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Transforming Urban Energy Demand: A Timely Challenge

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As I write this, most of the world is currently in some form of lockdown as a result of the Covid-19 crisis. With so many people confined to their homes, the issue of end-use energy demand has come to the fore of scientific and policy agendas. At no other point in time in recent history have people been more dependent on the social and technical infrastructures of the home to sustain their everyday social, emotional, and economic interdependencies. The pandemic has disproportionately affected urban dwellers, due to a combination of demographic, spatial, and political factors (Stier et al., 2020). This set of circumstances has vindicated the arguments made by a host of recent scholarly and policy-orientated contributions, who have emphasized the need for a deeper understanding of the technological and social forces that shape urban energy consumption so as to develop more comprehensive and determined responses to contemporary crises—epidemiological, environmental, and social alike (Moonen et al., 2012; Rutherford and Coutard, 2014; Elsner et al., 2019).

The arrival of a new journal section focusing on end use energy demand could hardly be more timely. It represents an apt recognition of the need to take energy dynamics seriously in the context of not only the ongoing Covid-19 crisis, but urban sustainability policies and research more broadly. Studying the relationship between energy and cities is a highly integrative endeavor, itself bringing together the interdisciplinary fields of energy and urban studies, in addition to an entire host of technical and social science disciplines: human geography, engineering, economics, sociology, political science, and planning to name a few. Thanks to the new section, we—the growing community of academics, practitioners, advocates and decision-makers working on this topic—are being given a unique opportunity to offer path-shaping perspectives at a critical historic juncture, in a manner that can deeply reconfigure our shared environmental and societal futures. This extends beyond the policy and public impacts of existing scientific research onto the capacity to formulate and imagine alternative visions of infrastructural and institutional development.

Scientific interest in end-use energy demand has been building for some time now. Even if energy research and policy were initially preoccupied with questions around the technical nature and geopolitical security of energy supply, the oil crises of the 1970s prompted a rising interest in matters of distribution and consumption (Adeyemi and Hunt, 2007). Since then, it has become increasingly apparent that achieving substantial transformations in urban energy end-use is a *sine qua non* when it comes to implementing successful climate change mitigation and related environmental objectives. In organizational terms, this recognition has culminated in the extensive presence of energy demand concerns in the work of the Intergovernmental Panel for Climate Change (Allen et al., 2019), as well as the establishment of dedicated large-scale international initiatives such as the United Kingdom's Centre for Research into Energy Demand Solutions, led by the University of Oxford (see https://www.creds.ac.uk/).

Much work remains to be done, however, with regard to understanding the urban specificities of energy flows. This is despite the widespread acknowledgment that urban energy consumption is embedded in the conduct of everyday life, the regulation of economic activity, and the practice of political power (Rutherford and Coutard, 2014; Creutzig et al., 2015). What is more, energy demand itself has been shown to shape the development trajectories of metropolitan centers

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and districts across the world (Rohracher and Späth, 2014; Bouzarovski et al., 2016). Cities can be seen as nodes of manifold energy metabolisms, where multiple systems and modalities of infrastructural provision are entangled with social, economic, and cultural connections (Caprotti and Romanowicz, 2013; Rosales Carreón and Worrell, 2018). They are subject to changing dynamics of governance, characterized by the entry of non-state actors, the increasing role of local authorities in infrastructure management—sometimes constrained by austerity policies—and continued dynamics of globalization. With accelerating dynamics of planetary urbanization (Brenner, 2018), the accomplishment of low-carbon transformations is thus predicated upon the restructuring of existing and future relationships between cities and energy.

When discussing contemporary urban end-use energy challenges, a question that often emerges is how to define cities themselves. Traditional thinking in urban studies has tended to conceptualize cities in line with pre-delimited criteria, such as their population size, surface area, built environment density, administrative importance, and position within the settlement hierarchy of a given nation. We are now, however, moving toward a much more process-based theorization of the "urban" (Robinson, 2016). This understanding prioritizes the social, spatial, cultural and economic transformations associated with dynamics of urbanization. There is also a post-colonial sensibility here, given that many cities in the Global South extensively experience bottom-up practices of maintenance, repair, and incremental infrastructural development (Lawhon et al., 2014). The urban can thus be seen to create highly distinctive concentrations of power, capital, people, emotions, social relations, and cultural production. In a sense, the emphasis here is on what particular places do, how they are evolving, and how they have come to be, as opposed to their inherited descriptive characteristics.

The scholarly encounter between contemporary energy and urban studies in the context of the global sustainability drive yields several research and policy challenges. The first among these, and possibly the most established, is the question of technological development. Even if there has been extensive progress on designing and deploying a whole host of highly energy-efficient end-use technologies and building materials in an urban context, significant advances in these domains continued to be made as we speak. These include improvements in the thermal performance of heating, energy recovery and storage technologies, cooling and lighting systems, as well as domestic appliances (Keirstead and Shah, 2013). Approaching transport as an urban end-use energy issue also opens an entire set of new research horizons in terms of innovations in fuels, distribution networks, vehicles, and public transport technologies (Sultana et al., 2019). Energy use in industrial processes, to the extent that it can be considered specifically urban, also presents significant research opportunities, particularly in terms of increasing the energy efficiency of production processes (Karner et al., 2016). Last but not least, the development and operation of information technologies in cities is possibly one of the most significant domains of potential new inquiry and discussion, even if some aspects of "smart" urban development are being increasingly seen in a critical light (Sadowski and Levenda, 2020). Of no less importance are the digital software and hardware of urban energy use—from the types of information technology support needed to implement sustainable energy infrastructures, to the broader challenges associated with the digital society implementation, "big data" and smart cities (Mosannenzadeh et al., 2017).

A second set of questions revolves around the social aspects of energy demand. This is now a vast and quickly developing field that is attracting wide scientific and policy attention—with the Covid-19 crisis raising further questions around the intersections between energy consumption and different forms of inequality (Tsui, 2020). Mirroring the transformation of urban studies, it too has moved from relatively narrow and static understandings of energy behaviors to a far more complex and nuanced theorization of urban social processes as they relate to energy. Work on energy-related social practices (Shove and Walker, 2014) and energy cultures (Strauss et al., 2013), in particular, has critiqued the deficit based model of household energy behaviors and attitudes to offer novel perspectives on the structural embeddedness of energy use in wider social, institutional, and infrastructural systems. These contributions have highlighted how different modalities of energy consumption are enmeshed with networks of provision and supply, as well as more abstract socio-cultural expectations and imaginations around the "benefits that energy services bring to human well-being" (Modi et al., 2005, p. 9). At the same time, political economy approaches have illuminated the power structures and governance arrangements that condition particular types of urban energy demand. The health and well-being implications of urban energy end-use represent a distinct line of work in this field, with a significant influence upon policy decisions and public debate (Milner et al., 2012). Bringing all such questions together in an urban context is a formidable conceptual task, requiring an integrated perspective on the socio-economic drivers and impacts of energy demand in cities.

Third, it is impossible to imagine any engagement with urban energy issues without giving due attention to the question of socio-economic inequality. Cities throughout the world are deeply unequal, for a host of historic, infrastructural, and political reasons—and indeed the Covid-19 crisis has made this even more apparent. Such inequalities extend beyond patterns of spatial segregation to encompass socio-economic differences that underpin the status of urban inhabitants—along lines of income, age, gender, ethnicity, and education (Graham, 2001). Many of these cleavages stem from hegemonic power relations that are difficult to challenge and unsettle. They are supplemented by differences with regard to the use of energy itself—for infrastructures demographic, cultural, or economic reasons. Such variations are difficult to discern or quantify due to the physically hidden and private nature of urban energy consumption, particularly in the residential sector (Bouzarovski and Thomson, 2018).

However, it is now well-known that cities are sites of overlapping and evolving energy injustices, whose existence may be exacerbated by climate change itself: not only due to long-term changes in temperature, humidity or extreme weather, but

also as a result of the distributional and procedural impacts of low-carbon interventions themselves (Knuth, 2019). It is now increasingly apparent that some urban dwellers and locations are being adversely impacted by climate policies, whether unintentionally or by design (Bouzarovski et al., 2018; Rice et al., 2020). Possibly one of the greatest injustices is the continued presence of energy poverty—a phenomenon characterized by the inability to secure a socially- and materially-necessitated level of energy services in the home (Thomson et al., 2019). Urban energy poverty affects millions of households across the world, primarily in the Global South, although many citizens in the Global North are affected too. As an intersectional and intersectoral problem, urban energy poverty requires research and action to address persistent injustices in infrastructure networks, intra- and inter-household inequalities, housing structures and political systems. Efforts to address energy poverty are increasingly engaging with the social and organizational granularity of cities—a good example is the EU-funded STEP IN project, which tackles urban energy inequalities and the delivery of energy efficiency measures through innovative "living lab" approaches (see https://www.step-in-project.eu).

Institutional, economic, and policy measures to transform urban energy demand are a fourth key avenue of future action and research. There has now been significant scholarship on the urban governance structures and practices necessary to achieve sustainability objectives, and the scaling up of low-carbon actions across different material sites (Bulkeley et al., 2011; Rosales Carreón and Worrell, 2018; Bouzarovski and Haarstad, 2019). However, the urban specificities of energy end-use regulation and policy require greater attention, particularly in light of the vast magnitude of the current climate challenge, and the need to achieve long-term, deep and sustained carbon reductions in a variety of economic sectors and activities present in cities: from households, to commercial activities, and transport (Grandin et al., 2018). However, the extent to which current market and regulatory structures that govern urban energy formations require radical change is currently a matter of heated debate (Ciplet and Harrison, 2019; Scoones et al., 2020). While some experts and activists believe that energy and climate sustainability can be achieved by working with the grain of existing economic and (e.g., through measures such as energy efficiency "market transformation," weatherization or tweaks to household behaviors), others argue in favor of a fundamental transformation of urban socio-natures, involving a complete rethink of how we conceive, work, and engage with the use of energy in cities. In this context, there is also a need to understand the specificities of emergent social and political movements that seek to shape changes in the governance and conduct of urban energy demand from below, as well as the process of energy municipalization and localization that is increasingly taking hold in many urban areas.

Ultimately, researching and shaping questions of end-use in cities under the conceptual umbrella of sustainable development immanently leads us to draw inspiration from whole systems thinking. In research terms, this requires an engagement with the demand implications of energy carriers (electricity, heat, gas) as they travel through the energy chain—from energy recovery to consumption. Of no less importance is the recognition that energy chains themselves are undergoing fundamental change, owing to the emergence of decentralized, micro-scale, and off-grid forms of infrastructural provision. The urban aspect of such processes also suggests the need for a movement beyond energy flows themselves, onto the historical and socio-economic forces that shape the evolution of cities and the broader lived experience of the urban. Emerging research in this domain suggests the need for questioning existing assumptions and models, while acknowledging that "the transformative potential of technical interventions is conditioned by social and political dynamics" (Grandin et al., 2018, p. 16).

To summarize: we are at a critical juncture in research and policy on urban energy demand, both as a result of the Covid-19 crisis and the broader climate imperative. There is significant uncertainty over the future durability and course of the rapid changes in urban energy and transport use that have occurred as a result of the ongoing pandemic, and their political and social implications (Boons et al., 2020). Nevertheless, it is without doubt that researching and transforming the relationship between end-use energy and sustainable necessitates an engagement with spatial processes and inequalities, convincingly captured through the notion of an "urban energy landscape" that brings together heterogeneous elements of social, ecological, and technical systems via joint dynamics of co-evolution (Castán Broto, 2019). A geographical perspective on the reconfiguration of urban energy landscapes opens fundamental questions about the socio-spatial organization of energy systems, "the potential for innovation in sustainable energy" (Castán Broto, 2017, p. 761) and "possible trajectories toward sustainability" (Castán Broto, 2017).

Together with the editorial board of Frontiers in Sustainable Cities, I am delighted to be opening the new section on "Urban energy end-use" for submissions. We will be welcoming high-quality fundamental and applied research from all aspects of urban end-use energy studies. In light of the challenges identified above, we hope to integrate work across the social and engineering sciences, while seeking to examine the driving forces and consequences of energy use in the context of the urban sustainability drive. We expect to receive articles that will feature interdisciplinary research on energy demand among urban households, commerce, transport and industry. We anticipate that all studies will contribute to the understanding of energy end-use from a socio-technical viewpoint, and against the background of urban sustainability processes. This should allow the section to provide significant advances in scientific knowledge while shaping a set of timely and prescient debates.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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