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**COMMISSION STAFF WORKING PAPER**

**Final report of the Advisory Group on the Energy Roadmap 2050**

**Summary record of the PRIMES Peer review Meeting**

**Results of the public consultation on the Energy Roadmap 2050**

**Accompanying the document**

**COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN  
PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL  
COMMITTEE AND THE COMMITTEE OF THE REGIONS  
Energy Roadmap 2050**

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## SUMMARY RECORD OF THE MEETING

**Subject: PRIMES Peer review Meeting, Brussels, Monday 26 September 2011**

The aim of the meeting was to assess the suitability of the PRIMES model for complex energy system analysis by independent reviewers having the necessary modelling knowledge and experience. The meeting was held at DG ENER premises on Monday 26/09/2011.

Following reviewers were invited:

1. Dr. Fatih BIROL, Chief Economist of the International Energy Agency and Ms. Laura COZZI, Principal Analyst, Deputy Head, Office of the Chief Economist, International Energy Agency as alternate, (both absent, excused)
2. Mr. Patrick CRIQUI, CNRS-Université Pierre Mendès-France, Grenoble,
3. Dr. Andy KYDES, OnsiteAnalytics, retired from US DoE, Energy Information Administration (absent, excused)
4. Dr. Felix Christian Matthes, Öko-Institut, Institute for Applied Ecology,
5. Mr. Hector Pollitt, Cambridge Econometrics Limited,
6. Prof Dr. Christian von Hirschhausen, Technical University of Berlin,

Other participants

Prof. Pantelis Capros, National Technical University of Athens

European Commission, DG Energy:

7. Mr. Tudor CONSTANTINESCU, acting Director A Energy Policy
8. Ms. Mechthild WÖRSDÖRFER, Head of Unit A1
9. Mr. Manfred DECKER
10. Ms. Livia VASAKOVA
11. Mr. Michal TRATKOWSKI
12. Mr. Tom HOWES
13. Mr. Marc RINGEL

The meeting was chaired by M. WÖRSDÖRFER who gave a short introduction on the context and purpose of the meeting and introduced the agenda. Peer reviewers had the possibility to send questions per email prior to the meeting. The Commission received questions and comments from all 4 peer reviewers present as well as from Prof. Kydes.

In order to structure the discussion on the basis of the questions received from peer reviewers, it was proposed to have three broad sessions followed by conclusions. This structure was accepted by all participants leading to the following sessions:

### **1. PRIMES modelling mechanisms**

## **2. Modelling context**

### **3. Modelling assumptions**

Prof. Capros prepared an extensive presentation on all three points that was distributed to all peer reviewers at the meeting, and sent afterwards. The presentation is annexed to the summary record.

The three sessions were followed by concluding remarks by each of the peer reviewer who were also asked about possible suggestions for improvement in the next modelling cycle.

#### **1. PRIMES modelling mechanisms**

Following issues were covered in session 1:

**(1) Are the PRIMES modelling mechanisms adequate in balancing the need for reducing complexity and providing a relevant picture of the European energy system?**

- 1.1 Final energy demand and representation of behaviour of agents
- 1.2 Perception of costs within the micro-economic budgeting problems
- 1.3 Power and heat generation in the overall supply system
- 1.4 Grid representation in modelling, interconnections and intra-EU trade
- 1.5 Market clearing and price formation (including consumer prices)
- 1.6 Energy investments and modelling dynamics
- 1.7 Expectations, foresight and risk management by agents
- 1.8 ETS modelling
- 1.9 Bio-energy modelling module
- 1.10 CCS: modelling of capture, transport and storage of energy and process emissions
- 1.11 Calibration (sources, procedures, experience gained in a suite of exercises)

Prof. Capros presented the first part of his slides (1-27) and replied to numerous questions from peer reviewers. The questions dealt in particular with the following points:

- Formation of electricity prices in the model and recovery of costs

All cost are fully recovered through prices including RES subsidies, hence the model is implicitly providing capacity payments (without simulating explicitly such a system) on top of the wholesale prices based on marginal costs. Prices are not the same for all final energy consumers but costs are allocated according to their price elasticity with industry having the lowest price reflecting the current situation. Marginal electricity costs can become very low but are never equal to zero, even in a hypothetical 100% renewables system based on wind and solar, as there are always costs for balancing and storage. Scenarios with high penetration of nuclear and CCS have a substantial part of baseload generation allowing lower prices for industry. Scenarios with very high renewables penetration have much less low cost baseload electricity and show convergence of prices for all final energy consumers.

Electricity imports are possible and might be significant for some Member States; the importer is considered to be a "price taker" and is not determining the price on the market of a given Member State.

- Perfect foresight and expectations of investors

PRIMES generally applies perfect foresight over a limited time horizon, e.g. 10 years in demand, 20 or 30 or more years in power generation. The reason for applying the assumption of perfect foresight and thus giving investors certainty over several years for their investments is that the model simulates technologies that work; usually the scenarios quantified by the model do not simulate technology or other failures; the foresight model options can be changed to quantify scenarios of different nature.

- Infrastructure modelling

For infrastructure modelling a two-step approach is being used. In a first step, running the fully integrated version of the electricity PRIMES model, electricity trade and the need for infrastructure is being determined. Then, in the second stage, net energy imports (exports) as well as infrastructure is being introduced into the country specific PRIMES model with full resolution of all technologies and types of consumers and with interaction with the demand models. The reason for this two stage approach relates to computing time, which even with the most modern equipment is very long (8 hours for one run) when using the fully integrated model. This is particularly important as many model runs may be required when iterations are performed between demand and supply and for meeting carbon and/or other targets.

The electricity trade model of PRIMES covers all countries in the European continent except countries of the CIS and Turkey. The model performs unit commitment, endogenous use of interconnectors (with given capacities and Net Transfer Capacities (NTC)) and also optimal power generation capacity expansion planning in a perfect foresight manner until 2050. Simulations of different electricity demand levels with the model allow identification of bottlenecks and of the amount of investment in interconnectors necessary to remove such bottlenecks. A typical load profile with 11 segments is considered.

Investment in new power plants is endogenous. The rate of use of power capacities and interconnectors is endogenous. Regarding the use of interconnectors the model performs a linear Direct Current optimal power flow under oriented NTC constraints defined per each couple of countries. The model makes distinction between AC lines and DC lines, the use of the latter being controlled by operators. All interconnectors existing today or planned to be constructed in the future are represented (one by one) in the model.

- Modelling of energy efficiency

There are different possibilities how to deal with energy efficiency in the model. Policy measures such as Eco-design or energy efficiency standards influence the technology availability and possible choices of consumers. Labelling and more information campaigns are represented by lowering "perceived" costs of technologies. Introduction of energy services companies (ESCOs) lead to a reduction of discount rates. Another possibility mainly used for unidentified measures is to work with energy efficiency value that is perceived as a cost influencing the mix and energy demand without entailing direct payment, unless it is a tax or a price of permits (white certificates). The model assumes rational behaviour of agents.

## **2. Modelling context**

Following issues were covered in session 2:

**(2) Is the PRIMES energy system model embedded in an appropriate modelling context?**

- 2.1 World modelling for international fossil fuel prices
- 2.2 Gas prices for Europe
- 2.3. Macro-economic and sectoral value added developments
- 2.4. Feedbacks on GDP
- 2.5 Modelling of transport activity including modal shift
- 2.6 Links to modelling non CO2 GHG including possible feedbacks

The PRIMES model does not work in isolation but relies on several other models for input (GEM-E3 for macroeconomic assumptions; PROMETHEUS for world energy prices; transport models for transport activity projections); has links to other GHG modelling (e.g. GAINS) and it is possible to provide feed-backs on GDP.

- World energy prices

PRIMES uses results from the PROMETHEUS or POLES model as inputs for fossil fuel import prices

- Macroeconomic modelling and GDP feed back effects

PRIMES can be linked to macroeconomic GEM-E3 model to provide feed-back effects of various energy and climate policies on GDP levels and growth rates. PRIMES takes macroeconomic and sectoral projections from GEM-E3 and produces energy system projections; the results (investment, prices) can be used to recalibrate parameters of the GEM-E3 model. So, GEM-E3 model produces a new projection of economic activity. PRIMES may run again with the adjusted economic activity projections. Several rounds of iterations can be introduced to "close the loop" making results progressively convergent. The linked model system was used to assess GDP impacts of 2020 targets for RES and GHG reductions with one closed loop for cost-effectiveness reasons.

### 3. Modelling assumptions

**(3) Are the modelling assumptions used in the 2009-2011 modelling cycle plausible?**

- 3.1 Assumptions on capital costs for present and future power generation, cost developments and learning rates
- 3.2 Decommissioning pathways and economics of lifetime extension
- 3.3 Sustainable bio-energy potential and way of sectoral allocation (linked to 1.9)
- 3.4. Demand side technologies for stationary uses
- 3.5 Transport systems and parameters used for electro-mobility (battery costs, recharging systems, etc)
- 3.6 Electricity storage and grids
- 3.7 Discount rates
- 3.8 CO2 storage potential including for bio-energy
- 3.9 Translation of policy measures into modelling parameters (e.g. information campaigns, energy service companies, energy saving obligations, eco-design standards, product labelling, promotion of CHP and micro-generation, smart meters)

The last part of Prof Capros's presentation related to the main assumptions of the current modelling exercise, with scenarios for the Energy Roadmap 2050. Besides the architecture of the model (geographical, sectors and technologies coverage and modelling mechanisms) assumptions are another element that significantly determines modelling results. Several aspects were discussed in this context:

- Discount rates

To simulate capital budgeting decisions of agents (consumers, producers) in a realistic way, the model uses sector specific discount rates. Subjective discount rates are used for decisions by households and for private cars, whereas weighted average cost of capital (WACC) rates are used for business decisions. A vast literature has provided statistical evidence about subjective discount rates, which can be substantially high for low income classes; these rates reflect risk aversion, cash flow shortages, access to bank lending, etc. If the model used social discount rates to simulate private capital budgeting decisions, the results would be unrealistic (historical developments could not be explained) and the energy saving or abatement possibilities would be overestimated. Social discount rates are used to calculate cumulative energy system overall costs by scenario.

- Assumptions on policy measures

Certain energy savings measures can be simulated by changing discount rates for parts of the sector, e.g. in areas where the representative agent employs energy service companies. PRIMES has a rather wide spectrum for capturing the various types of policy measures. While some of them can be directly introduced by changing variables, such as taxes and capital subsidies others require changes in modelling parameters (see energy efficiency point). Targets for CO<sub>2</sub> emissions, energy efficiency, renewables and others are handled through their dual (shadow) variable.

- Capital costs for power generation technologies

Prof Capros presented a short comparison of capital costs for main power generation technologies with those of the US DOE estimates for 2010 (sent by Prof Kydes prior to the peer review meeting). While the costs are broadly similar for most technologies there are significant differences for wind and nuclear. This can be explained by a rather small database of realised projects in the last years. It was noted that if off-shore wind costs at present were to be revised upwards there might be steeper cost reductions (technology learning) afterwards; circumstances for nuclear would be different from this. There is also a need to monitor solar PV costs as recent developments show significant price reductions. Given the importance of the capital cost estimates, a sensitivity analysis using alternative trends might be a useful exercise.

- Decommissioning and lifetime extension issues

For existing plants, decommissioning schedules are based on information in the power plant inventory; however extension of lifetime and retrofitting are handled endogenously if permissible. For new plants, decommissioning is scheduled at the end of pre-determined lifetime; extension of lifetime is handled endogenously. Extension of lifetime entails investment costs (much lower than overnight capital costs); retrofitting costs add to the other extension of lifetime costs.

#### **4. Conclusions and suggestions for improvements**

**All peer reviewers agreed that the PRIMES model is a suitable tool for complex analyses of the energy sector/system, especially regarding its use for appropriate scenario analysis of energy policy at the EU level. There was also a general agreement, that given the importance of the exercise transparency is a key element and main assumptions and results should be made publicly available. .**

Some suggestions for improvements were brought forward by individual peer reviewers.

**Prof Dr. Christian von HIRSCHHAUSEN**, highlighting the integrated nature of the exercise including macro-economic and climate aspects, suggested further improving infrastructure modelling and including sensitivity analyses for main input parameters. In particular, efforts should be invested into a more detailed electricity (and perhaps natural gas) network, including perhaps constraints on transmission expansion.

**Dr. Patrick CRIQUI** recommended further improving macro-economic feedbacks and identified some challenges for future modelling of energy systems – system with strong penetration of renewables, storage, local management through smart grids and other infrastructure. PRIMES appears fairly well equipped to deal with making the technology process endogenous, which is however an area for research.

**Dr. Felix Christian MATTHES** recommended standard sensitivity analyses in order to show sensitivities of the model to some key input parameters. He highlighted the usefulness of the agent based approach in PRIMES that allows examining transfers (ETS, taxes, etc) among sectors rather than just focusing on overall costs given the expected policy debate on such issues. Recognising that infrastructure modelling is important with respect to long term bottlenecks, it is also important to consider that current load profiles might be improved in the future as costs are also strongly dependent on storage.

**Mr. Hector POLLITT**, highlighting uncertainty and the usefulness of sensitivities, particularly with regards to discount rates, perfect foresight and rational behaviour, and recommended to study more carefully the macroeconomic feedback issues as well as the linkages of energy policies to biomass and land use..

**Professor Pantelis CAPROS** addressed some of the concerns, especially regarding infrastructure, and mentioned what are the improvements of the model planned for the near future: further improvement of the representation of the building sectors and modelling of renovation policies for existing buildings and improvements of biomass modelling depending on better statistical data availability.

Mechthild Wörsdörfer

Annexes:

1. List of participants,
2. Prof. Capros's presentation,



## **Annex 1 - List of participants**

1. Mr. Patrick CRIQUI, CNRS-Université Pierre Mendès-France, Grenoble,
2. Dr. Felix Christian Matthes, Öko-Institut, Institute for Applied Ecology,
3. Mr. Hector Pollitt, Cambridge Econometrics Limited,
4. Prof Dr. Christian von Hirschhausen, Technical University of Berlin,
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