Long-term dynamics of European decarbonisation without nuclear

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Abstract

1. Overview

Following the Fukushima nuclear power plant accident in March 2011, most countries with nuclear power plants announced safety reviews of their reactors and in some cases a revision of their energy policies and planning. In Europe, Germany is to phase out nuclear power by 2022, Switzerland by 2034 and Belgium by 2025 (IEA, 2012). Projects already under way in France and Finland have suffered delays, and the construction of new nuclear power plants seems uncertain in countries that were considered to have a strong commitment to nuclear power prior to Fukushima, such as the Czech Republic and the UK. France and Germany, countries at the core of the Eurozone, hold differing views on the future role of nuclear power. However, while France - and the UK - are unlikely to eliminate nuclear power programmes in the near future, it is currently improbable that the nuclear industry in Europe will grow significantly.

Achieving the EU's near- and long-term goals on decarbonisation and the resilience of energy supply (EC, 2012) is a challenging target. Achieving this with a limited role for nuclear (as a commercially-ready low-carbon technology) implies that renewable energy sources – such as solar, wind, hydro and biomass – penetrate the market quickly and that the continued use of fossil fuels is enabled through carbon capture and sequestration (CCS) technologies, which is not yet a commercialised technology. In this context, energy strategies that phase out nuclear power plants before the end of their lifetime are likely to affect the European energy system differently than those that maximise their use.

This paper looks at the long-term dynamics of European decarbonisation through different development paths of the system in the space of four plausible scenarios:

a) Maximisation of existing and planned nuclear power plants plus viability of renewables, CCS and reduced demand;

b) Maximisation of existing and planned nuclear power plants but failure of renewables, CCS and reduced demand;

c) No nuclear power generation, but viability of renewables, CCS and reduced demand;

d) No nuclear power generation and failure of renewables, CCS and reduced demand.

In light of Fukushima and the EU's CO_2 reduction targets, what would be the impact of the nuclear policy path chosen by Europe in terms of economic efficiency, energy security and environmental sustainability?

2. Methods

This paper utilises the newly developed ETM-UCL – a comprehensive E4 (energy, economy, environment and engineering) energy systems model built on the TIMES (The Integrated MARKAL-EFOM System) model generator (Loulou and Labriet, 2007), which is developed and maintained by the Energy Technology System Analysis Programme (ETSAP) of the International Energy Agency (IEA). TIMES is the successor to MARKAL with

new functions and flexibilities. Both MARKAL and TIMES frameworks have been used by over 100 institutions around the world (Barreto and Kypreos. 2002; Anandarajah and Strachan, 2010; Chen et al., 2007) to develop national regional and global models to analyse energy, environment and climate policies. TIMES is a technology rich, bottom–up, linear programming, partial equilibrium model that minimises total discounted energy system cost in the standard version and maximises societal welfare (consumer + producer surpluses).

ETM-UCL model has been developed by the Energy Systems research team at the UCL Energy Institute. The model represents the energy systems of 11 European regions covering the EU27 member states plus Croatia, Norway, Iceland and Switzerland. Each region in ETM-UCL is described and modelled in its supply sector (fuel mining, primary and secondary production, exogenous import and export), its conversion sectors (electricity and heat) and its demand sectors (residential, commercial, industrial, etc.). Each region in the model has its own energy system and is enabled to trade fossil fuels, biomass and electricity. The base-year (2010) energy production, conversion, trade and final consumptions are calibrated to the latest version of the IEA extended energy balance. Future energy service demands are projected using appropriate drivers (such as GDP per capita, sectoral output, population etc.) and respective elasticities. Resource availability and technology data have been taken from various sources.

The ETM-UCL model provides a basis for estimating European energy dynamics over a multi-period time horizon (2010-2100), hence allowing us to analyse the effect of different nuclear energy policies at regional and EU levels in terms of system costs, CO_2 emissions, electricity trade, demand, technology trade-offs, etc.

3. Results and Conclusions

In a context of highly ambitious short-term targets for decarbonisation and low carbon technology deployment, it is necessary to understand the energy-economic implications of a European future without nuclear as well as the effects of shutting down nuclear reactors before their energy contribution to the system can be replaced entirely by non-fossil fuel sources. The presentation will focus on how large would the risk be of not meeting CO_2 emission targets or how costly could it be to meet them inefficiently.

This paper presents results and policy implications of four possible nuclear futures, focusing both on near- vs. long-term trade-offs as well as regional implications.

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