

*Neil Strachan and Ramachandran Kannan*

## **QUANTIFYING TECHNOLOGICAL AND ECONOMIC IMPLICATIONS OF LONG-TERM CARBON REDUCTION SCENARIOS FOR THE UK**

Policy Studies Institute  
50 Hanson Street, London, W1W 6UP  
Tel. 0207 9117540; e-mail. [strachan@psi.org.uk](mailto:strachan@psi.org.uk)

### **Overview**

The United Kingdom has set itself an ambitious climate change mitigation target with the publication of a long-term national CO<sub>2</sub> reduction target of 60% below year 2000 levels by 2050. This paper details the results of two year modelling project undertaken by the UK Energy Research Centre (UKERC) to quantify long term carbon reduction scenarios for the UK. This has involved the construction of a new MARKAL-Macro model for the UK (Strachan et al 2006). A particular focus has been on characterizing the technological and economic implications from deep uncertainties between alternate energy pathways.

### **Methods**

MARKAL is a dynamic technology-rich energy systems economic optimisation model of the entire UK energy system. Outputs of the model include a determination of the technological mix at intervals into the future, estimates of total system cost, energy demand (by type and quantity), use of energy infrastructures, the mix of input fuels, energy commodity prices, investment in efficiency options and environmental emissions. The new UK model has been substantially rebuilt and enhanced including detailed sectoral (industry, transport, commercial, residential) representation, fossil and renewable resource supply curves, and explicit depiction of key energy processes including the refining sector, hydrogen and biomass chains, nuclear fuel cycle and centralized-decentralized electricity grids.

A major methodological extension has been the integration of this very rich technological characterization of the UK energy system with a neoclassical macroeconomic model with an aggregated view of long-term economic growth. This MARKAL-Macro approach has two key advantages: allowing a behavioural demand response to supplement technology pathway optimization, and facilitating direct analysis of the impacts (i.e., consumption and GDP) of various energy and environmental policies on the growth of the economy.

### **Results**

A range of long-term carbon abatement scenarios for the UK were run using the new UK MARKAL-Macro model. Baseline projections were calibrated to historic trends and UK Government forecasts of final energy and CO<sub>2</sub> emissions (DTI, 2006). A range of scenarios under long-term carbon constraints were quantified. These included technological characterisation in the power and transport sector, resource prices, potential of energy conservation, and the elasticity of energy service demands. These runs map out the landscape of possible futures and illustrate the key technology pathways for such a major restructuring of the UK energy system. Overall, economic and energy system costs were comparable to assessments of the literature on long-term carbon emissions reduction (Stern, 2006). However significant trade-offs are exhibited in the technological make-up of a decarbonised UK energy system. Notable issues include the use of coal with carbon capture vs. 3rd generation nuclear plants vs. remote renewables for base-load electricity supply, the scope of demand reductions – both behavioural change and through technology adoption,

and technological pathways in the transport sector – notably the penetration of conventionally fuelled hybrid vehicles vs. an early transition to a hydrogen infrastructure.

### **Conclusions**

Formal energy-economic modelling of the technological and economic implications of long-term carbon abatement scenarios for the UK was undertaken via a two year UKERC modelling project. This quantification illustrated the economic feasibility of meeting the target, along with the profound structural uncertainties in the various technological pathways in the development of a decarbonised energy system. Future work will investigate the potentially competing public policy objectives of security of supply, fuel poverty reduction and economic competitiveness in light of the UK's long-term carbon reduction target.

### **References**

- Strachan N. et al (2006) *2nd Interim Report on the Development of the UK MARKAL Energy Systems Model*, UKERC working paper, [www.ukerc.ac.uk/content/view/142/112](http://www.ukerc.ac.uk/content/view/142/112)
- DTI (2006) *The Energy Challenge, Energy Review Report*, Department of Trade and Industry, July 2006
- Stern N. (2006) *Stern Review: The Economics of Climate Change*, HM Treasury, October 2006