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Building energy demand pathways for reaching a net-zero carbon society

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Editorial

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Abstract

Buildings are major global energy consumers, accounting for 20%–40% of total energy use in developed nations, exceeding industrial and transport sectors. This rising consumption, caused by population growth, higher living standards, and pervasive energy-intensive technologies, underscores the urgent need for enhanced energy efficiency in the built environment. These measures are vital for environmental sustainability, societal well-being, and balanced development.Reducing building energy demand is both an environmental and societal challenge, requiring a holistic approach. This includes energy efficiency, renewable energy adoption, and occupant behavioural changes, balancing technical and societal challenges to achieve net-zero aspirations. Achieving net-zero aspirations demands collaboration among stakeholders, including governments, developers, and building occupants. We invite contributions on the role of buildings in urban energy reduction, focusing on services technologies, new design initiatives, and AI in building management. The importance of existing building archetypes and their potential for energy demand management through efficient envelopes and technological advances is also a key consideration. We welcome various formats, including literature reviews, research papers, and case studies, that use both quantitative and qualitative data to analyse pilot projects, stock modelling, or city-scale proposals.

Impact statement

Advancing building energy efficiency through integrated, data-driven retrofits and innovative technologies is crucial for sustainable, net-zero urban environments.

Buildings play a significant role in global energy demand and carbon emissions. They not only provide shelter from the outdoor elements but also contribute to societal well-being, economic activity and, more recently, the impact they have on our environment and the interplay with our existing cities and surrounding infrastructure. According to the recent Global Energy Review 2025 (IEA, 2025), electricity demand from buildings grew four times faster in 2024, compared with 2023. In 2024, global electricity use in buildings increased by more than 600 TWh compared with the year before, at just under 200 TWh. Although this increase means higher carbon emissions, it's the type of fuel or resource used to generate that electricity that should be in question, rather than the observed growth itself. However, the global increase can simply come from a drive to recover and reach pre-COVID-19 industrial production levels, an increase in electrical heating systems (heat pumps), uptake of electric vehicles, an increase in global temperatures and a disheartening of society with the politicisation of net-zero initiatives towards set targets.

The way buildings are planned, designed, occupied and managed can steer their overall energy demand and impact on the environment. The interplay between these stages of a building's life is crucial for the planning of cities, reaching sustainable growth and maintaining the existing building stock.

Building energy intensity can account for up to 33% of the total global energy, mainly attributed to the operational energy demand, to maintain its day-to-day operation for heating, cooling and powering appliances. This equates to contributing 30% of the world's carbon emissions (Koezjakov et al., 2018). However, the share between operational energy and energy used to manufacture the materials to construct buildings is changing as buildings are becoming more energy efficient, but they keep using high-intensity materials. In the United Kingdom, a new residential building is estimated to contribute up to 49% of total carbon emissions on regulated and unregulated energy use, whereas the manufacturing and construction stages (including the embodied carbon of materials) contribute the remaining 52% (Sayce and Wilkinson, 2019; RICS, 2024).

The methods used to operate buildings play a big part in the building stock end-use load profiles, shaping the future transmission of energy to specific buildings or areas in a city. However, to meet

net-zero targets and to drive energy demand down, there needs to be a shift to becoming more frugal about energy use and to create consciousness among building users. The impacts on society from increased energy demand and carbon emissions can have profound consequences for economic development, public health and our environment as a whole. The high costs of energy can also affect society, particularly in countries with high temperatures, requiring cooling and in colder climates for heating, both seeking thermal comfort and refuge from the effects of a changing climate. Reaching net-zero carbon levels needs to consider a fair and equitable transition to a low-carbon economy, minimising impacts and disruptions to people, while also making it affordable.

The transition to renewable energy and the decarbonisation of our electrical grid supply, coupled with new district heating systems by efficient heat generation or waste heat, can reduce carbon emissions. However, harnessing adequate energy through new processes and technology should consider the societal and existing limitations of towns and cities, particularly in high-density settings with existing buildings with heritage and listing status.

The actual operation and upkeep of existing buildings can have one of the largest impacts on energy demand in towns and cities. Through poor building envelopes and high heat loss, many of our existing buildings consume vast amounts of energy, and a balance is needed between energy efficiency and new technological advances in heating and cooling. Building carbon and energy reduction should not be centred around only adopting efficient heat/cooling technology; it is one piece of the puzzle, but not the only solution to consider. The role of balancing technology and building envelope performance with smart technologies using automated control systems, smart energy management platforms and the integration of digital twins and IoT can contribute to reducing demand and carbon emissions towards net-zero targets.

This editorial explores the connection between buildings, energy consumption and the broader societal implications of these choices, highlighting the need for a holistic approach to energy efficiency, technological choices and the role of building operations. It also brings together the way new technologies and the interplay with existing building archetypes require a deeper understanding and analysis, where high-density buildings and retrofit solutions need to be considered for new energy infrastructure solutions being proposed.

For this issue, we are inviting papers that explore the balanced approach between the high energy demands of buildings and the available solutions to drive consumption and carbon emissions that meet net-zero targets. These can include discussions, analysis and solutions at a building or city scale, implementing traditional, technological or modelling proposals. We welcome contributions that are based on the complexities experienced in historic and heritage city examples, as well as those proposed for new designs that can contribute to the efficient onset management of energy demand in buildings. We look forward to accepting publications from researchers based in universities and research institutions all over the world, prioritising those from developing countries.

Open peer review. To view the open peer review materials for this article, please visit https://doi.org/10.1017/etr.2025.10002.

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