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Editorial

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Editorial

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This is my first editorial since being appointed as the Honorary Editor and Chair of the Editorial Advisory Panel of *Energy*. It is a challenging time for the energy sector in the UK and internationally. The most recent (2013) scientific assessment by the Intergovernmental Panel on Climate Change (IPCC) asserts that it is 'extremely likely' that humans are the dominant influence on the observed global warming since the mid-twentieth century (IPCC, 2013). In response to this climate change imperative the British government introduced a demanding, legally binding target of reducing the nation's carbon dioxide (CO_2) emissions overall by 80% by 2050 in comparison to a 1990 baseline (Climate Change Act 2008; DECC, 2011). Carbon dioxide is the principal 'greenhouse gas' (GHG) with a residence time in the atmosphere of about 100 years. Achieving the UK carbon dioxide reduction target will require a challenging transition in its systems for producing, delivering and using energy that is not only 'low carbon', but also secure and affordable; thus resolving the so-called energy policy 'trilemma' (Chilvers *et al*., 2017). However, the 2015 Paris Agreement following the United Nations Climate Change Conference (COP21) in that city aims to keep temperatures 'well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1·5°C above pre-industrial levels' (Ares and Hirst, 2015: p. 3). The 2°C figure is broadly consistent with the 2050 present UK carbon dioxide emissions target. However, bottom-up pledges received by countries prior to the Paris Conference (the so-called 'Intended Nationally Determined Contributions' (INDCs)) for national GHG mitigation efforts are expected by analysts of the United Nations Framework Convention on Climate Change (UNFCCC) (Ares and Hirst, 2015) to result in a warming of around 2·7°C. So the world still faces a significant test of reducing GHG emissions further in order to bring global warming into line with the aspirations in the Paris Agreement. Indeed, the IPCC in their recent 'special report' on the implications of keeping temperatures down to 1·5°C (IPCC, 2018) argued that humanity has just 12 years to respond to the climate change challenge (i.e., by about 2030 rather than 2050 presently incorporated in international agreements), if it wishes to keep global warming to 1·5°C above pre-industrial levels. Thus, it needs to instigate appropriate actions in the very near future.

Last year the UK government asked its independent advisors, the Committee on Climate Change (CCC), to give it advice on the possible tightening of the 2050 target in light of the Paris Agreement (Ares and Hirst, 2015). Its subsequent report advocated a new emissions target for the UK: net-zero GHGs by 2050 – that is, balancing emissions with carbon dioxide removal. The CCC argued that this target is 'achievable with known technologies, alongside improvements in people's lives, and within the expected economic cost that Parliament accepted when it legislated the existing 2050 target for an 80% reduction from 1990' (CCC, 2019: p. 11). They also advised that the steepest reductions in GHG emissions must occur before 2030. The CCC suggested that the readily available options include low-carbon electricity (from nuclear power and renewable energy sources (bioenergy, solar photovoltaic (PV) arrays, and wind turbines), which would need to quadruple by 2050), energy-efficient buildings with low-carbon heating (required throughout the UK's building stock, both new and existing structures), electric vehicles (which they view as the only proven light vehicle option by about 2035), developing carbon dioxide capture and storage (CCS) technology (Hammond, 2013) and low-carbon hydrogen (which the CCC regard as necessities not just options). In addition, the CCC propose phasing-out potent fluorinated gases, increasing tree planting, adopting measures to reduce GHG emissions on farms, and stopping biodegradable waste going to landfill. Such policies should together deliver tangible GHG emissions reductions, whereas the CCC viewed current UK climate change policy as being insufficient to meet even the existing 2050 targets (CCC, 2019) – that is, an 80% reduction against the 1990 baseline. At the time of writing, the UK government has still to confirm whether or not it will adopt net-zero GHG emissions as its new target.

This journal encourages contributions that address energy production, storage and use in the context of climate change, as well as having regard to the other key elements of the policy trilemma: energy affordability, price competitiveness and security of supply. Electricity generation has historically been based around the concept of large, centralised (thermal) power stations: based on fossil fuel combustors and, more recently, nuclear reactors. This centralised model has delivered economies of scale and reliability, but it exhibits significant drawbacks (Chilvers *et al*., 2017). A move towards more decentralised or 'distributed' energy systems that utilise renewable energy technologies is consequently desirable. The preferred route to a 'decarbonised' power-generation system is likely to be some mix of renewables (e.g., bioenergy, onshore and offshore wind power, solar PV arrays and solar thermal systems), nuclear power and fossil-fuelled power plants with CCS. Methods will consequently be required to evaluate such options that include technology assessment, systems analysis and the optimisation of energy processes, along with the appraisal of energy policy instruments and strategies that may incorporate energy and environmental regulation. This will necessitate innovations and research, development and demonstration (RD&D) in the areas of energy systems, processes and systems integration. Such systems would embrace power generation, the processing and transmission of energy carriers, energy storage systems and energy end-use (Hammond, 2015). Energy systems integration (ESI) is also needed to ensure that individual energy systems work efficiently with one another. It brings together power generation, the processing, storage and transmission of energy carriers, and their end-use.

The present issue reflects both energy supply-side, storage and demand-side contributions. The first paper, by Madhavi and Nuttall (2019), provides a comprehensive survey of the challenges that face global coal usage out to 2030. (William (Bill) Nuttall was my noted predecessor as Honorary Editor of this journal. He has been Professor of Energy at the Open University since 2012, where he leads research on energy-related materials, including plutonium, helium, uranium, thorium and hydrogen, as well as on 'system dynamics' applied to the problems of resource depletion. The Editorial Advisory Panel and the publishers are grateful for Bill Nuttall's contributions to the development of the journal during his period in office.) This piece builds on the earlier findings of international bodies like the International Energy Agency (IEA, 2017), whose 2022 forecast suggests that coal's share of the world energy mix will remain at about 26% on this timescale. Madhavi and Nuttall (2019) observe that a variety of factors will impact on coal use going forward: the planned 'phase-out' of coal in European countries (such as Denmark, France and the UK), changes of fossil fuel policy in China, alterations in import-dependency within India and the drop in US coal demand. They note that there was a major fall in world coal production over the period 1971–2015. This downward trend has recently been somewhat reversed under the Trump administration in the USA, which has been dismissive of climate change concerns (pulling the US out of the Paris Agreement (Ares and Hirst, 2015)), supporting new coal-mining activities and scrapping various environmental regulations (including President Obama's Clean Power Plan). Consequently, Madhavi and Nuttall (2019) review the technologies that are likely to be available to secure 'clean coal' usage, particularly CCS and carbon dioxide capture and utilisation (CCU) facilities that produce materials for food processing and the chemical industry. Finally, they examine the international coal trade, and how it might develop in the short-term (out to 2022) (guided again by IEA forecasts (IEA, 2017)). Emphasis is placed on developments in North America (Canada and the USA), China and India; all of which are viewed as major demand centres for coal that are likely to remain so at least until 2050.

The second article in this issue is related to the requirements of small hydropower plants: a renewable energy technology. Mohammadi *et al*. (2019) have studied the optimal location of the associated water-supply pipelines. Pressure-reducing valves (PRVs) are often used in such pipelines to prevent the downstream hydraulic energy from exceeding a set value. But the excess head could be exploited to generate hydropower by using turbine and/or pump as turbine (PAT) devices. In order to evaluate this possibility, Mohammadi *et al*. (2019) employed 'multi-attribute optimisation' methods, where the criteria of choice included cost, maintenance and operation, as well as distances from the consumption area and the main road. Leakage factors also played important roles in the selection process. Six scenarios (based on the maximum allowable pressure of 5, 12·1, 15, 17·5 and 20 bar (1 bar = 100 kPa) and the current pressure) were considered, and the effects of selection criteria were examined in each case. The scenario with a maximum pressure of 17·5 bar was, in this case, identified as the most effective scheme. This result was in line with that found using cost analysis, and indicated that the water leakage factor was mitigated by some 24%. Mohammadi *et al*. (2019) argue that the methods based on analytical and fuzzy analytic hierarchy employed by them could therefore yield useful tools for determining suitable locations for installing of hydropower plant on water-transmission pipelines.

Finally, the last paper in this issue deals with the development of a phase-change material (PCM) for heat storage in gypsum-based building materials (Khamooshi and Kani, 2019). Expanded vermiculite was used as a base for a coconut oil (CtO)–vermiculite composite PCM. A maximum mass ratio of CtO retained in the vermiculate of 27% yielded the best particle-size distribution. Consequently, a thermal energy store (TES) utilising PCMs was found to exhibit high storage density at constant temperature during phase change, and to reduce energy usage in buildings. The behaviour of the TES displayed increasing temperature above the melting point of the PCM, where phase change took place and the PCM underwent an endothermic process: one accompanied by or requiring the absorption of heat. CtO is potentially a thermally and chemically stable form of PCM that can withstand thermal (melting–freezing) cycling. It was incorporated into a gypsum matrix thereby producing a TES suitable for construction and industrial applications. Khamooshi and Kani (2019) measured the melting temperature and latent heat of the gypsum-based heat-storage material, which were found to be some 22·3°C and 24·2 J/g, respectively. Thermal cycling tests showed that there was no significant change in thermal property of the composite after 1000 thermal cycles. Thus, the CtO–vermiculite composite appears to be a promising PCM for gypsum-based building materials in TES applications.

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