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Editorial

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Engineers have appreciated the need to reduce the drivers of climate change for many years. Energy use in buildings is a significant driver, especially where the prime energy is sourced from fossil fuels, where combustion yields significant greenhouse gas (GHG)/carbon dioxide (CO₂) emissions. They have used three main approaches: fuel substitution, for example moving from coal toward natural gas; improving the energy-efficiency of use, for example by improving building insulation and the efficiency of industrial processes; and finally, in the electricity sector, improving generation (and transmission) efficiency and adopting low-carbon dioxide generation (especially renewables) to reduce GHG emissions per MWh significantly.

This issue of *Energy* contains two papers relating to improved building insulation, plus one related to deployment of renewables (in Pakistan), plus one that explores the challenges of reducing GHG emissions associated with disparate industrial processes.

The first paper, by Cooper and Hammond (2018), notes that UK government technology roadmaps exhibit quite large uncertainties, and reducing carbon dioxide emissions over the long term will depend critically on the adoption of a small number of key technologies, alongside the ‘decarbonisation’ of electricity supply. Industry in the UK accounts for some 21% of GHG emissions and the authors advocate tailored solutions for the widely differing industrial/commercial processes/industries in order to achieve the significant GHG reductions required economically. ‘Circular economy’ interventions have the potential to make significant energy savings that are complementary to other energy-efficiency measures. This chimes with examples in other areas, where historically a silo approach has incentivised the adoption of instantaneous gas-fired combi-boilers and the reduction of thermal storage in the UK’s housing stock, which limits the scope for flexible demand control, potentially increasing GHG emissions from electricity generation, whereas some other countries in Europe have retained a greater degree of thermal storage in their building

stock. Cooper and Hammond identify that in some industrial sectors, such as pulp and paper, there is scope for the adoption of demand-side flexibility (DSF) techniques, whereby levels of electricity demand are increased, reduced or shifted, and on-site energy storage then enables the optimisation of electricity usage. While the authors focus on on-site optimisation, wider optimisation would better match industrial demand profiles to renewable energy production. The authors note that UK industry has weak data on industrial energy use and the potential for GHG emissions reduction, with just six sub-sectors accounting for 81% of UK industrial emissions. The seven Industrial Decarbonisation and Energy Efficiency Action Plans (voluntary) of the UK government’s Department for Business, Energy and Industrial Strategy (BEIS) aim to improve energy productivity by at least 20% over the period to 2030 (BEIS, 2017). It should be noted that closure of some energy-intensive industries (e.g. large steelworks) has reduced UK emissions, but may have exported such emissions to other countries. The use of a new metric – the emissions intensity ratio (EIR), defined in terms of GHG emissions per unit of national income – may not fully reflect such ‘exports’. Therefore, the development of an international accounting system for embodied carbon dioxide emissions could help countries work together to reduce global warming. The new BEIS Energy Innovation Programme includes greenhouse gas removal (GGR) technologies (chiefly industrial carbon dioxide capture and storage (CCS)) plus new industrial heat-recovery initiatives. The UK government has flirted with developing a sustainable CCS industry that might capture emissions from clusters of industrial process plants and electricity power stations linked together by a pipeline network transporting carbon dioxide to suitable storage sites offshore. However, it is debatable whether opportunities to take this forward have been missed over the last two decades, which has undermined the prospects for future development. A number of opportunities and priorities for industrial ‘decarbonisation’ and improved resource efficiency in the UK have been articulated. But the task for both industrial and policy decision-makers will be challenging.

The second paper, by Arshad and O’Kelly (2018), explores the current electricity problem in Pakistan and the scope of wind power to aid in its solution. Pakistan is currently experiencing one of its worst periods of power shortages. At present, almost 25% of the total population in Pakistan has no access to electricity and those that are connected live without electricity on a daily basis for more than 12–14 h in cities and even longer in rural areas. In addition to reductions in non-technical losses and enhancing investment attractiveness, the authors recommend diversification of the present electricity-generation mix, with a significant increase in wind power. In addition, upgrading and overhaul of existing power plants and network infrastructure will be required to facilitate improved and affordable electricity supply and mitigate the current and projected long-term electricity supply–demand gap. The current electricity-generation mix in Pakistan is highly skewed towards thermal electricity, principally oil and natural gas, which creates issues with imports and balance of payments plus limits the scope for GHG reduction. Compared with (imported) oil- and gas-fired power generation, wind power is potentially the cheapest source of electricity generation for Pakistan.

The third and fourth papers focus on reducing GHG emissions by way of improving thermal insulation of buildings.

The third paper, by Çetintaş and Yılmaz (2018), proposes a new approach to determine insulation material and thickness from a life-cycle perspective. Focusing on new building standards is recognised as ignoring the legacy of older buildings, and energy-efficient retrofitting of buildings needs to be considered. Adding thermal insulation to the building envelope is the most common and well-known measure, but existing strategies for energy-efficient retrofits do not consider the life-cycle energy consumption and carbon dioxide emissions of the insulation materials. This paper introduces a new approach for selecting the optimum insulation material and thickness based on life-cycle energy consumption and carbon dioxide emissions.

European approaches aim to achieve low U values in the building envelopes. However, optimum insulation material and thickness should be evaluated based on the climate zone and

building typology. Mediterranean seasonal climates trigger both cooling and heating requirements. Retrofitting a thick insulation layer in the building envelope may not be as effective at reducing carbon dioxide emissions as mechanical cooling systems using electricity from renewable sources. The authors’ research highlights the advantages of a life-cycle approach.

The final paper, by Ram *et al.* (2018), assesses energy efficiency in buildings using synergistic walling material. Specifically, a low-thermal-conductivity building block was developed using co-fired blended ash (CFBA). The physical and mechanical properties of the blocks were investigated according to Indian standards, as was the thermal conductivity. Building performance analysis was carried out with the help of a case study. This suggests that peak cooling load reduction by 8, 11 and 15% should be achievable for single-, two- and three-storey buildings, respectively.

Bricks developed using CFBA (up to 15%), suitable for use in non-load-bearing walls, had significantly reduced thermal conductivity. Moreover, the dead load and cost of the building were both reduced by 5%.

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