SCIENTIFIC SUPPORT PLAN FOR A SUSTAINABLE DEVELOPMENT POLICY

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MARKAL/TIMES, A MODEL TO SUPPORT GREENHOUSE GAS REDUCTION POLICIES
CP-22

KUL - VITO

SPSD II

PART 1
SUSTAINABLE PRODUCTION AND CONSUMPTION PATTERNS

- GENERAL ISSUES
- AGRO-FOOD
- ENERGY
- TRANSPORT

This research project is realised within the framework of the Scientific support plan for a sustainable development policy (SPSD II)

Part I "Sustainable production and consumption patterns"

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Scientific support plan for a sustainable development policy (SPSD II)
Part I: Sustainable consumption and production patterns

FEDERALE DIENSTEN VOOR
WETENSCHAPPELIJKE, TECHNISCHE EN CULTURELE AANGELEGENHEDEN

MARKAL/TIMES, a model to support greenhouse gas reduction policies

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INTRODUCTION

1.1. General Context and Summary

Despite the disappointing result of COP 6 in The Hague in November 2000 and the withdrawal of the USA from the Kyoto protocol, climate change is and remains a high priority research theme because an efficient and effective international and national climate policy is a necessary condition for sustainable development, as stressed by the new IPCC Working Group II Third Assessment Report which was approved in Geneva in February 2001. The commitments regarding GHG emission reductions will need important efforts from different sectors and actors and there is therefore a need for an instrument to evaluate the role of sectors and technologies in a verifiable and consistent manner and MARKAL/TIMES is such a tool. Besides the continuing update and quality control of the model database, the international dimension will be integrated in the Belgium model for the electricity sector and the GHG emission trade. Policy studies related to the Belgian climate policy are also planned.

1.2. Objectives

The main objective of this project is to support the Belgian climate change policy with the MARKAL model and its successor TIMES. While the primary focus of this project is on climate change policy, it can also contribute to the evaluation of other policies. This can be energy policies, e.g. investment/rational use of energy, both on the demand and the supply side, or conventional air pollution policies within the energy system, The project lies in the prolongation of a previous project with MARKAL, financed by DWTC/SSTC and builds on the experience and model development done during that project.

1.3. Expected Outcomes

The expected outcomes at the end of the project are twofold:

- a fully updated Belgian TIMES model inclusive an international dimension allowing the evaluation of the Belgian climate and other energy related policies within the EU context
- policy studies contributing to the climate policy debate in Belgium.

2. METHODOLOGY

MARKAL/TIMES is a technico-economic model, which assembles in a simple but economic consistent way technological information (conversion-efficiency, investment- and variable costs, emissions, etc.) for the entire energy system. It can represent all the energy demand and supply activities and technologies for a country over a horizon of 40/80 years, with their associated emissions (CO, CO2, SO2, NOx, VOC and PM) and the damages generated by these emissions. TIMES follows the same paradigm as MARKAL but the model formulation is completely revised such as to allow more transparency and greater flexibility in view of the continuous development of the model. The development of TIMES is done jointly with different partners within ETSAP.

The further development of the modelling framework concerns two aspects, the integration of the international dimension in the Belgian model and the integration of a refinery module. For the international dimension, the project will concentrate on two domains where it is most important: electricity production and GHG emission reductions. Furthermore, as the reliability of MARKAL/TIMES depends to a large extent on the quality of the database, the database maintenance remains an important activity.

The activities regarding policy analysis will mainly be related to the Belgian climate policy. Besides the contribution to the national communications (as has been done in the previous project with MARKAL), possible topics for more specific case studies are sectoral or intersectoral cost-efficiency studies, evaluation of the cost of GHG emission reduction targets to which Belgium can commit itself for the post Kyoto period, comparative analysis of the efficiency of policy instruments: taxes, permits or equipment or fuel standards. The precise specification of the case studies will have to be done in close collaboration with the policy makers during the project.

3. INTERMEDIATE RESULTS

The project having practically started only in September 2002, the intermediate results remain limited for the first year. The work has been concentrated on the learning of the model by the new researchers and on two aspects related to policy design (Task C in the Work Program), one linked to the modelling framework and the other to the application of MARKAL for the analysis of cost-efficient CO2 reduction in the Flanders region

3.1. Program for computation of marginal abatement cost

The ranking of sectors and technologies for CO2 reduction in terms of their relative cost and potential contribution, has been a frequently asked question in the policy debate. Therefore it was interesting to develop a program which would do this, based on MARKAL simulations. It will facilitate the communication with policy makers

The program has been written in visual basic and computes, with MARKAL, marginal abatement cost functions for GHG emissions for Belgium. It gives for a range of emission reductions, the marginal abatement cost and the technologies entering and leaving the system. A preliminary report is in Annex.

3.2. A Markal analysis of cost-efficient CO2 emission reductions in the Flanders region.

Markal-Vlaanderen is a Markal model for the Flanders region. The database for this model has been developed at Vito on request of and financed by the Flanders authorities. Contrary to the national Markal model, which has a typical long term horizon, Markal-Vlaanderen has been designed to give answers on a horizon of 8 to 12 years. In practical terms this medium term approach translates in the following model specifications:

- a database for 2000-2020 with a two yearly interval
- use of exogenous residual capacity estimations up to 2010
- only technologically mature reduction options are included
- no use is made of endogenous price reactions (Elastic Markal of Markal-Micro) as price adaptations are assumed to take time.

The latter three approaches will result in higher CO2 reduction cost estimations. Besides other reasons this explains why reduction costs in Markal-Vlaanderen tends to be higher than in the national Markal model.

In this study Markal-Vlaanderen has been used to explore sectoral cost-efficient emission reduction opportunities for CO2, based on a least cost principle. It is not the objective to make a proposal on sectoral emission reduction objectives.

The focus is on the period 2008-2020. The evolution of marginal abatement costs in this period is derived for three scenario's:

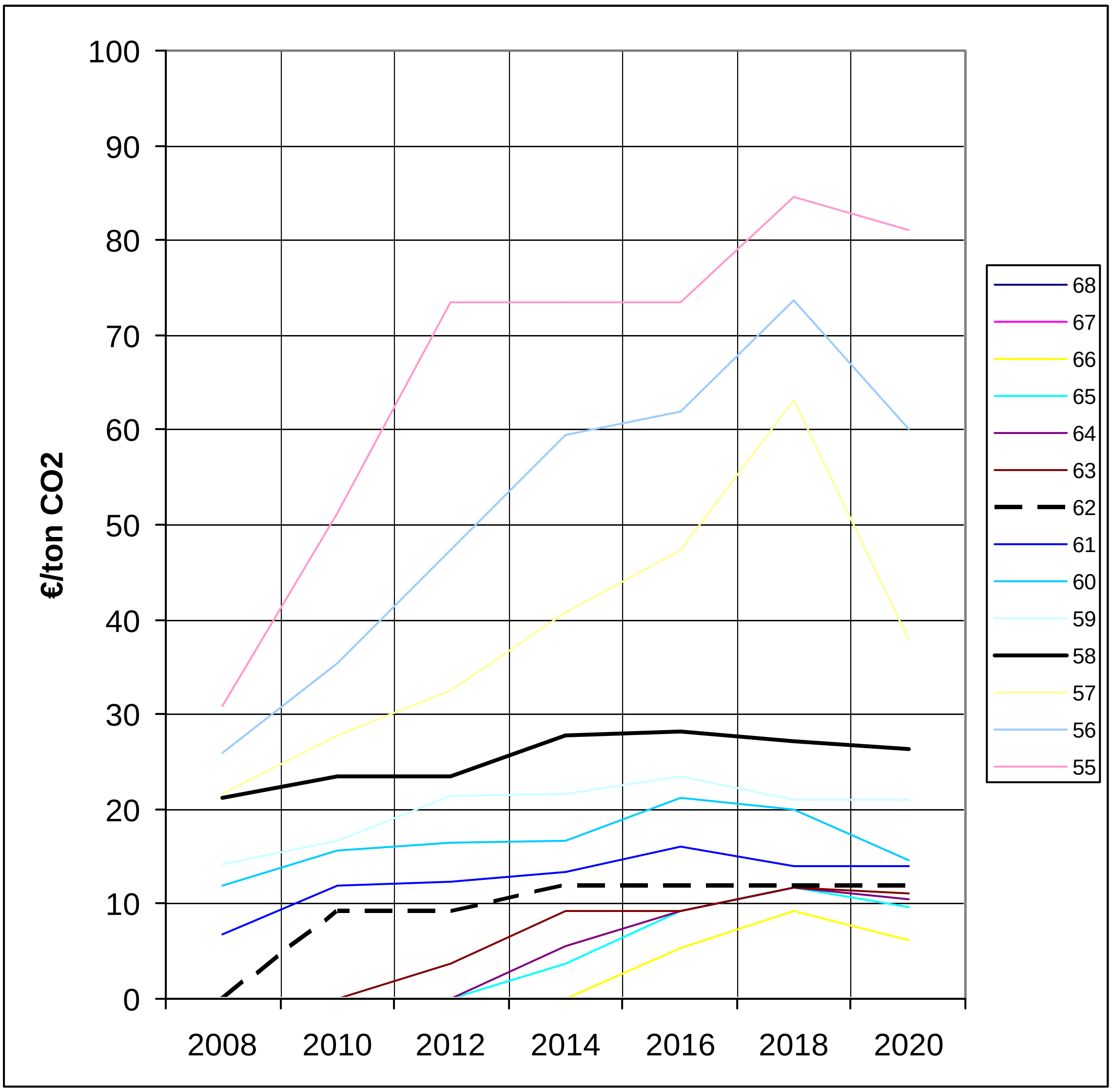
- a base scenario with a relative low gas price and modest growth assumption,
- a high gas price scenario, relaxing the assumption of low gas price
- a high growth scenario, relaxing the assumption of modest growth

Figure 1 shows the evolution 2008-2020 of the marginal CO2 abatement costs for different emission ceilings in the base scenario. The interpretation of the figure is the following: if the emissions

(Flanders CO2 emissions excluding transport sector) are reduced up to 58 Mton (dark black curve), then the marginal abatement costs will be slightly above € 20 /ton in 2008 and will reach the top level of € 28.5 in 2016.

It is obvious that both in the high gas price scenario and in the high growth scenario these marginal reduction cost are significantly higher. For instance, in the high gas price scenario the marginal abatement cost to respect the 58 Mton limit equals €40 /ton CO2 in 2008 and € 90/ton CO2 in 2018. In the high growth scenario the marginal abatement cost equals €30/ton in 2008 and beyond the scale of the graph from 2012 onwards.

Figure 1: Marginal CO2 abatement costs for different ceiling levels



The results of the study are summarized in Table 1. The figures in the table give the ratio of the cost effective emission level and the unabated emission level in the scenario for 2008. For instance in the base scenario and at an international trading price of € 30/ton CO_2 the emissions of the electricity sector will be 75 % of the base scenario emissions in 2008.
One can see that important domestic reductions can be realised in a cost effective way if the gas price is low and the trading price for CO_2 is relatively high. If growth is high, then significant reductions can be realised as well, but the resulting emission levels are still significantly above the low growth scenario as the reference emission level is significantly higher as well.

Table 1: Cost effective distribution of emission reductions. Ratio of abated emission levels to the unabated emission levels for different emission trading prices.

	€ 10/ton CO2			€ 30/ton CO2		
	Base scenario	High gas price	High growth	Base scenario	High gas price	High growth
Electricity production	0,99	1,00	0,93	0,75	0,92	0,73
Refineries	1,00	1,00	1,00	0,97	1,00	0,97
CHP	1,00	1,00	1,00	1,11	1,19	1,11
Industry	1,00	1,00	1,00	1,00	0,97	1,00
Residential	0,93	1,00	0,89	0,87	1,00	0,84
Commerce and services	1,00	1,00	1,00	0,99	0,94	0,90
Agriculture	0,87	1,00	0,85	0,84	0,95	0,82

4. FUTURE PROSPECTS AND PLANNING

The planning for 2003 will follow the scheme as proposed in the technical annex of the project and can be summarised as:

1. developing TIMES and converting MARKAL to TIMES
2. development of the international dimension for the Belgian MARKAL/TIMES
3. implementing refineries in MARKAL/TIMES Belgium
4. technology database extension, maintenance & quality check

4.1. Developing TIMES and converting MARKAL to TIMES

One of the priority of this project is to continue to participate in the development of TIMES, the new MARKAL. TIMES follows the same paradigm as MARKAL but the model formulation is completely revised such as to allow more transparency and greater flexibility in view of the continuous development of the model. The basic modelling code has been defined and the first task is to check if the basic version of TIMES can reproduce exactly the MARKAL results under the same assumptions. The second step is to evaluate the specific features of TIMES which allow to avoid the use of the numerous tricks which were implemented in MARKAL and were reducing the model transparency. This work is done jointly with different partners within ETSAP, but has taken some delay at ETSAP level.

4.2. Development of the international dimension for the Belgian MARKAL/TIMES

The international dimension has becoming increasingly important for energy and environmental policies in Belgium. The global dimension in climate change and the transboundary characteristics of more local pollution imply that every domestic policy addressing these issues must integrate these aspects. The liberalisation of the energy markets within the EU and more specifically the electricity market accentuates further the importance of the international dimension. It will clearly have an impact on the domestic market (production and consumption) and hence on the potential and the cost of GHG emission reduction in Belgium.

It is therefore important to be able to integrate this dimension within the modelling framework for policy evaluations. The project will concentrate on two domains where the international dimension is most important: electricity production and GHG emission reductions.

Two approaches will be evaluated:

1. integrate the Belgian model into a simple but comprehensive model for the EU; this model would include the main features needed to represent adequately the supply of electricity and of GHG abatement possibilities.
2. construct a reduced form for electricity production and GHG emission reduction in the EU and integrates this in the Belgian model, in the form of marginal production cost and marginal GHG abatement cost functions (supply curves for electricity and GHG pollution permits from outside Belgium)

Depending on this evaluation, the data and modelling work for one approach will be elaborated and implemented. It will be tested with different relevant policy scenarios.

4.3. Implementing refineries in MARKAL/TIMES Belgium

A refinery is a complex system of conversion technologies. The input energy carriers are various types of crude oils. The main output energy carriers are Propane, Butane, LPG, Gasoline, Naphtha, Kerosene/Jet Fuel, Diesel Oil, Heavy Fuel oil, and Bitumen. Naphtha is used by petrochemical industry. Bitumen is used in road construction. Other products have typical energy applications. The typical refinery processes are atmospheric distillation, vacuum distillation, cocking, visbreaking, thermal cracking, hydrocracking, and fluid catalytic cracking. Products properties are determined in the blending process. A typical environmental activity is desulphurisation.

The modelling of refinery activities consists of three phases, datacollection, building of a flowdiagram and finally introducing the data in Markal and testing the model.

1. Data-collection of the following data:

- Existing capacities of the different processes in 4 refineries in Belgium and the residual lifetime of these installations
- Energy and heat consumption data related to these processes.
- Technical coefficients form all processes considering different modes of operation.
- Crude specifications: an element of refinery flexibility is related to the choice of crude oil. Many different crude types are available on the international markets. For the model a number (2 to 5) of representative crudes will have to be selected.
- Blending-specifications for refinery products as these are different from country to country: octane, viscosity, and upper limit sulphur content, upper limit aromatics e.o.
- Technical specifications of boilers and furnaces in refineries and alternative options, including CHP

2. Flowchart design: The different processes in are connected to each other by various intermediate products, and this results in a complex flowchart diagram which has to be drawn before organising naming conventions.

3. Modeling work: entering all figures in MARKAL database and testing of the module by running scenarios with variations in output product mix and control of shadow prices

4.4. Technology database extension, maintenance & quality check.

The reliability of MARKAL/TIMES depends to a large extent on the quality of the database. Thus database maintenance is a prerequisite to keep the model operational and is crucial for the credibility of the model results. Database maintenance activities include the follow-up of energy demands and analysing shifts in energy demand, including new (emerging) technologies, analysing market penetration of existing technologies, gathering information on existing installations (existing capacities - residual lifetime), reviewing energy prices, follow up of industrial developments and activities. The working of the model might improve as well by increasing the number of final demand categories and improving the process representations. Special attention will be devoted to the update of the data regarding biomass and CO2 capture. Some sources of greenhouse gas emissions are not directly linked with activities modelled in MARKAL/TIMES. To allow however for a global and consistent evaluation of the cost of GHG emissions, we will try to integrate abatement cost function for GHG emissions outside the energy system (e.g. emissions from agriculture) within the model.

5. ANNEXES

5.1. Publications/Presentation

At the ETSAP/ABARE Joint Seminar, "Integrating Top-Down and Bottom-Up Modeling Perspectives" in Canberra, May 2002, Denise Van Regemorter presented a paper "The EU Kyoto target and the choice of policy instruments, the contribution of a general equilibrium analysis with GEM-E3 compared to a partial equilibrium analysis".

At the ETSAP Seminar in Torino, october 2002, Jan Duerinck made a presentation "Contributions with Markal to the Flemish research program to reduce emissions of SO2, NOx, NH3 and VOC."

5.2. Detailed Results

The detailed results are given in the two annex reports:

Roel Claes and Denise Van Regemorter (CES-KULeuven), Jan Duerinck, (VITO), "The Computation of Marginal Abatement with MARKAL".
Jan Duerinck and Koen Claes (VITO), "Een analyse van de kostenefficiënte verdeling van emissiereducties in Vlaanderen: een analyse met Markal".