What kind of low carbon future do we want?

Tim Foxon summarises new academic research examining the major choices for the UK as the nation tries to de-carbonise its electricity system.

The 2008 Climate Change Act set a goal of reducing the UK's carbon emissions by 80% by 2050 (from 1990 levels), based on recommendations from an independent Committee on Climate Change. The Committee's initial recommendations, corresponding to a 34% reduction by 2020 and a 50% reduction by 2025, have been accepted by the UK government as legally-binding targets. The latest Carbon Plan[1] for reaching these targets was published in December 2011. This sees the government setting the framework for achieving an affordable, low carbon and secure energy supply, with businesses, particularly large energy firms, having a key role in providing innovation and investment to deliver 'low carbon solutions'. The Plan focuses on technological solutions, principally 'front-of-pipe' solutions, such as low carbon electricity generation mainly through offshore wind turbines and new nuclear power stations, and 'end-of-pipe' solutions, such as capturing and storing emissions from coal and gas-fired power stations. Measures to reduce energy demand, such as the government's Green Deal[2] financial mechanism, which is due to come into operation in autumn 2012, rely on households voluntarily installing measures to improve their energy efficiency to reduce their energy bills over the lifetime of the measures. However, there is little discussion in the Plan of the role of wider civil society in bringing about a low carbon transition, or of alternative visions of a low carbon future.

In work undertaken by the author in collaboration with engineering and social science colleagues at nine UK universities, we have been exploring alternative pathways to a low carbon electricity future for the UK[3,4,5]. This work aims to investigate how adopting alternative ideas and frameworks governing energy systems could lead to quite different outcomes in terms of electricity demand and the mix of technology used to generate it by 2050. Drawing on interactions with stakeholders from the UK government, advisory bodies such as the Committee on Climate Change, energy companies such as E.On and National Grid, and NGOs such as WWF and the Centre for Alternative Technology, and modelling of electricity networks, we developed three 'transition pathways' for the UK electricity system from now to 2050.

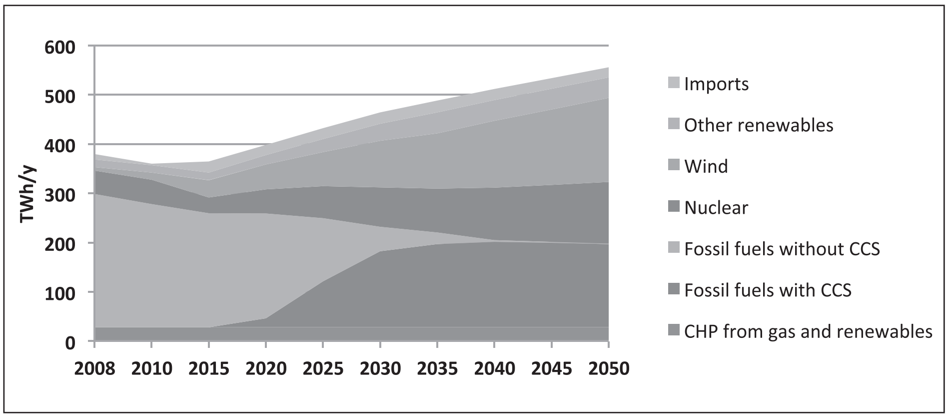

Figure 1. Electricity generation (TWh/y) in the industry-led pathway 2010-2050[6]

In our industry-led and state-led pathways, electricity demand continues to increase, as the impact of voluntary or state-led energy efficiency measures is balanced by increased demand for electric household heating, such as air-sourced heat pumps, and electric vehicles, including plug-in hybrid and battery electric cars. This demand is met by high levels of new large-scale centralised low carbon generation, in the form of onshore and offshore wind, new nuclear power stations and coal and gas generation with carbon capture and storage, with unabated gas power stations acting as backup. The mix of generation to 2050 in the industry-led pathway is shown in Figure 1.

Clearly, there are significant risks associated with this pathway. In the coming years, both nuclear power and carbon capture and storage technologies could be ruled technologically unfeasible or prohibitively expensive, and society could decide that new nuclear power stations are unacceptable for proliferation, safety and waste reasons. Large-scale renewables, such as offshore wind, are also likely to be expensive, and the costs of investing in them would lead to higher household energy bills, putting pressure on low-income households living in poorly insulated homes.

In our community-led pathway, wider civil society plays a leading role in a low carbon transition, as more people become involved in groups such as Transition Towns and take a more active role in managing their energy demand and providing local energy solutions. Community-led energy service companies (ESCos) increasingly take over energy provision from large energy companies that fail to adapt. In this pathway, overall electricity demand is reduced and there is much more local generation, in the form of onshore wind, solar photovoltaics, solar water heating and biomass-fuelled combined heat and power (CHP) systems. As these technologies become more widely adopted and accepted, their costs come down, and the large-scale, capital-intensive nuclear power and carbon capture and storage technologies are gradually seen as more expensive and less desirable. The mix of generation to 2050 in the community-led pathway is shown in Figure 2.

Of course, there are also significant risks associated with this pathway. Local generation technologies could turn out to be more expensive and difficult to install, particularly in the retrofitting of existing houses and the building of district heating schemes. The emphasis on biomass-fuelled CHP would result in a huge demand for locally sourced energy crops and the infrastructure for distributing them, to avoid reliance on imports of unsustainably sourced biofuels. Efforts to reduce final energy demand could be partially offset by 'rebound effects', in which households choose to use some of their cost savings to increase other energy-intensive activities. Moreover, this pathway relies on significant numbers of people being willing and able to take an active role in managing their energy consumption and where their energy supply comes from.

This work highlights the challenges involved in realising any pathway to a low carbon energy system in the UK, but they are not insurmountable. Current UK government carbon plans may be relying too much on market solutions, large energy firms and voluntary incentives to deliver the wholesale transformation of our energy systems needed to meet our carbon targets. At the very least, these changes require wider public consent and probably much higher levels of public involvement in energy demand and supply issues. We hope that this and

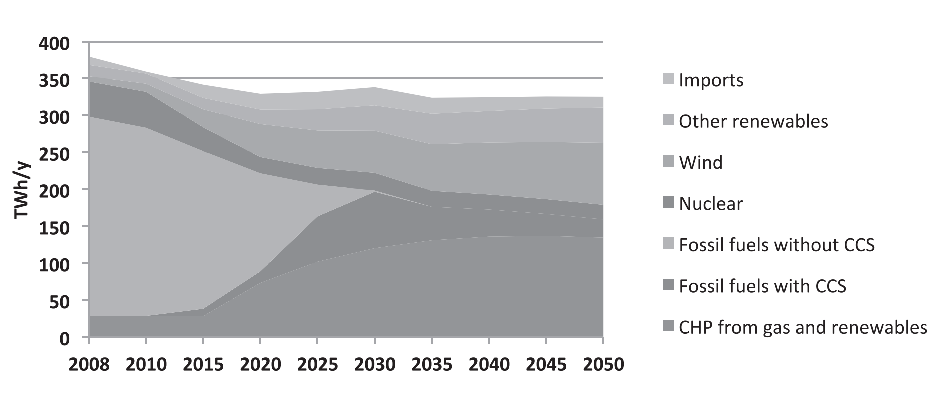

Figure 2. Electricity generation (TWh/y) in the community-led pathway 2010-2050[5]

other work can contribute to a more informed and engaged public debate about what kind of low carbon future we want, which is surely needed.

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Energy from the ocean: the UK dimension

AbuBakr Bahaj outlines the recent positive progress in generating electricity from offshore wind, wave and tidal current resources in the UK. He also assesses the future challenges in a sector in which the UK is a global leader.[a]

Over the last 20 years, renewable energy has become a critical part of the supply mix, driven by our desire to use sustainable resources, reduce pollution emanating from fossil fuels, and create new industries and jobs. Although still driven by what are termed as subsidies, the renewable energy industry is maturing, with huge investments being ploughed into it. Global investment in the sector in 2011 was estimated at $257 billion, a 17% increase on 2010. A large proportion of the funds have targeted solar and wind power, and overall investment in these two sectors exceeded that for traditional fossil fuels. This is now a major industry that is likely to grow further, displacing and augmenting traditional electricity generation facilities.

Offshore wind power

In the last five years, the deployment of offshore wind power has rapidly increased – particularly in the UK where 1.8 gigawatts (GW) of installed capacity was achieved in early 2012. Going offshore, the wind resource is much larger than onshore – with higher wind speeds being present for longer periods. It also avoids the aesthetic objections that some have to onshore turbines. Currently the UK is leading the way with a potential of 18 GW of capacity to be realised by 2020. These achievements are extremely important, especially in responding to government targets for reducing carbon emissions from energy generation, while diversifying the energy mix and creating new industries. The UK's targets and support policies have resulted in major investments by large companies, such as Siemens and Samsung, in manufacturing, installation, infrastructure, and job creation – especially in 'Round 3' wind farm development, which is planned to take place up until 2020.[1]

The challenges of an expansion in offshore wind generation are multifaceted, encompassing the technical, economic and human resources needed to support the deployment and maintenance regimes for these wind farms. Initially, wind turbines with a power rating of 2 MW were installed in the early 2000s, but now 5 MW is the norm with 10 and 20 MW machines under serious design consideration. Prototypes of these latter turbines are expected to come on stream within the next three years. From a technical viewpoint, operating in the sea clearly has its own challenges, including the design of the foundations, electrical cabling and operation within a constrained weather window. Going far from the shore and using larger machines will need new and innovative thinking in terms of materials, components and other measures to enhance reliability and ease of maintenance. Bringing power to the shore will require new infrastructure at ports to support manufacturing, deployment and maintenance, as well as new cable topographies based on high voltage DC and – more importantly – grid outlets geared to cope with the intermittence of power generation sources.

Power from waves and tidal currents

Other ocean-based energy resources are tidal currents and waves. The UK is at present the world