



# **SUMMARY OF THE UKERC- USEPA RESEARCH HOTEL ON MARKAL ENERGY SYSTEMS MODELLING**

Meeting Report, 6-10 February 2006

## THE UK ENERGY RESEARCH CENTRE

The UK Energy Research Centre's (UKERC) mission is to be the UK's pre-eminent centre of research, and source of authoritative information and leadership, on sustainable energy systems.

UKERC undertakes world-class research addressing the whole-systems aspects of energy supply and use while developing and maintaining the means to enable cohesive research in energy.

To achieve this we are establishing a comprehensive database of energy research, development and demonstration competences in the UK. We will also act as the portal for the UK energy research community to and from both UK stakeholders and the international energy research community.

### The Energy Systems and Modelling (ESM) Theme of UKERC

The UKERC's ESM research activities are being undertaken by the Policy Studies Institute (PSI) and the Cambridge Centre for Climate Change Mitigation Research (4CMR) at the University of Cambridge, with collaboration from Cambridge Econometrics.

## Overview

This report summarizes the key issues and outcomes from a Research Hotel on Energy Systems Modelling. This event, which included the MARKAL modelling teams of the USEPA and UKERC, together with additional external experts, was held at the Policy Studies Institute in London from February 6<sup>th</sup> to 10<sup>th</sup>, 2006.

This Research Hotel is one of a series of Research Hotels being run by the UK Energy Research Centre. These hotels provide a unique opportunity for active researchers from different institutions, disciplines, and countries, to work together on topics related to sustainable energy research. The Research Hotel concept is to take forward new ideas or tackle old problems in new ways, by combining researchers and knowledge from different communities and disciplines. Formats are flexible and may include anything from a single activity ranging from two days to six months, to a series of workshops with offline work between meetings - or another approach altogether.

Research Hotels are run through UKERC's Meeting Place function, based at Oxford University.

## Aims and Objectives

A key research effort under UKERC's crosscutting theme of Energy Systems and Modelling is the development of a UK energy model using the MARKAL modelling system. In relation to this major initiative, a "research hotel" was hosted to bring together international experts in MARKAL modelling from the UK and the USA for a dedicated period of time to extend progress in developing the new UK MARKAL model as well as generate insights into a range of technical energy modelling issues of interest to both research groups.

The objectives of this research hotel included:

- Sharing progress on state-of-the-art energy technology modelling in the UK and USA;
- Identifying and addressing technical issues in the iterative construction of the UK MARKAL model (building on the advanced expertise of our American colleagues, and sharing UK insights), including;
  - Resource supply curves
  - Energy infrastructures including hydrogen pathways
  - Representation of technological change and future technology characteristics

- Incorporation of key carbon mitigation options, including efficiency, nuclear, and carbon capture and storage.
- Consideration of international fuel commodity markets
- End use detail in the industrial, residential, commercial and transportation sectors
- Incorporation of combined heat and power and distributed generation options.
- Finally the discussion would cover incorporation of model variants, including;
  - Elasticity of demand
  - Macroeconomic impacts (GDP etc)
  - Formal sensitivity and uncertainty analysis
  - Goal programming
  - Exploration of near-optimal solutions
  - Endogenous technological learning

This research hotel was interdisciplinary in focus and included the integral involvement of associated discipline-specific energy experts from UKERC institutions. Furthermore the US-EPA team presented at two dedicated seminars: the first at the Policy Studies Institute on *Uncertainty and sensitivity analysis in energy modelling*; and the second as part of the ESRC-UKERC Hydrogen Economics Seminar on *Future Economics and Markets for Hydrogen Applications & Infrastructure*. The latter event was open to the full range of UK energy modelling practitioners and policy makers.

The agenda, discussion topics, key outcomes, and summaries of the seminar events are provided below.

# Work Programme

UKERC / USEPA MARKAL Modelling Research Hotel

Date: Monday 6th – Friday 10th February 2006

Location: Policy Studies Institute, 50 Hanson Street, London

Visit Objectives:

- Discussion and review of UK MARKAL energy systems model
- Strengthened links between the USEPA and UKERC MARKAL modelling teams

## **Principal Attendees**

US EPA;

Dan Loughlin, Carol Shay, Joe DeCarolis, Samudra Vijay (ORISE Postdoctoral Fellow)

PSI;

Neil Strachan, Nazmiye Ozkan, Simon Dresner, Kannan Ramachandran, David Joffe  
(PSI / Imperial)

Future Energy Solutions (FES);

Peter Taylor, Nikolas Hill

University of Oxford;

Russell Laybury

## Agenda

Monday 6th February

9.30am-12pm

Overview of structure and issues in UK MARKAL model  
Overview of structure and applications of USEPA MARKAL model  
Prioritization of modelling topics for discussion

12pm-1pm

Lunch

1pm – 4pm

Discussion of:

- Technological change
- Data sources and issues
- Resources module

Tuesday 7th February

9.30am-12pm

Discussion of:

- Processes module
- Nuclear
- Hydrogen

Presentation and discussion of UKERC Hydrogen scenarios

12pm-1.30pm

Internal PSI Seminar Series:

USEPA Presenting on; Identifying alternative strategies for achieving emissions or technology goals – Modelling to generate alternatives

Wednesday 8th February

9.30am-12pm

Discussions of:

- Electricity and CHP module
- Industry module

12pm-1pm

Lunch

1pm – 4pm

Discussions of:

- Transport module (including upstream transport chains)

8pm

Workshop dinner

Thursday 9th February

9.30am-12pm

Discussions of:

- Services module
- Residential module

12pm-1pm

Lunch

1pm – 4pm

Open session dependent on practical outcomes and actions

Friday 10th February

9.30am – 4.30am

ESRC-UKERC Hydrogen Economics Seminar;

Future Economics and Markets for Hydrogen Applications & Infrastructure

(including a presentation by Dan Loughlin, USEPA; Hydrogen Modelling with the US MARKAL Energy Systems Model)

## Key Issues

A number of key issues arose in the discussion:

### **General**

The USEPA team emphasized the importance of selecting an appropriate baseline for evaluating the implications of various scenarios. For example, the environmental benefits of hydrogen fuel cell vehicles may appear very different when compared to a conventional vehicle-dominated future than to a hybrid vehicle-dominated future.

Since MARKAL is a least cost model, it may prescribe the transition from one technology to another based on cost alone. In the real world, human behaviour comes into play, and there often is a hesitance to switch to new technologies. To more accurately reflect this hesitancy, the use of hurdle rates was advocated by the USEPA team.

There was a discussion about sources of data on future technology characteristics (e.g., efficiencies and costs).

### **Resource Module**

Global resources supply curves (for oil, LNG etc) are obtained by EPA from EIA data. The EPA team expressed interest in additional sources of resource supply data, including that used by European modelling teams.

There was a discussion regarding the required characteristics of resource supply curves for each model. The EPA model has dynamic supply curves, whereas the UK model has static supply curves. The UK team believes static supply curves are sufficient for their model because UK fuel demands are not large enough to have a large impact on the global resource markets.

### **Process Module**

There was a discussion about how the nuclear fuel cycle and nuclear technologies are handled in MARKAL by each team. The USEPA discussed its recent revamping of the nuclear power representation, including the inclusion of advanced nuclear technologies.



**Hydrogen Module**

The discussion dealt with H<sub>2</sub> distribution and spatial issues. The PSI team described the process by which they are identifying and evaluating alternative H<sub>2</sub> economy futures. The EPA team described the use of modelling options such as lumpy investments, endogenous technological learning, and hurdle rates to more accurately represent future hydrogen fuel cell vehicle penetration scenarios.

**Electricity Module**

There was discussion about how to account for electricity transmission in MARKAL and about retrofitting pollution control and carbon capture and storage technologies.

**Industrial Module**

The discussion covered modelling of fuel substitution, modelling of efficiency measures (insulation type) and industrial classifications.

**Service Module**

Data availability and sector classifications in the two countries were compared.

**Residential Module**

Energy service demands, building types and micro-generation were discussed.

**Transport Module**

Biomass fuel chains in the two countries were discussed. The prospects and characteristics of diesel and gasoline-electric hybrids were compared. The approach that the USEPA team is using to reflect buyer preferences with hurdle rates was discussed.

## Key Outcomes and Action Points

1. Strategic understanding for the two modelling teams to share insights, data and methodology. Examples include:
  - approaches for extrapolating demands and technology characteristics into the future
  - representation of global resource supply curves
  - use of hurdle rates to more appropriately represent the behaviour of individuals and firms
  - experience with modelling approaches such as the inclusion of economic feedbacks with MACRO and the use of the elastic demand and stochastic variants of MARKAL
2. Bilateral communications and sharing of key data sources and relevant reports between individual team members. All email and written communications are to be copied to Neil Strachan and Dan Loughlin to ensure a repository of communications is held at both institutions.
3. Conference report on the research hotel to be made available on the UKERC website (and potentially linked to by US EPA). To be drafted by Neil Strachan and reviewed by Dan Loughlin.
4. Regular conference calls (every three months or so) to discuss specific topics and maintain ongoing ties between the two modelling groups. Neil Strachan to arrange first conference call in early May. All to advise or non available dates.
5. Explore options for peer reviews of each other group's models (as and when required).
6. Explore options for an energy technology database (in the longer term). This could take the form of a linkage to the anticipated technology repository that is focusing on areas of data paucity, aggregation of survey information from vendors, or an Endnote database of key sources.
7. Explore options for joint academic publications, including (for example) comparative studies and model development.
8. Explore opportunities to promote best practice in MARKAL modelling, either through a web-based forum, or through dissemination of model documentation.

9. Investigate potential joint work projects on future (international) projects. PSI/FES require paid projects, while USEPA must ascertain procedures for signing on to individual projects.

# Associated Seminar

## **Seminar 5 in the ESRC Hydrogen Seminar Series**

### **Future Economics and Markets for Hydrogen Applications & Infrastructure**

Billiard Room, UKERC Headquarters, 58 Princes Gate, London SW7 2PG

Friday 10th February 2006, 9:30 am – 4:30 pm

#### **Agenda**

9:30 am Registration

9:50 am Introduction – Mike Hodson, University of Salford

10 am Future markets for H<sub>2</sub> applications

Paul Harborne, Cass Business School

Paul Ekins, Policy Studies Institute

11:20 am Discussion

11:45 am Tea & Coffee

Midday Insights from energy-economic modelling of hydrogen pathways using the USA MARKAL model

Dan Loughlin, US Environmental Protection Agency

12:40 pm Discussion

1 pm Lunch

2 pm Economics of hydrogen infrastructure development

David Joffe, Imperial College London

Steve Cook, BP

3:20 pm Discussion

3:50 pm Tea & Coffee

4:15 pm Wrap up – Paul Ekins

4:30 pm Close

# Report on the ESRC / UKERC Seminar on the Future Economics of Hydrogen

10th February 2006

This seminar on the 'Future Economics and Markets for Hydrogen Applications & Infrastructure' was held at the UKERC headquarters, Imperial College London. The seminar was the 5<sup>th</sup> of the ESRC Analysing Social Dimensions of Emerging Hydrogen Economies seminar series, which is coordinated by Mike Hodson at SURF within the University of Salford.

As it happened, UKERC had brought the US Environmental Protection Agency MARKAL modelling team over that week, to discuss their work with the MARKAL team at the Policy Studies Institute. The event was therefore modified to include an EPA speaker and co-badged as an ESRC/UKERC event.

The attendance on the day was very good, with a total of approximately 45 people attending for some or all of the day. The venue was excellent, as was the standard and efficiency of the catering.

The seminar was split into two parts, with the morning concentrating on future applications for hydrogen (the demand side) and the future economics of H<sub>2</sub> infrastructure development (supply side). On the applications front, there were presentations from Dr Paul Harborne of the Cass Business School and Professor Paul Ekins of the Policy Studies Institute.

Interesting discussion followed these talks, particularly on the 'sailboat effect' which could prompt improvements in conventional technologies as a result of the emergence of hydrogen / fuel cells. Also of interest was discussion of the reasons why consumers may or may not be willing to compromise on the performance of vehicles, when the benefits are public rather than private.

Before lunch, Dan Loughlin of the US EPA presented some interesting results from their MARKAL modelling work, with a focus on hydrogen. This was of particular interest to the PSI MARKAL modelling team, but also stimulated a wider discussion. In the afternoon, the focus was on the economics of H<sub>2</sub> infrastructure development. David Joffe of Imperial College London and Dr Steve Cook from BP presented from different angles of this subject. David's presentation focused on the production and distribution aspect, while the BP focus was on the business case for infrastructure development and how to phase it in discrete chunks.

Discussion included reference to different approaches to H<sub>2</sub> at the regional level within the UK, with Scotland, Wales and London cited as being particularly keen. It

was considered that the national government was starting to catch up with the regions in this area.

Finally, Prof. Ekins gave a wrap up and challenged the audience with the question: 'If hydrogen is the answer, what is the question?'