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EDITORIAL

Guest editorial note

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This special issue is produced in co-operation with the European Council for an Energy Efficient Economy (eceee). Within it, we present current findings on a broad range of energy efficiency policies and measures. Starting with a series of papers dealing with energy efficiency within the wider energy system, we then move on to other papers focusing on buildings and appliances and their respective policies and measures.

Many of the papers highlight the consideration of the human factor in policy design, modelling and technological development. The discrepancy between modelling, testing and real life is in many cases a major challenge.

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A common theme in many of the key energy efficiency policy and practice questions today is how we deal with increasing complexity. This may be the technical complexity of deep refurbishment of a building; the market complexity of delivering retrofits involving multiple trades or the need to think more widely about a part of the energy system so that the outcome of policy and practice across a range of different interests can be optimised.

Energy efficiency in the wider energy system

Deep refurbishment of buildings has implications for other elements of the energy system, which can be positive but may also be negative. Padäm et al. consider the interconnections between energy efficiency, indoor environment and district heating. Energy efficiency improvements are often carried out by building owners according to refurbishment needs and with no reference to the energy supplier. This research, based in Sweden, finds that, in a Nordic climate, there is potential for energy efficiency improvements to deliver winter-skewed energy savings that cut peak demand. In this case, the savings have a positive impact on the district heating energy supplier as well as on the indoor environment. Deeper energy savings will retain a positive impact on indoor environment but can have a negative impact on the economics for the district heating system. For the energy supplier to achieve a positive outcome over a wider range of energy saving levels, new business models that make

income less reliant on the number of kilowatt hour sold are needed. This suggests the potential value of a more collaborative approach to refurbishment between the energy supplier and the building owner.

The energy efficiency of the building stock is increasing due to the different policies on the demand side for the transition towards the nZEB concept. Efficiency gains on the supply side, especially in district heating systems, may raise the question whether the systemic optimum requires these higher efforts on the demand side. Drysale et al. analyse in a case study from Denmark the interactions between supply and demand side efficiency in the building stock. Their findings suggest that a vast reduction of the energy demand might not lead to systemic optimum in terms of decarbonisation. Still, they highlight the importance of demand-side energy efficiency.

The increasing electrification of the demand side is expected to have an impact on the electricity supply networks, potentially requiring grid investments for reinforcing their capacity, especially at peak times. Hanmer et al. provide useful insight on how electrification of space heating in the UK will potentially create additional stress on the grid during peak times in the morning. In their contribution "How household thermal routines shape UK home heating demand patterns", they explore the role of social routines related to for example work and school impact thermal demand practices. They provide useful recommendations with respect to how the morning routines could be taken into account when designing future energy systems and how flexibility can be targeted by appreciating that the timing of use is linked to other routines and practices. Flexibility is also a core topic of the contribution from Wohlfarth et al. In their paper "Demand side management in the service sector – setting course for energy flexibility and efficiency", they demonstrate how the service sector in Germany, e.g. supermarkets, hotels and office buildings, is the locus of considerable unused DR potentials thanks to a high stock in flexible cooling appliances, air conditioning and ventilation. This unused potential could be a valuable resource to balance regional unbalances, but the authors discuss that the untapped potential is also the result from a non-conducive regulatory framework, and lacking incentives in particular, but also a lack of knowledge and marketing.

The need to think about more than one element of the system also applies to the transport sector, and to the elements that influence the direction and rate of system transformation. Traditionally, modelling of the transport system has tended to exclude lifestyle changes and elements of the socio-cultural trends that shape the system. Brand et al. present a series of scenarios for the system in Scotland, developed using an integrated transport-energy-environment model that does incorporate these elements. The scenarios compare the impact of lifestyle and socio-cultural factors against the more traditional transition pathways of electrification and the phase out of conventionally fuelled vehicles. The idea is not to develop a single vision of the future, but rather to illustrate how action across both the technical and the social spheres has value and that both are needed for us to meet our air quality and climate change objectives.

Buildings and construction technologies and systems

Yao et al. discuss how heating and cooling demand of Swedish multi-storey residential buildings can be minimised in "Design strategies to minimise operation energy use for passive houses under different climate scenarios". They discuss strategies such as efficient household equipment and technical installations, bypass of ventilation heat recovery unit, solar shading of windows, window size and properties, building orientation and mechanical cooling in the context of different climate change scenarios for Southern Sweden.

The calculated and measured energy performance of buildings often does not match. Especially in the context of energy performance certificates, this mismatch has received broad attention and caused criticism of the calculated energy performance used for the certification. Hoerner et al. use larger datasets, which cover both measured and calculated demand and propose a statistical correction of calculated demand based on their regression model.

The work presented by Filippidou et al. is situated in the same context. Within their analysis, they used a large dataset from the Netherlands to identify the effectiveness of different renovation measures in terms of actual savings. Their findings support the need for the use of measured savings as they can show the mismatch between modelled and metered savings based on their dataset. A general understanding of the differences between metered and measured savings is crucial for the proper planning and implementation of energy efficiency measures.

Minimised use is targeted from the perspective of the users in the contribution "'Everyone has a Peer in the Low User Tier': The Diversity of Low Residential Energy Users" by Deumling et al. The authors nuance the common assumption that low residential use is the result of poverty, thermal discomfort or small dwelling size, at least when it comes to CA. Their study found that yes, low use often does relate to smaller dwelling size, but also that the lowest 10% users actually deliberately, enthusiastically experiment to achieve low usage, and that these people are an untapped potential for peer-to-peer engagement in energy reduction.

The involvement of multiple technologies, and hence multiple tradespeople, in energy efficient residential building refurbishment can present a barrier to market growth in this sector and could prevent us achieving the 2.5–3% per annum refurbishment rate that we need. Mlecnik et al. examine the value of new business model development in helping SME businesses in this sector to develop more collaborative visions and to better understand the need for a customer-oriented approach and the value of project management. They also highlight the limits to what business models can achieve, noting the need for action plans and a focus on customer advice and quality assurance when translating business models into new collaborative offers to the market.

Buildings policies, directives and programmes

The Paris Agreement requires significant reductions in greenhouse gas emissions from across the economy. As buildings are one of the most important sectors in Europe in terms of greenhouse gas emissions, it is evident that in order to achieve such reductions, a significant decarbonisation of the building stock is needed. Kranzl et al. argue that in Europe, this needs to be at least 85–95% in greenhouse gas emissions by 2050. Assessing different EU Member States and policy-driven scenarios for reducing carbon emissions, their research shows that just 27% of the more ambitious scenarios achieve reductions above 85%. They conclude that the limited ambition is a reflection of policy makers' hesitation to apply more stringent policies and in particular regulatory measures. In other words, the level of ambition even in the most ambitious scenarios is limited by imagination and political will. There are of course exceptions to this, and Bürger et al. develop a number of different scenarios for a nearly decarbonised building sector in Germany by 2050. Their model shows that in terms of the relative cost-effectiveness, there is no clear preferred scenario when comparing options with many energy efficiency improvements versus those with a high share of renewable energy. The authors conclude that other factors will thus be more important than purely the costs to society and they name public acceptance of different technological interventions as a key factor to consider.

It is clear that without significant policy support, the emission reductions modelled in those scenarios are not attainable. An important question arising from such scenario assessments is therefore how the decarbonisation can be driven by policy. Sebi et al. compare and contrast policies for building sector decarbonisation in three countries, namely the USA, Germany and France. The authors show how those countries can learn from each other: Germany adopted one of the most comprehensive national technical assistance and finance policies; France is experimenting with mandating renovations; and the USA is a leader in utility energy efficiency programmes but also some very successful local programmes and the Energy Star programme. However, the devil is often in the detail, as Bright et al. show by focusing on energy efficiency retrofits in mixed tenure social housing in the UK. Their paper shows that governance issues can significantly affect the progress and financing of retrofit projects. Using a large refurbishment project of five tower blocks by Oxford City Council as a case study, they identify a number of key issues that, if not carefully considered, can hamper energy efficiency retrofits of social housing. Those issues include property law, allocation of project costs and benefits, and issues of communication, engagement and decision-making.

The paper by Bleyl et al. makes a related argument for office buildings. They show that deep energy retrofits of offices are unlikely to be financially attractive when looking purely at future energy cost savings. Instead, the paper makes the case for including the value of higher rents and real estate values, maintenance cost, CO2 savings and higher work productivity in business models promoting office retrofits. In some EU Member States, the issue of energy security—and the ability of energy efficient buildings to enhance it—plays a key role also (in addition to the non-energy benefits identified by Bleyl et al.). Staniaszek et al. focus on Central and South Eastern Europe and assess the vulnerability of the building sector to gas supply interruptions, the impact of energy efficiency infrastructure upgrades to the

building stock of the region and the availability of funding for demand-side measures. The authors show that an "alternative energy security path" would lead to financial returns of €106 billion in reduced energy bills in the region.

Fawcett et al. reflect on one of our longest-standing policies for energy efficiency in residential buildings: the Energy Efficiency Obligation. They ask what its role is in policy today and going forward. It is clear that Obligations have delivered significant energy efficiency improvements, in particular where there is a lack of regulation or minimum standards. It is also clear that they will continue to have a key role going forwards. However, the increasing complexity of deep retrofit provides a challenge to this policy, as it does to any. Long-standing obligations, in the UK and Denmark, have been criticised as costs have increased, and this could constrain the role they play in the future. Obligations will have to be designed carefully to ensure that they retain energy company, public and political support.

Appliances

Performance and energy consumption of appliances is usually tested in a well-defined laboratory environment. Although the well-established test procedures laid down in the different standards normally try to reflect user behaviour, there might be a discrepancy between the use patterns of test environment and the real-life usage. Currently, there is no methodology to assess whether a standard is a good representation of the actual user behaviour. Spiliotopoulos et al. have developed a methodology to fill this gap. Within their paper, they show the application of the methodology for several case studies. They can show that criteria like repeatability, reproducibility and cost are usually prioritised within the standards and that additional efforts are necessary to match the artificial laboratory testing with real life.

Regulation of standby has led to significant reduction of standby power consumption for conventional devices. In recent years, connected devices have become more common. They usually draw more power over time due to their continuous network operation. Meyer proposes a new approach for a progressive standby approach, which is targeting a reduced standby consumption of connected devices. He proposes approaches like energy harvesting or short cycle off-grid operation. In several sensitivity concepts, the general applicability of the approach is shown.

Apart from the energy consumption in the use phase, other design aspects of products have come into the focus of Ecodesign regulation in recent years. Durability of products is an important issue regarding the life cycle impact of products, especially if costs are transferred from the use phase to the initial investment in the life-cycle costs approach (LCC). As increased durability also has an impact on the price of the product, a local optimum for the least life-cycle costs might exist. Luth Richter et al. did a statistical analysis of the LCC of LED products concerning durability of the products. Their findings indicate that the lifetime required by the Ecodesign regulation might be increased to improve the LCC of the product.