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**Energy**

# Editorial

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The UK *Institution of Civil Engineers'* [ICE] proceedings journal '*Energy*' (published by Emerald Publishing Ltd.) has for some time adopted the 'strapline' of support for innovation in energy systems in the context of "transitions in the era of climate change". 'Global warming' (alternatively known as 'global heating') caused by the enhanced *greenhouse effect* resulting principally from fossil fuel burning, presents the inhabitants of *Planet Earth* with major environmental risks. 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, although 20–60% remain airborne for a thousand years or longer (Archer and Brovkin, 2008). Thus, the need to secure a just energy transition towards the international net-zero GHG emissions, or 'carbon neutrality', target by 2050 in line with the *2015 Paris Agreement on Climate Change* (Ares and Hirst, 2015). The six highest $CO_2$ equivalent ($CO_{2e}$) emitter nations/regions in recent years were the People's Republic of China (PRC) – 16.0 Gt (30.0% of total GHG emissions), United States of America (USA) – 6.0 Gt (11.3%), India – 4.1 Gt (7.8%), EU-27 - 3.2 Gt (6.1%), the Russian Federation – 2.6 Gt (5.0%), and Brazil – 1.3 Gt (2.3%) (Statista, 2024; data updated from Darby *et al*., 2024). Unfortunately, the second US Donald J Trump Administration — often termed 'Trump 2.0' – that was inaugurated in January 2025 has been averse to methods of climate change mitigation and so-called clean energy technologies. It has indicated its intention of withdrawing from the *Paris Agreement* (Ares and Hirst, 2015) and prefers drilling for oil and gas than investing in renewable energy technologies. As the second largest national $CO_{2e}$ emitter nation that sets a poor example for China and other high emitters. It will make achieving progress at the next annual United Nations (UN) Climate Change *Conferences of the Parties* (COP) difficult. This will take place at what will be designated COP30 to be held within the lower Amazon basin at the Brazilian city of Belém in late 2025 (Darby *et al*., 2024). Other nations and regions, such as the European Union, with therefore need to do the 'heavy lifting' on climate change mitigation at COP30. The *Intergovernmental Panel on Climate Change* [IPCC], in its most recent (2023) scientific assessment, asserted that human activities have "unequivocally" caused observed global warming since the mid-20th Century (IPCC, 2023), with mean global surface temperature reaching 1.1°C above 1850–1900 levels in the last decade. Such changes affect the energy balance of the global climate system, that will give rise to even higher surface air temperatures in future causing extreme weather events that are already having significant impacts on the biosphere (CAT, 2023; Darby *et al*., 2024; IPCC, 2023; WMO, 2023).

This issue of ICE *Energy* illustrates the international nature of the climate change challenge and the development of clean energy technologies. In this regard it includes papers related to renewable energy technologies (solar PV and tidal power plants), load frequency control of micro-grids, and the fundamental thermal properties of geothermal resources. All of them stem from authors based in Asia, including contributions from two of the largest $CO_{2e}$ emitter nations: China and India. The first paper by Rashod *et al*. (2025) addresses the performance of solar power plants subject to seasonal variations. They have experimentally examined various efficiency-related parameters of polysilicon-based solar PV arrays located in the Clement town area of Dehradun, Uttarakhand State, northern India. The output of solar cells fell below that expected during the months of March to June (spring-summer), because of dust and other pollutants. In contrast, better performance was observed during July to October (summer-autumn), due to relatively heavy rainfall that cleans the PV arrays. During the latter months a drop of around 9.0% in the cell efficiency was recorded, whereas in November-February (winter) the fall was only about 2.4%. However, in the spring-summer period a reduction in efficiency of some 22.2% was observed. The authors argue that these findings provide valuable insights for plant operators, other researchers, and policymakers seeking to optimise the performance of polysilicon-based solar PV arrays sited in northern India; the third highest emitter nation in terms of GHGs.

The second paper by Jo and Kim (2025) deals with the performance of tidal power plants with venturi- versus culvert-type sluice passages. These are the two most common sluice passage configurations in use today. Optimised tidal power plants can clearly contribute worldwide to the achievement of UN *Sustainable Development Goal 7* (SG 7) on affordable and clean energy. Here *computational fluid dynamics* (CFD) simulations were employed using the Flow-3D code, and experimental validated via a laboratory open channel flume at the Research Institute of Hydraulic Engineering in the Democratic People's Republic of Korea (often referred to as 'North Korea'). Comparisons have also been made with a 'two-tank' or 'flat-estuary/basin' (i.e. 0-D) model that assumes flat water levels either side of the barrage. These tools were used to estimate the discharge capacity of the two types of sluice passages. The culvert-type passage was found to be superior in terms of both discharge capacity and resultant power output when the output area of the two passages were the same. However, the authors go on to emphasise some of the attractive features of the venturi-type sluice passage. They suggest that their findings will aid other researchers in selecting appropriate sluice passage types.

The third paper by Wang *et al*. (2025) concerns integrated energy micro-grids that incorporate traditional fossil-fuelled power plants and variable renewable sources, like solar PV and wind turbine generators. This study focuses on *load frequency control* (LFC) of such a micro-grid. It included a pumped storage unit and *electric-hydrogen-electric* (EHE) units, based on electro-chemical conversion, to stabilise frequency fluctuations. A *fractional-order proportional-integral-differential* (FOPID) controller was implemented for LFC, together with a *gradient-based optimiser* (GBO) to adaptively adjust the controller parameters. Through a case study and comparisons under various scenarios, the authors found that the proposed GBO-FOPID (EHE) scheme reduces frequency deviation performance indicators. They commendably highlight research challenges going forward, including the need for (i) a broader range of renewable energy sources and energy storage systems; (ii) real-time adaptive tuning of the GBO-FOPID parameters; (iii) the assessment of the impact of different load profiles and varying levels of grid interconnection; and (iv) the evaluation of the economic consequences of the GBO-FOPID-based LFC scheme.

The final paper by Wu *et al*. (2025) addresses one of the fundamental issues in the thermal sciences that underpin geothermal resources, although the scope for further geothermal power exploitation in China is very restricted (see, for example, Darby *et al.*, 2024). According to Wu *et al*. (2025) the performance of a geothermal energy pile varies with different flow rates. A one-dimensional numerical model of heat transfer through a sand column was therefore developed to study the distribution of seepage temperature fields at different heights and time intervals within the flowing water. The results of this model were validated using an experimental rig that demonstrated good agreement. Wu *et al*. (2025) found that particle size and seepage path length had the most significant impact, although water level difference also affected the temperature field. Pearson correlation analysis was used to determine the importance of the factors influencing the outlet water temperature. This enabled them to devise a practically useful mathematical expression for this temperature.

Darby *et al*. (2024) in their review of the outcomes of the *Dubai Climate Summit* (COP28) noted that the first *Global Stocktake* (GST) of national and regional GHG reduction pledges reported there enabled the climate change mitigation achievements of individual countries and regions to be assessed. In terms of fossil fuel production/operations and the uptake of clean technologies, CAT (2023) found that China, USA, India, the EU and Saudi Arabia were all moving in "the wrong direction". They also criticised countries aiming to adopt what they regard as unrealistic technological options that come into play after fossil fuel has been burned, such as *carbon capture and storage* (CCS) – a process not yet proven at scale (Darby *et al*., 2024). Likewise, the IEA (2023) observed that to date CCS had been a story of "underperformance". Nevertheless, the IPCC view this technology as being potentially valuable in mitigating hard-to-abate sectors, such as cement and plastics (IPCC, 2023). The COP28 *Parties* (i.e., participating nations and regions) did agree to "transition away from fossil fuels" in order to reach 'net-zero' anthropogenic GHG emissions by 2050 in line with the *Paris Agreement* (Ares and Hirst, 2015), as well as to triple renewable energy capacity and double energy efficiency by 2030 (Darby *et al*., 2024). Energy research of the type presented in this issue of ICE *Energy* will contribute towards meeting these challenging commitments.

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