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Editorial

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Editorial

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This issue of the Institution of Civil Engineers' Proceedings journal *Energy* is being published in the run-up to the critically important 26th UN Climate Change Conference of the Parties (COP26) to be held in Glasgow, UK over 31 October–12 November 2021. It is being organised by the UK government in partnership with Italy, and will bring together governments from around the world to agree coordinated action to tackle climate change. In addition, the conference will provide space for governments, businesses, local authorities and civil society to discuss and showcase climate action. This journal now has a 'strapline' of energy 'transitions in the era of climate change' (Hammond, 2020), and that reflects our focus on the mitigation of climate change. Energy systems are at the heart of this agenda, and our interest in the outcome of COP26.

'Global warming' caused by the enhanced greenhouse effect resulting principally from fossil fuel burning presents the inhabitants of planet Earth with major environmental risks. In November 2019, the World Meteorological Organisation (WMO) summarised the state of the global climate in an important publication (WMO, 2019). Human activities since 1950 have led to dramatic increases in atmospheric concentrations of carbon dioxide (CO_2) – the dominant 'greenhouse gas' (GHG) with an atmospheric residence time of 50–200 years, with 20–60% remaining airborne for a thousand years or longer (Archer and Brovkin, 2008). These have risen, for example, from 330 parts per million (ppm) in 1975 to about 410 ppm by 2019. Such changes in atmospheric concentrations of GHGs affect the energy balance of the global climate system, and the resulting extreme weather events are having significant impacts on the biosphere and human lives on every continent (WMO, 2019). Thus, the most recent (2013) scientific assessment by the Intergovernmental Panel on Climate Change (IPCC) asserts that it is 'extremely likely' that humans have been the dominant influence on the observed global warming since the mid-20th century (IPCC, 2013).

The WMO (2019) contends that humanity is not on track to meet climate change targets, and thereby restrict atmospheric temperature increases to those recommended at the 2015 Paris Agreement on climate change (Ares and Hirst, 2015; IPCC, 2018). This climate accord aimed 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 (IPCC, 2018). In its 'special report' on the implications of keeping temperatures down to 1.5°C the IPCC argued that carbon dioxide removal (i.e., 'negative emissions') technologies would be needed to compensate for residual GHG emissions and return global warming to 1.5°C, following a peak in about 2030 (IPCC, 2018). However, bottom-up national pledges – so-called nationally determined contributions (NDCs) – on GHG mitigation efforts received in connection with the Paris Conference are expected to result in a warming of around 2.7°C (Ares and Hirst, 2015). Humanity will therefore be required to take significant action in order to bring these emissions down to zero between 2050 and 2070.

The UK introduced a legally binding target for achieving net-zero (or 'carbon neutrality') by 2050 in June 2019 (HMG, 2019), whilst announcing in April 2021 that it would adopt an interim target of cutting GHG emissions by 78% by 2035 (compared to 1990 levels). A few other countries in Europe (Hammond, 2020) have adopted even more stringent early targets of net-zero by 2030 (Norway), 2035 (Finland), 2040 (Iceland) and 2045 (Sweden). In this context, the European Commission recently proposed to enshrine a 2050 climate-neutrality target into its first European Climate Law as part of a broader *European Green Deal* (EP, 2020). It also adopted a new interim target for emissions cuts of around 55% by 2030. Other stepped-up commitments – or NDCs – by China (of carbon neutrality by 2060) and by the new Biden–Harris administration in the USA (of reducing GHG emissions by 50–52% by 2030, compared to 2005 levels) hold out the prospect of agreeing stronger global climate mitigation action at COP26 later in the year.

The present issue reflects energy transitions towards a 'low-carbon' future in terms of both supply-side and demand-side contributions. It opens with a topical briefing on the use of the rapid pyrolysis process to generate hydrogen (H_2) from natural gas (NG). Clarke and Abánades (2021) identify this as a potentially important component of a 'low-carbon' transition pathway (Foxon *et al.*, 2020a, 2020b). This is typically referred to as 'blue hydrogen', because of the significant carbon dioxide content of NG (producing hydrogen at ~40 gCO_2e/kWh), in contrast to currently more expensive 'green' hydrogen processing by way of electrolysis that greatly reduces the generation of carbon dioxide emissions in order to underpin a net-zero economy (yielding hydrogen at ~14 gCO_2e/kWh). Conventional 'grey' hydrogen from steam methane reforming (SMR) without carbon dioxide capture generates hydrogen at ~355 gCO_2e/kWh, and therefore blue hydrogen can be viewed as part of a transition towards low-GHG supply-side fuel to meet a variety of energy demands: for home heating, industrial processing, transport and thermal power generation. Clarke and Abánades (2021) argue that this blue hydrogen transitional route would enable the 'energy majors' to utilise their enormous resources, technical ingenuity and investment capacity to lead the development of a low-emissions future. They also suggest that the UK has a critical role in directing efforts to bring hydrogen to the fore, both at home and abroad, in the run-up to the COP26 climate conference.

The application of environmental life-cycle assessment (LCA) to evaluate the impact of solar hot water (SHW) systems is reviewed by Wei *et al.* (2021) to examine their impacts. They note that LCA (see also Foxon *et al.* (2020b) for an outline of the methods and sources) can identify the environmental impacts over the full supply chain from 'cradle-to-grave' (or, more commonly, 'cradle-to-gate'). In the case of SHW systems, they found that such impacts mainly emanate from manufacturing and acquisition of raw materials, which depend on the type of system and their embedded materials. In general, SHW systems are viewed as having a low 'carbon footprint' in comparison with (say) gas boilers. The energy and financial payback periods were found by Wei *et al.* (2021) to be far shorter than the lifespan of the SHW system (roughly 15–20 years). Nevertheless, across the research papers surveyed, the LCA performance parameters varied greatly, due to differing climates, SHW system designs and the construction raw materials employed.

The third paper in this issue is a contribution emanating from the Hydrogen Energy and Energy Technologies (HEET2019) international symposium held in Osaka (Japan) over 12–13 December 2019. Wu *et al.* (2021) report an innovative visualisation experiment on the flow characteristics of the working fluid inside pulsating heat pipes (PHP). These can be utilised to enhance compact micro-electronics cooling devices, heat-recovery systems, renewable energy systems and many other applications. The results of the present study indicate that various operating modes (including small pulsations, bulk pulsations and circulation) are sequentially observed within pulsating heat pipes as the heat input is increased. When the diameter of pulsating heat pipes decreases, the flow resistance and capillary instability become higher, shorter 'slugs' are then witnessed and the 'bubble flow' is less significant.

Three transport-related energy and emissions papers complete this issue of the journal. The transport sector accounts for approximately 23% of global, energy-related carbon dioxide emissions (IPCC, 2013). In the first of the present contributions, Xiao *et al.* (2021) examine vehicle emissions predicted by way of a combination of a totally asymmetric simple exclusion process (TASEP) model and a microscopic vehicle emissions model based on the VITO (Flemish Institute for Technological Research) on-the-road emission and energy measurement (VOEM) system. In diesel cars, carbon dioxide emissions and volatile organic compounds (VOCs) were found to exhibit the highest emission levels, whereas nitrogen oxides (NO_x) and particulate matter (PM) displayed the lowest levels. The situation was observed to be vice versa in liquefied petroleum gas (LPG) vehicles. Xiao *et al.* (2021) contend that these findings are due to the burning temperature in the respective engines, as well as to grained impurities in the fuel. The results from the combined TASEP–VOEM models hold out the prospect of providing guidance on real-time vehicle emissions control, and indicate the type of policies that would be needed for improved traffic management. A second automotive contribution to the current issue is that of Adu-Mensah *et al.* (2021), who examine the partial hydrogenation of biodiesel made from cottonseed and soyabean oil. Biofuels are one possible option for producing low-GHG-emissions road transport. However, normally biodiesel has limitations when utilised in diesel engines, including poor cold-flow properties and oxidation stability. It is suggested by Adu-Mensah *et al.* (2021) that partial hydrogenation is one way of limiting these constraints. Before and after hydrogenation, the fatty acid methyl ester (FAME) contents of cottonseed and soyabean biodiesel were detected using gas chromatography–mass spectrometry. An improvement was observed in fuel properties, such as cetane number and kinematic viscosity, while the iodine value decreased following partial hydrogenation. Thus, Adu-Mensah *et al.* (2021) argue that this is an effective method of upgrading biodiesel fuel properties.

The last paper, by Li *et al.* (2021), concerns transport energy consumption specifically related to rural households on the Tibetan Plateau of China. They argue that there is a significant knowledge gap in terms of transport energy at the household or individual level, and that it is of great significance for carbon dioxide emissions and promoting sustainable development more broadly. Field-based surveys and semi-structured interviews were conducted to determine the transport energy demand in rural households in the Qinghai Province from the perspectives of the sub-regional geography (agricultural, pastoral and agro-pastoral areas) and income levels. The vehicles used for household mobility were mainly cars, motorcycles, agricultural vehicles and electric vehicles. Rugged terrain across the Tibetan Plateau resulted in road conditions that impaired fuel consumption, as vehicles clearly consume more fuel on rough roads than on flat roads. The fuel used for motorcycles on the plateau was ethanol gasoline (or petroleum), which is affordable and welcomed by local residents. Li *et al.* (2021) found that diesel vehicles were significant contributors to NO_x emissions and PM production, although their carbon dioxide emissions are less than those of gasoline vehicles; a similar observation to that of Xiao *et al.* (2021).

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