Editorial

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One of the aims of an editorial is to identify a topical theme that connects the papers. That could be complicated with the divergent topics in this issue – but there is a strong binding thread. We seek papers ‘relevant to the primary global concern over energy use and climate change’. What could be more appropriate, coincident with COP26? Each of the papers in this issue address that imperative, albeit in very different scenarios.

The two most problematic sectors, that have been almost totally reliant on fossil fuels for decades, are transport and the heating and cooling of buildings. The second paper in this issue is about improving the efficiency of the internal combustion engine, and the other three are about heating and cooling buildings.

For buildings, as well as the urgent need to ‘decarbonise’, we have increasing energy prices, fuel poverty and related social consequences to deal with. Investing in deep renovation (Norton *et al.*, 2021) will help resolve these issues, and promises a better long-term solution than contributing to high energy bills for energy-inefficient homes over extended periods. Reducing energy use is a prerequisite to the effectiveness of ‘low-carbon’ energy sources and the range of related benefits. Because the necessary investment has very long payback periods, the economic case must reflect the social benefits as well as the reduction in energy use.

Around 85 to 95% of existing buildings will still be in use in 2050, so reducing greenhouse gas emissions depends on increasing the depth and rate of energy-efficient renovation. The rate must reach a staggering 90 000 homes per week across the EU. On the other hand, that presents considerable opportunities for a diverse supply chain for insulation and low-carbon heating technologies. The paper by Norton *et al.* (2021) contains several useful tables about the technologies applicable to energy-efficient buildings and low-carbon energy supplies with their opportunities, challenges and barriers, financing, priorities and actions. There is no ‘silver bullet’. But there are

recommendations for policy, legislation, resources and skills development, supply chains, financing and much more.

It might seem odd to include a paper about the internal combustion engine but, given that in the hierarchy of the means of reaching net zero, improving the efficiency of energy use is second only to not using energy at all, the logic becomes clear. Further, the paper by Karagöz *et al.* (2021) is relevant to the use of both petrol and biofuels (and hydrocarbon–hydrogen blends) for hybrid cars.

Hybrid vehicles are now a firmly established part of the pathway to net-zero transport because of the limitations of batteries, and the authors suggest that low-power spark-ignition engines operated with alternative fuels will become widespread. Switching to biofuels, and optimising the ignition advance, reduces harmful emissions of nitrous oxides and particulate matter as well as carbon dioxide (CO₂). Several previous studies were reviewed prior to undertaking laboratory tests and mathematical modelling of a single-cylinder engine with petrol and with methane, the tests validating the modelling. However, a potential concern is that the authors report a dramatic increase in emission of unburnt hydrocarbons when using methane.

Ren *et al.* (2021) describe the economic and environmental benefits of a rooftop photovoltaic (PV) installation in Shanghai, China. Ironically, the PV output, and therefore economic return, are degraded by atmospheric dust (measured as PM_{2.5}) from the burning of fossil fuels, though the effects are difficult to quantify. Pollution (sulfur dioxide and nitrogen oxides as well as carbon dioxide and particulates) is recognised as being excessive, with devastating effects on human health. Reducing pollution is a further incentive to invest in PV, especially if it displaces coal-fired generation. The authors also make the point that PV is not entirely green because of the embodied energy associated with production and recycling,

emphasising the importance of life-cycle assessment. The paper includes considerable detail about the analysis of the energy, pollution-reduction and economic benefits of PV, and a range of subsidy schemes.

Last in this issue, but by no means least, we have a paper on the prospects for geothermal systems in their broadest sense, use of the thermal inertia – stable, considerable but unexploited low-grade heat – just below the surface of the Earth. In the right circumstances, it is durable, can achieve high efficiency and is useable for heating in winter and cooling in summer. Gondal (2021) sets out the options for using this resource for space heating and cooling of buildings across a broad spectrum of climatic conditions.

The author examines systems with and without heat pumps (active and passive, respectively), and how they can be enhanced by integration with renewable energy resources and thermally active building envelopes. The examples are wide-ranging in their application; they demonstrate that good design appropriate to the climatic circumstances can improve efficiencies and yield net-zero-energy buildings. The complementary technologies that can help achieve net zero include solar thermal and PV, wind, evaporative and radiative cooling, solar chimneys and wind tunnels. In the high latitude of the UK, I have tended to think about air or ground source heating only for keeping warm; solar does not help much in winter. My imagination had not extended to the variety of solutions available for other regions

that are identified here. Figures for this paper (Gondal, 2021) are available in the online supplementary material.

To limit global warming to no more than 1.5°C, we need to deploy existing technologies urgently. These papers provide optimism that, sometimes with development and integration, there are many solutions already available that can help us accelerate progress. We must implement them now. *Energy* welcomes more papers that illustrate pathways to net zero.

Do also look at ‘Ahead of Print’ papers as well as previous issues of *Energy* online.

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