Editorial

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Energy policy in the UK has moved over the last decade from an emphasis on climate change mitigation towards considerations of affordability and security of supply. These reflect the three components of what has become known as the energy policy 'trilemma'. End-use energy demand is likely to remain roughly around its current level, although the energy transition out to the mid-twenty-first century will require some switching towards greater electricity use, particularly for heating and transport. Thus, achieving the UK carbon dioxide (CO₂) emissions reduction target of 80% by 2050 against the 1990 level (Climate Change Act 2008 (2008)) will require a greater emphasis on systems for producing, delivering and using energy that is not only low-carbon, but also secure and affordable for consumers both large and small (Hammond and Pearson, 2013). The preferred route to a decarbonised power-generation system (ERP, 2010) is likely to be a mix of renewables (mainly onshore and offshore wind power), nuclear power and fossil-fuelled power plants with carbon dioxide capture and geological storage (commonly known as 'carbon capture and storage' (CCS) (DECC, 2011; IEA, 2009)). The UK government is supportive of building a new generation of nuclear reactors to replace those currently undergoing decommissioning, but their recent cancellation of the £1 billion CCS competition suggests that this technology may have an uncertain future in Britain. In any event, the UK electricity supply network is in need of major renewal and reconfiguration in terms of both power plants and grid infrastructure over the coming decades (Hammond and Waldron, 2008).

The present issue of *Energy* contains three contributions aimed at providing to a better understanding of the challenges facing UK deployment of low-carbon power generators, tidal range schemes (Binnie, 2016) and community-scale solar photovoltaic arrays (Sweet *et al.*, 2016), as well as to the climate-resilience of electricity and gas networks (Metz *et al.*, 2016). The UK Department of Energy and Climate Change short-listed a number of tidal power schemes in its *Carbon Plan* (DECC, 2011), including tidal barrages, as well as some alternative, embryonic schemes which would take advantage of the tidal stream. But in October 2010 the then UK coalition government announced, following a 2-year cross-government feasibility study of different Severn estuary tidal barrage and lagoon schemes (DECC, 2010), that it could not see a strategic case for public investment in a Severn tidal power scheme in

the immediate term, although private sector groups would continue to investigate the potential. The costs and risks for the British taxpayer and energy consumer were regarded as being too high in the current financial situation – that is, the post-2008 economic recession. However, it wished to keep the tidal barrage option open for future consideration. The decision not to rule out a scheme in the longer-term recognises its significance as a large-scale UK renewable energy resource. Binnie (2016) has therefore evaluated various schemes applicable to the estuary of the River Severn (also known as the 'Bristol Channel'), which has the second highest tidal range in the world. He notes that the estuary is too shallow to accommodate the current generation of tidal stream arrays, but that the Cardiff-Weston ebb-generation barrage, together with the Bridgwater Bay and Swansea Bay tidal lagoons, could potentially supply 7% of UK energy demands. In his piece, Binnie (2016) demonstrates that this power supply would be predictable decades ahead and continuous from a 'whole systems' perspective (i.e., if aligned with the tidal lagoons that have been proposed for location on the North Wales coast and elsewhere). But the barrage itself would restrict access to upstream ports in the Severn estuary (such as Bristol (Portbury and Avonmouth), Cardiff, Newport and Sharpness) and lead to significant ecological burdens. In contrast, lagoons are likely to have a smaller environmental impact.

Another potentially important renewable energy technology is solar photovoltaic (PV) arrays. It is one of a range of so-called 'micro-generators' that can produce electricity or heat from a low- or zero-carbon source. The term embraces a variety of technological options that also include heat pumps, micro-wind turbines, solar hot water (SHW) systems and micro-combined heat and power (CHP) units. Some of these technologies are based on renewable resources (e.g., micro-wind, PV and SHW) that are essentially zero-carbon, whilst others (such as heat pumps and micro-CHP) increase the energy efficiency of fossil fuel use and are consequently low-carbon options. One forecast indicates that micro-generators could provide 30–40% of the UK's electricity needs by 2050 (EST, 2005). Sweet *et al.* (2016) have examined the extent to which the rooftops of Cardiff City Hall in Wales could be used as sites for commercial-scale PV schemes. They measured the unshaded roof area, orientation and tilt angles, along with the associated experimental performance of two PV technologies:

the popular polycrystalline silicon (p-Si) arrays and a system based on novel 'heterojunction with intrinsic thin layers' (HIT). This case study found that such PV systems could reduce the building's grid demand by 1093 MWh p.a. based on its 2014 load. However, orientation and shading effects were found to have a dramatic influence on the power output and response of the PV modules. The HIT system displayed higher 'fill factor' (the ratio of the maximum obtainable power output of the device to the product of the open circuit voltage and short circuit current) that did not fall significantly as the sunlight became more diffuse, unlike that for the p-Si technology. Similarly, the HIT system was found to be more suitable for summertime operation than the p-Si counterpart. A HIT installation of 88 kWp on the Cardiff City Hall could supply 8.1% of the annual electricity demand and avoid some 40 000 kg of carbon dioxide p.a. Its 'levelised cost of electricity' (LCOE) for this technology (£0.11/kWh) was found to be less than the present day tariff for grid imports (£0.1173). Thus, Sweet *et al.* (2016) contend that, on technical, climate change and economic grounds, the HIT system would exceed the performance of the more popular p-Si arrays.

The resilience of the UK electricity and gas infrastructure overall in the face of climate change impacts is the focus of the contribution by Metz *et al.* (2016). They suggest that the investment requirements associated with the task of incorporating climate change adaptation measures into system design will amount to some £200 billion by 2030, which they believe will mainly have to come from the private sector. Thus, the financial burden and risk of ensuring that the UK electricity and gas system becomes climate-resilient will largely fall on consumers, rather than taxpayers in general. Metz *et al.* (2016) therefore conducted research to determine ways of incentivising the private sector to deliver climate adaptation measures. They undertook mainly qualitative research based on a literature survey, followed by semi-structured interviews with key stakeholders in three categories: 11 design engineers, eight investors or consultants working with energy project financiers and three regulators or policy-makers. Key points arising from the analysis were first that the design engineers exhibited a lack of confidence in future climate change projections (i.e., wind speed and direction, as well as the likelihood of extreme weather events) and some were unaware of the availability of critical adaptation actions and decision-making tools (particularly for the design of new assets and requirements for asset life extension). They also identified what they regard as critical interdependencies between the energy sector and the water, transport and information and communications technology sectors. Finally, Metz *et al.* (2016) argue that potential

investors lacked climate change expertise and displayed a rather short-term mind-set in the face of this long-term challenge. The authors recommend a number of actions to offset these inadequacies from bodies like the Environment Agency, the UK Regulators Network, the Energy Networks Association, the Committee on Climate Change and the Green Investment Bank (supported by HM Treasury). They conclude that greater collaboration is needed between these bodies, and a clearer vision is required in order to deliver climate-resilient UK electricity and gas systems.

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