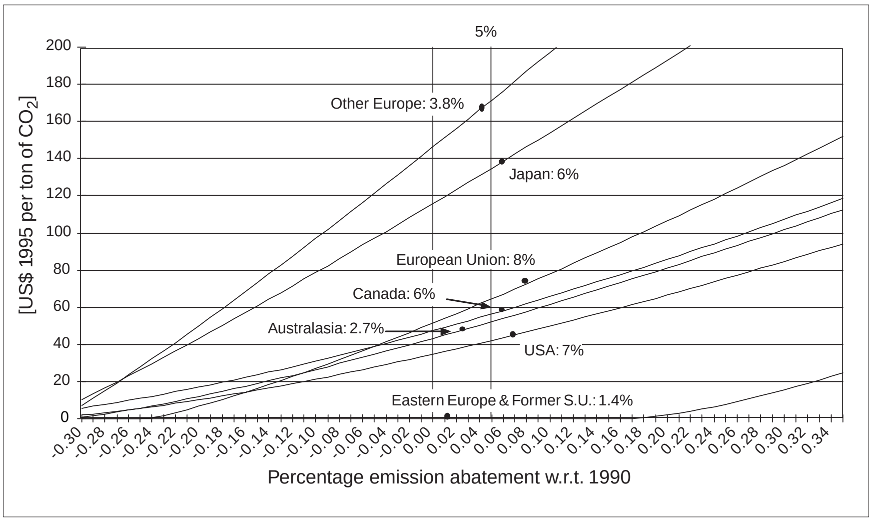

Figure 1. Marginal abatement cost functions. The dots show the Kyoto targets.

In a scenario without the USA, the countries of Eastern Europe and the former Soviet Union would wish to export 26 percent of its permits. Therefore, they are constrained by the Commitment Period Reserve in the amount of the permits it may sell. This is evident in Figure 2 which shows that the two Commitment Period Reserve possibilities require higher internal emissions than would occur in the case of the Kyoto Protocol without USA.

However, the total compliance costs for the countries of Eastern Europe and the former Soviet Union are lower under the Commitment Period Reserve regime. This is because the supply of permits is limited, and their price rises about 30 percent. Likewise, the total cost to the Annex B countries other than the USA (hereinafter Annex B*) rises by about 30 percent.

Thus, the Commitment Period Reserve benefits the countries of Eastern Europe and the former Soviet Union. But they can do even better if they exert their considerable market power by restricting their exports of permits. The optimal level of exports from their point of view is shown in Figure 3.

The figure shows the equilibrium market price of emission permits and, for a number of countries and regions, the total cost as a percentage of GDP versus the level of the Commitment Period Reserve. The vertical dotted line indicates the likely minimum Commitment Period Reserve (Option b) of the countries of Eastern Europe and the former Soviet Union at 78 percent of its Assigned Amount Units. It is apparent that these countries would minimize their cost by restricting export of permits to 17 percent, thus maintaining the Commitment Period Reserve at 83 percent. If exports are less than 7.5 percent (Commitment Period Reserve of 92.5 percent), these countries lose because the effect of the export ceiling dominates the price effect.

Both the trade gains of the permit exporting countries (China and India) and the compliance costs of the permit importing regions increase monotonically because of the increasing permit price. However, the magnitude of the monopoly gains of the countries of Eastern Europe and the former Soviet Union are relatively small.

Joint Implementation by Eastern Europe and the former Soviet Union

In the prior analysis, it was assumed that emission reductions in the countries of Eastern Europe and the former Soviet Union are due to domestic measures, such as a cap-and-trade system or a general carbon tax. At the other extreme, these countries may make only those reductions through Joint Implementation projects financed by other Annex B countries. These emission credits would be used by the sponsoring countries to meet their reduction requirements, and would be automatically deducted from the accounts of the countries of Eastern Europe and the former Soviet Union. (For the calculations, it was assumed that only 60 percent of feasible Joint Implementation are implemented.) This behavior can be considered as choosing the amount of hot air to be sold.

Table 1. Comparison of conditions under the Kyoto Protocol.

Conditions	2010 World Emissions [Gton CO_2]	vs. 1990 [%]	Annex B* Emissions 2010 [Gton CO_2]	Carbon Permit Price [95$/ton CO_2]	Compliance Cost [% GDP] World [%]	Annex B* [%]
Business As Usual	28.04	+30.1	10.28			
1997 Kyoto Protocol	24.91	+15.6	8,88	22	0.058	0.108
Without USA	26.94	+25.0	9.45	10	0.008	0.029
With CPR Flexible Mechanisms	26.94	+25.0	9.56	14	0.008	0.038
And with JI in CEU + "hot air"	26.69	+23.8	9.36	17	0.014	0.058
Or with carbon sinks	27.24	+26.4	9.78	10	0.004	0.021

Notes: Annex B* = Annex B countries except the USA
GDdP = Gross Domestic Product
CPR = Commitment Period Reserve
JI = Joint Implementation
CEU = Countries of Eastern Europe and the former Soviet Union

Under these circumstances, the Commitment Period Reserve is not binding. The countries of Eastern Europe and the former Soviet Union export only 18.5 percent of its Authorized Amount Units, about half from Joint Implementation projects and half from hot air.

As the countries sell only 62.5 percent of their hot air, world emissions increase by 23.8 percent over 1990, compared to 25 percent otherwise.

World total costs are higher. The increase is due not only to the market power of the countries of Eastern Europe and the former Soviet Union, but mainly to the restricted accessibility to Joint Implementation.

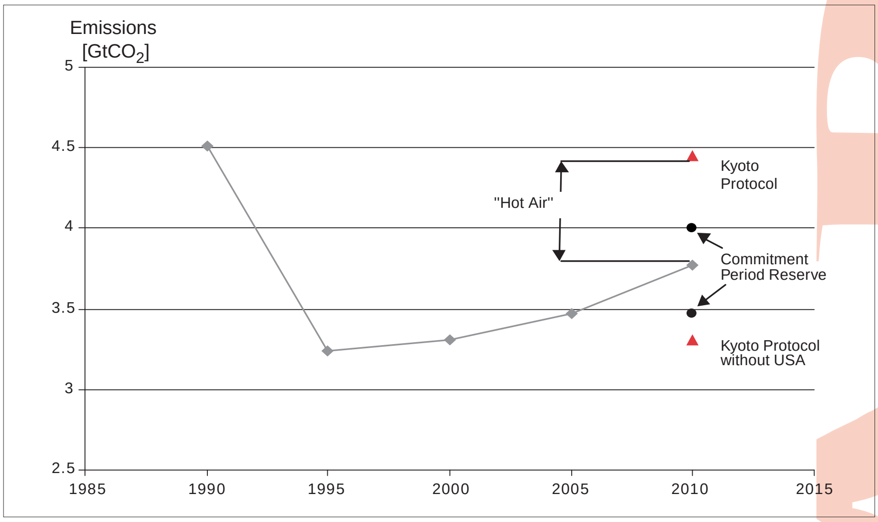

Figure 2. Emissions trajectory, assigned Amount Units, and Commitment Period Reserve of Eastern Europe and Former Soviet Union.

Carbon Sinks

The Bonn agreement included definitions of such concepts as afforestation, reforestation etc. Reforestation and afforestation projects under the Clean Development Mechanism (CDM) are capped at a maximum of one percent of the donor country's base year emissions. Caps are set on the use of carbon absorption from forestry management and agriculture.

Limits have also been set upon the use of certain land use, land use changes, and forestry activities.

Carbon sinks are much debated because there is no easy way to measure the carbon sequestered by changes in vegetation.

The modelers assumed that land use changes and forestry activities constitute free abatement options and that countries will try as much as possible to use existing projects without additional costs to meet their emission reduction obligation.

The general principle that net changes in carbon sinks can be used by Annex B countries to meet their greenhouse gas emission reduction targets was accepted in the Kyoto Protocol. However, the precise definitions of carbon sinks and the way to account for them has been one of the major issues discussed. Presently, different kinds of land use, land use changes, and forestry are subject to different rules and constraints.

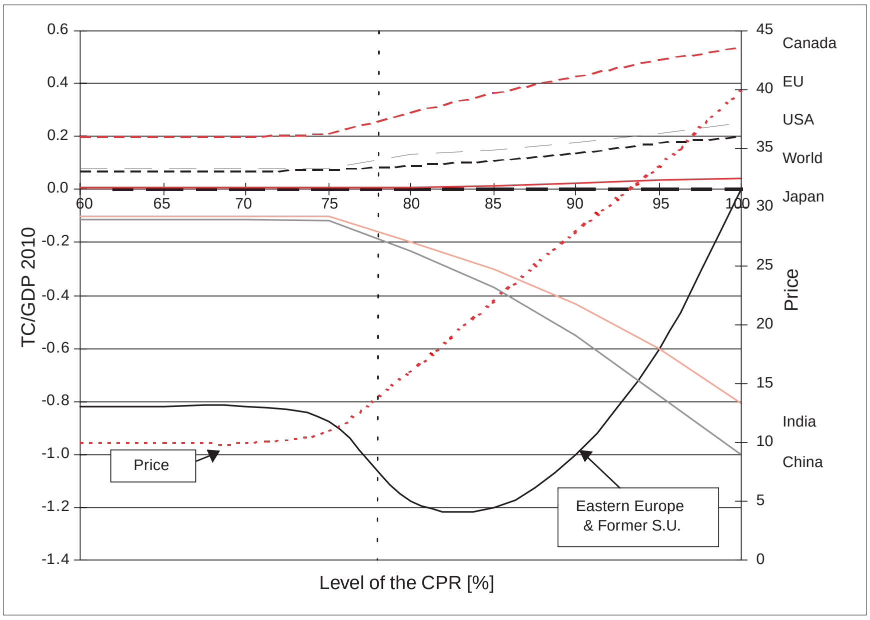

Figure 3. Total costs and permits price with alternative Commitment Period Reserves.

For projects under the Clean Development Mechanism, only afforestation and reforestation may be added to the donor country's assigned amount of greenhouse gases, and they may not add more than one percent to the donor country's 1990 emission level.

For the calculation, it is assumed that sinks in Clean Development Mechanism projects and forest management activities have zero cost, on the grounds that such activities are likely to be undertaken anyway. Therefore, they are capped at one percent of the 1990 emissions.

Although activities that enhance carbon sinks should in principle not modify world carbon dioxide emissions, introducing them into the agreement is likely to reduce carbon emission reduction efforts.

This will erode the global emission target even further, and will lead to a further decrease in total world costs by half. Annex B* countries' cost would also be reduced.

As a result of the use of carbon sinks as well as the flexible mechanisms under the Commitment Period Reserve, world emissions would increase by 26.4 percent by 2010.

Sensitivity Analysis

Increase in the cost estimates

The marginal abatement cost functions derived from the GEM-E3-World model are based on optimistic assumptions as to domestic carbon reduction measures. However, full cost efficiency is rarely achieved in environmental policy making, for instance, because of transaction costs, or because some sectors are exempted from a carbon tax. Therefore, an alternative set of marginal abatement cost functions was assumed, in which five groups of sectors in each region were distinguished: energy sector, energy-intensive sector, other industries, services, and households. Emission abatement targets are assumed to be allocated uniformly over the groups, but within each group abatement efforts can be reallocated in order to equalize marginal abatement costs. Across groups and countries, they can differ.

Under these circumstances, the equilibrium price of permits and global compliance costs are higher. Since domestic abatement is more expensive, Annex B countries make more use of the CDM. CDM countries are better off, but compliance costs in the Annex B countries increase by about 25 percent.

"The degree of inefficiency in the national implementation of a carbon policy has strong repercussions for the equilibrium price and overall compliance costs," Van Regemorter noted.

Baseline emission 5 percent lower in 2010

This small reduction has a strong impact on the results because it becomes easier to comply with the Bonn Agreement. The permit price falls to 4 $US\$_{1995}$ton/$CO_2$. If baseline emissions in 2010 were reduced by 10 percent, the hot air would suffice to cover all abatement requirements, and the permit price would fall to zero.

Higher accessibility and lower transaction costs in the Clean Development Mechanism

In the previous analysis, it was assumed that only 30 percent of the projects eligible under the Clean Development Mechanism were actually carried out due to practical, legal or administrative limitations. These carried a 20 percent transaction cost to the host country.

Assuming higher accessibility (60 percent instead of 30 percent) and lower transaction costs (10 percent instead of 20 percent) for CDM projects, the equilibrium permit prices and compliance costs would fall sharply as these projects become easier and cheaper to implement.

Different levels of Joint Implementation

The countries of Eastern Europe and the former Soviet Union might discourage Joint Implementation projects in their region because restricting total exports of permits increases their price. For a given limit on exports, the lower the Joint Implementation accessibility, the higher the amount of hot air that can be sold, and the lower the abatement costs. World emissions are higher under these circumstances because more hot air is sold.

Sensitivity analysis emphasizes the key role of Russia and Ukraine. If business-as-usual emissions in 2010 were only 10 percent less in all countries - given USA withdrawal and the inclusion of sinks - no further emission reductions would be needed to satisfy the Protocol's emission targets. Hot air meets all the requirements, and the permit price falls to zero.

"We conclude that the US withdrawal and the Bonn Agreement have indeed eroded completely the Kyoto Protocol's emission targets," states the CES report. "However, the agreement has the merit of saving the international climate change negotiation framework."

Reference

J. Eyckmans, D. Van Regemorter, and V. van Steenberghe. Is Kyoto flawed? An analysis with MacGEM. Working paper series No. 2001-18. Center for Economic Studies, Catholic University of Leuven, Belgium. September 2001. <http://www.kuleuven.ac.be/ete>

The MARKAL Family of Models

For the reference of readers who may wonder about the several versions of MARKAL referred to in these pages, here is a brief glossary which shows the variety of applications of the model:

MARKAL is a family of models that represent energy systems by the set of technologies used to extract, transport or transmit, convert, and use energy to meet projected future energy service demands. The basic MARKAL is a bottom-up linear programming model, but its variants include coupling with top-down economic models and nonlinear solution algorithms. The solution to a MARKAL model represents the optimum set of technologies that, with perfect foresight, meet the projected energy demands within the constraints that are specified; for example, the maximum level of carbon dioxide emissions permitted.

The various versions of MARKAL have generally been developed by individual participants in ETSAP to meet their specific needs. However, with the exceptions noted below by an asterisk, they are now incorporated in a common model. The user activates these features by providing the appropriate data and/or switches. Most of the MARKAL versions can be coupled to combine desired features.

MARKAL-ED: MARKAL with elastic demands. In this "partial equilibrium" approach, the projected energy demands, rather than being fixed for future years, are modified as part of the solution of the program in response to the changing cost of energy. The energy demands are represented with a stepwise linear approximation, where the user provides own-price elasticities for each "flexible" demand sector.

There is also an extension to MARKAL-ED that permits income elasticities (MEDI) also to be provided by sector.

Managing Materials to Reduce Carbon Dioxide Emissions

Modeling studies of future requirements to reduce greenhouse gas emissions from Western Europe find that managing the flow of materials substantially increases the reductions that can be achieved over managing the flow of energy alone. Nevertheless, the prospect of reducing greenhouse gas emissions by managing materials continues to be virtually ignored.

Culminating a four-year program, the Dutch National Institute of Public Health and the Environment has published the comprehensive results of the MATTER Project (T. Kram et al, 2001). An integrated systems engineering model, coupled with detailed studies of individual industrial sectors, was used to evaluate technologies for reducing future greenhouse gas emissions. To achieve the sharp reductions likely to be needed in the long run, changes in materials technology have the potential to reduce carbon dioxide emissions by another 50 percent over what can be achieved with only energy technologies.

Some quantitative results of the MATTER Project were reported previously in IEA ETSAP News (Vol. 6, No. 7, June 1999). The new report provides a comprehensive summary of the project results, conclusions and recommendations.

To evaluate the potential contribution of changes in the management of materials to reduce emissions, the MATTER (MATerials Technologies for greenhouse gas Emission Reduction) model was created by extending the MARKAL model to include material flows as well as energy flows. As with the energy system, the materials system was characterized by the set of technologies that produce, convert, and use materials to satisfy a set of projected demands. The results suggest changes in industrial and governmental policies as well as the choice of technologies.

Emissions of greenhouse gases can be reduced significantly by measures related to the production and use of materials. In the model of Western Europe, emissions related to materials amount to 1,200 $MtCO_2$ equivalents of 5,100 $MtCO_2$ for the combined energy and materials system. With emission penalties of 100 Euro/tCO_2 this can be reduced by 800 $MtCO_2$ equivalents, a reduction of two-thirds.

A limited number of materials from natural resources produce most of the carbon dioxide due to materials production.

These consist of three groups:

- Most important, *bulk materials* of two types: synthetic organic materials (plastics) produced with fossil fuel feedstocks, and materials that require a large amount of energy to be produced (e.g., steel and aluminum).
- Second, materials produced by *chemical processes that emit large amounts of carbon dioxide*, mainly cement.
- Third, *wood products* from forests that are not as yet managed in a sustainable way, mainly timber from old-growth rainforests.

Steel, cement, and plastics produce most of the carbon dioxide emissions from Western European manufacturing.

The relationship between materials and greenhouse gas emissions is not yet widely considered in greenhouse gas policy-making, nor is the use of fossil fuels for non-energy uses, such as feedstocks. More attention should be given to substitute feedstocks in the petrochemical industry, and to reducing greenhouse gas emissions with substitute materials, improved material quality, the development of new materials, product redesign, and waste management strategies.

The case studies for buildings and infrastructure, steel and biomass provide examples of the potential for significant emission reductions. For *buildings and infrastructure*, these include:

- Replacement of non-renewable tropical timber with renewable substitutes.
- Improved cement production, including the increased use of clinker substitutes such as slag, ashes, and geopolymeric cement.
- Improved material quality for steel, cement, and wood products.
- Redesign of buildings from the point of view of materials efficiency.
- Improved building and construction waste recovery systems.

The *steel* industry may choose from a labyrinth of production possibilities, depending upon tax levels, energy prices, electricity emission factors, carbon dioxide storage capacity, the presence of excess energy markets, and the success of the cyclone converter furnace now in the pilot phase.

The MARKAL Family of Models

- Continued -

MARKAL-ETL: A nonlinear version of MARKAL in which the unit costs of technologies may decline with increasing total capacity as a result of endogenous technological learning, that is, down the learning curve.

MARKAL-EV: A version that includes for a combination of pollutants the calculation of environmental damage, or nonlinear optimization of an objective function that includes the damage calculation.

MARKAL-GP*: A variant of MARKAL used for goal programming. Rather than "hard" constraints, such as maximum allowable emissions of pollutants, target values are specified. With different weights given to their importance, a set of Pareto-efficient solutions can be found to enable decision-makers to examine a range of solutions representing different goals.

MARKAL-MACRO: A nonlinear, dynamic optimization model that links MARKAL with MACRO, a top-down macroeconomic growth model. Multiple MARKAL-MACRO models may be linked to represent trade among countries in energy and emission permits.

MARKAL-MACRO-MERGE*: An integration of one MARKAL-MACRO region (e.g., USA) with MERGE regions that define a global trade model.

MARKAL-MICRO: Like MARKAL-ED, a partial equilibrium approach. In this case, projected energy demands are represented as nonlinear functions, and the solution is obtained using nonlinear programming techniques.

MARKAL-Stochastics: A version that allows for uncertainty in such input values as the permitted future level of carbon dioxide emissions, prices of energy and technologies, and levels of demand. Probabilities are assigned to alternative future scenarios. The model calculates the hedging strategy: the singular optimal mix of technologies for the near term until the uncertainty is resolved at an assumed future date.

The MARKAL Family of Models

- Continued -

MATTER: An extension of MARKAL that includes the flow of materials as well as the flow of energy.

RMARKAL: Regionalized MARKAL in which a set of MARKAL models may be linked by flows of energy, materials, and emission permits.

Global RMM*: A global RMARKAL model with five world regions, trade, and endogenous learning that includes spillovers among regions.

SAGE: System to Analyze Global Energy, a version of MARKAL that permits stepped (or "myopic") solutions in successive time periods to the model horizon.

TIMES: The Integrated MARKAL-EFOM System, which is the evolutionary replacement of MARKAL. It offers the analyst greater flexibility and additional features.

Reference

Energy planning and the development of carbon mitigation strategies: Using the MARKAL family of models. International Resources Group. 1999. <ggoldstein @ irgltd. com> and http://www.ecn.nl/unit_bs/ etsap.

Most of these routes would reduce carbon dioxide emissions considerably.

With more severe penalties on carbon dioxide emissions, the most important strategies for the use of *biomass* are energy (increasingly for transportation fuels), materials such as feedstocks for chemicals, and afforestation for carbon storage.

For newer materials and products, even greater potential for emission reductions can be expected.

Aside from carbon dioxide, the most important greenhouse gases resulting from materials are methane from landfill sites, nitrous oxide from the chemical industry and agriculture, and perfluorocarbons from aluminum smelting.

With stringent greenhouse gas emission reduction measures, emissions in many parts of the materials and energy systems will be reduced. It is necessary to use an integrated system model to consider the interaction among these measures to avoid overestimating the potential for emission reduction. These results in some cases offer striking differences from earlier partial assessments.

For example, if emissions are reduced in the production of materials - that is, if the materials themselves become less carbon-intensive - the benefit of reductions in the later use of those materials is reduced. Another example: If coal-fired power plants are phased out, the production of cement using fly ash will be affected. Again: the use of lightweight automobiles reduces the demand for transportation fuel. The selection of building materials affects the heating and cooling requirements of the buildings. Several industries compete for energy recovery from waste; if such interactions are not considered, potential emission reductions from waste recovery will be overestimated.

It is not possible to categorize 'good' and 'bad' materials from the point of view of greenhouse gas emissions, and no generic strategies can be recommended. The case studies show that each material must be analyzed within the context of a specific application. However, an integrated approach is required. It is of absolute importance to account for interactions on the level of the whole economy to avoid suboptimal emission reduction strategies. The output of the MATTER model, which can be found on the Internet, can be useful in developing materials strategies [http://www.ecn.nl/unit_bs/ etsap/MARKAL/ MATTER/main.html].

Relationship to the Energy System

Comparison of the MATTER results for Western Europe with the earlier results for the Netherlands alone suggests that the attractiveness of emission reductions in the materials system is not influenced by the initial configuration of the energy system.

In the long term, the potential for improvements in materials efficiency becomes independent of the configuration of the energy system, for example, when electricity generation becomes virtually free of carbon dioxide emissions because of the use of renewables.

Effect of Emission Penalties

Greenhouse gas abatement measures are represented in the model as financial penalties on emissions. Such penalties will favor the use of certain materials, for example, aluminum in the transportation sector, and wood for building, paper production, and as a substitute for fossil fuel feedstocks. These penalties will have a far greater impact on materials *production* and *waste* handling than on the *consumption* of materials. The case studies for the building sector, iron and steel, and biomass offer clear examples of this.

Thus, for industries at the upstream and downstream ends of the materials system - such as materials producers and waste-handling companies - emission penalties will have a significant impact. Financial instruments are likely to affect their decision-making.

On the other hand, greenhouse gas emission reductions through changes within the materials system will have little impact on the price of consumer products, because the cost of materials is a small fraction of the price of the product. This suggests that pricing instruments alone will be insufficient to effect significant changes in the *use* of materials.

Other policy instruments must be developed, such as legislation and covenants for industry, improved information for industrial designers, and R&D programs aimed at industries consuming materials, especially those with small and medium-sized enterprises. Nevertheless, rigorous pricing of greenhouse gas emissions remains an indispensable element to reveal the cost implications through the highly complex and interlinked systems of materials and energy flows.

Reductions in greenhouse gas emission from Western Europe by more than half will require penalties of emissions of more than 50 Euro/tCO_2. This will increase the cost of producing materials there, and can result in large-scale relocation of industries producing materials to regions without such penalties. A major problem, therefore, is carbon leakage. Carbon leakage may be controlled in various ways. One way is to make industrial emission reduction targets international. Another is to regulate imports. A third is to subsidize domestic industrial emission reductions.

To address the problem of carbon leakage, MATTER should be extended to become a regionalized global model that complements the econometric models being used for such evaluations.

Sustainable Development

The model calculations show that a long-term policy perspective must be provided to avoid short-term optimization with undesirable long-term consequences. Policy makers have not yet provided emission reduction goals beyond the 2008-2012 Kyoto Protocol time horizon. Without such goals, industry is unlikely to take future emission reduction requirements into account in their current investment decisions. Because of the long-term consequences of investment decisions, this is a major barrier to moving in the direction of sustainable development.

To achieve the major reductions in carbon dioxide emissions that will ultimately be required, penalties on emissions will have to exceed 100 Euro/tCO_2. This is much higher than carbon tax levels presently under consideration. Industry should be given clear guidelines regarding future emission targets to inform decisions on investments with a life span of two, three or more decades.

Many of the measures that will reduce carbon dioxide emissions will also increase the sustainability of the economy. Thus, they can be viewed as the operationalization of the concept of sustainable development.

Limitations of the Analysis

These results are predicated on assumptions of an ideal market, rational behavior, perfect foresight, fixed future demands, and a closed system. Consequently, they may underestimate certain barriers to emission reduction. On the other hand, some options that are not included in this analysis may further reduce emission reductions. These include redesign of products, longer product life, materials of better quality, and changing lifestyles.

Because the elements of the MAT TER model are technologies, its results emphasize technological solutions. However, this should not be taken as a recommendation for technological solutions alone. Governments should develop non-technological strategies as well, such as education, research, and international exchange of expertise.

The report was published within the framework of the Dutch National Research Programme on Global Air Pollution and Climate Change. The participating organizations were the Energy research Centre of the Netherlands, Groningen University, Utrecht University, and the Free University of Amsterdam.

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ECN Policy Studies

The International Energy Agency ETSAP Newsletter is published under Annex VII of the 'Implementing Agreement for A Programme of Energy Technology Systems Analysis'. Operating Agent for ETSAP/Annex VII is the Energy research Centre of the Netherlands, acting through ECN Policy Studies, Petten.

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ISSN 13823264

ETSAP OECD IEA

Progress on IEA Energy Technology Perspectives

Since the ETSAP workshop in Venice in May 2001, the IEA Secretariat has been working with ETSAP modelers to agree on specifications for the global energy technology model to be used in the *Energy Technology Perspectives* project (see *ETSAP News*, Vol.7, No.6, October 2001). The project will take advantage of progress made by ETSAP to develop the next generation of the MARKAL model, TIMES. The modeling group expects that the global 15-region model for the project will be running in TIMES by the summer of 2002. The progress of the modeling process was also discussed at the most recent ETSAP workshop at the IEA Headquarters in Paris in October 2001. During the meeting the group made significant progress in resolving technical issues, such as the inclusion of energy technology learning in the model. It is expected that a demonstration version of the model will be available in February 2002. The IEA Secretariat wants to use this version to show how technology learning in oil and gas production can affect the development of energy supply in OECD countries.

Tom Kram Departs

Tom Kram, the project head of ETSAP since 1990, has departed from the Energy research Centre of the Netherlands (ECN) to take up a position at the Dutch National Institute for Public Health and Environmental Protection (RIVM). After many years of overseeing ECN's use of the MARKAL model, he will take on the responsibility for the further development and applications of the RIVM integrated assessment model IMAGE.

During his tenure as ETSAP project head, ECN has introduced or made major contributions to a number of advances in the application of MARKAL. These have included the integrated energy and materials systems engineering model MATTER, multinational sharing of greenhouse gas emission reductions, stochastic applications of MARKAL to deal with uncertainty, and the incorporation of learning curves in the model.

During this time, Tom presented results and insights from ETSAP studies to bodies of the UN Framework Convention on Climate Change. He has also supported projects for Dutch authorities and the European Union, for example, on burden sharing strategies to mitigate climate change, and endogenous technological dynamics. He has been active in the work of the Intergovernmental Panel on Climate Change since its inception in 1988, most recently as lead author of the Special Report on Emission Scenarios (SRES).

Koen Smekens of ECN succeeds Tom as project head of Annex VII of ETSAP.