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Perspective

From individuals to collectives in energy systems — A social practice, identity and rhythm inspired lens

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ABSTRACT

The need for socially smart energy systems that incorporate both individual and collective social, spatial, and technical dimensions is increasing. However, the social, spatial, and technical interplay between individual and collective scales has been poorly studied and lacks a conceptual basis. Most research to date has focused on social, technical, socio-technical, or spatial approaches at the individual level, or at the collective level independently of the individual. Therefore, overlooking the complex underlying dynamics between the individual and the collective and the multidimensional and multimodal nature of energy use and demand across scales. In response, we propose a novel integration of social practice, social identity theory, and rhythm analysis, with a focus on the collective capabilities of energy users, observable across neighbourhood social contexts and spatial scales. Our conceptual framework offers analytical benefits to energy research and policy by viewing energy users within their individual and collective socio-technical contexts across rhythms of everyday routines. This approach can inform future research in energy systems, as well as policy and practice in the design of new governance mechanisms and engineering requirements for socially smart grids, devices, and collective energy systems.

1. Introduction

Calls for socially smart collectively managed energy systems are growing in urgency in recent policy and research [1–3]. Energy systems are seen here as distributed entities that provide elements of flexibility such as smart devices and grids [3]. The future collaborative smart grid [4] calls for the integration of information and communication technologies, as well as collaboration amongst energy stakeholders across spatial scales. This increased focus on collective means of socially managing energy is coupled with acknowledging peoples' empowerment and identities in the energy system [5–7]. Despite the recognised need for collective engagement in energy systems, there are limited conceptual approaches capable of analysing the inherently socio-spatial multidimensional characteristics involved. This multi-faceted issue is particularly visible in the context of home energy management (HEM) and neighbourhood settings [8].

Home energy systems are mostly studied through either a social, technical, socio-technical, or spatial lens [9,10]. Socio-technical dimensions in these systems are often seen as individuals or collectives with spatial dimensions or as geographies of micro or macro levels. In terms of social dimensions — the focus is placed on understanding individuals' practices through a Social Practice Theory (SPT) lens [11]. Where the interplay of individual and collective dimensions is considered in SPT, the focus is on understanding the role of social structures, institutions and norms shaping and being shaped by those individual practices [12]. Holmes [13] takes this interplay further by contending that practices are embodied through interactions between people, technologies and spaces and that different spaces enable or constrain certain practices. Holmes's [13] study is helpful in presenting the importance the spatial context has at multiple social levels; however, the interplay of spatial scales is characterised in a geographically compartmentalised way with insufficient attention paid to the inhabited interfaces between scales.

With spatial context being seen mainly through a geographical lens,

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spatialities tend to be generalised overlooking the diverse ways spaces are inhabited across scales. Architectural studies have for some time observed the importance of socio-spatial relations between individually and collectively inhabited spaces, times, and energies [14–16]. Lefebvre's [14] rhythm-analysis approach attempts to understand the diverse interplays between inhabited forms of space, seeing socio-spatial interactions between scales as socially produced temporal orderings. To Lefebvre and Régulier [17] interplays between place and time are viewed as 'expenditures of energy' manifested through rhythms. According to Lefebvre & Régulier [17], rhythms can be composed of different qualities, intervals, and frequencies and can be distinguished in daily routines of urban life, particularly at city and neighbourhood scales. Though mostly applied in urban studies, rhythm-analysis has been increasingly called upon in energy research [18,19] mainly in combination with SPT as a useful lens to study socio-spatial and temporal energy use and demand [13,20]. While combining rhythm-analysis and SPT offers a helpful analytical lens to examine socio-spatial and temporal dynamics of energy use, the approach does not fully capture the relational and identity dynamics involved. Social relational dynamics are particularly significant in shaping collective energy use in daily life, with increasing calls highlighting the need for their study [21,22].

Social Identity Theory (SIT) is primarily concerned with how these relational dynamics and how social relations shape and are shaped by collective action or inaction. It, therefore, offers a helpful 'collectiveness' analytical dimension, lacking in SPT and Rhythm-analysis. Combining SPT and Rhythm analysis with SIT offers beneficial analytical opportunities in the context of socially smart energy systems. The following sections discuss these analytical opportunities and ways they could advance energy research. Section 2 discusses the current limitations of socio-technical approaches and SPT while expanding sing discussion on SIT. Section 3 considers the significance of spatial and temporal rhythms and elaborates on the analytical benefits of Rhythm-analysis. The paper concludes with a discussion of how the proposed conceptual lens helps advance empirical research and policy guidance in energy research.

2. Characterising energy systems across socio-spatial scales — combining SPT, SIT and Rhythm-analysis

2.1. The "spatial turn" in Social Practice Theory and socio-technical approaches

Social Practice Theory (SPT) studies on home energy have tended to focus on what shapes individuals' use of energy in the home through the study of meanings, competencies and materials involved [23]. However, there has been less consideration of the effects different socio-spatial characteristics of neighbourhoods have on home energy [24]. The importance of better understanding the implications of socio-spatial scales in SPT energy research has been recently argued in a study by Rinkinen et al. [12]. Their work provides a conceptual approach for understanding relationships between urban densities, energy demand and social practice — however largely looking at a macro perspective scale, rather than the interplay of micro and macro scales. Holmes [13] also provides an expanded understanding of the role of spatial scales — exploring how the design and layout of housing developments influence energy use patterns, and how social norms around heating and cooling practices are shaped by broader cultural and political factors. Svennevik [25] highlights the importance of analysing how social practices are scaled up or down, and how they interact with other practices and systems at different scales. Breadsell et al. [26] explore consumption practices at different scales — individual households and wider society.

The 'spatial' has been traditionally seen in terms of geography and territory, rather than architecturally designed space, with scales seen as operating in parallel rather than simultaneous entangled interactions. A socio-technical perspective has similarly been exploring the adoption of energy innovations such as smart home technologies [27], energy-efficient heating systems [28] demand-side management interventions and the uptake of insulation measures for homes [29,30] within specific intensities and frequencies of use. SPT and socio-technical studies contend in the domestic context at least, that practices are influenced by social interactional dynamics and normative frameworks within the home, as well as by the form and frequency of social relations external to the home, without offering the analytical capacity to study across and between both. Though Hargreaves et al. [31] and Skopik et al. [32] provide an overview of the likely characterisation of these social relations in smart energy systems, the spatial scales have been seen as static and mono-dimensional.

Conceptual underpinnings of SPT or socio-technical accounts more widely, are not well positioned or equipped to examine the relationship between individuals and collective scales in order to observe how energy systems are or could be maintained, reconfigured and communicated collectively. While the spatial turn in SPT and socio-technical inspired energy research has been productive in generating new insights into the relationships between energy systems and spatial scales, it has often overlooked the interplay of social relations and identities across these scales.

2.2. On combining social practice and social identity theory

Studies in emergent environmental events where collective action is suddenly needed or within energy communities where collective sharing is assumed [33] offer helpful analytical benefits. In those studies, the dominant analytical frame employed has been social identity theory (SIT)-particularly well equipped to understand an individual's capacity and willingness to engage in collective action and the ways the individual identifies within a collective setting [34]. Ntontis et al. [35] discuss emergent togetherness that can be observed in sudden environmental disasters through the social identity model of collective psychosocial resilience. They state that shared social identity can have a range of helpful outcomes: it allows survivors to orient towards shared goals, increases expectations as well as the provision of social support, increases collective efficacy, and empowers collective action. Drury [36] suggests a social identity model for the study of collective behaviour in emergencies and disasters postulating that understanding facets of shared social identities helps develop an understanding of how collective actions emerge, are sustained and also expand or dissolve.

Combining Social Practice and Social Identity theory offers insights into both socio-technical individuals' practices of energy use, as well as an approach to engage within a collective socio-spatial setting such as a block of flats, street, or neighbourhood. However, while providing strength in their combined framing, neither of them helps provide ways to study their socio-spatial interaction. A helpful approach can be found in rhythm-analysis approaches discussed below.

2.3. Bringing SPT and SIT together and the analytical benefits of rhythm-analysis

Rhythm-analysis has emerged as a valuable approach to understanding the different types of spatial dimensions of social practices [20,37,38]. Rhythms also play a helpful role in characterising the ways social identities manifest in social relations between individual and collective scales of neighbourhood and urban life [18,39] through understanding for instance frequency or repetition of social interaction [40,41]. Rhythms shape and are shaped by the diurnal, weekly and annual experience of spaces (in the home and neighbourhood), social practices of energy use and social identities within and across them. Southerton [39] argues that spatial and temporal coordination of everyday life is an important aspect of social practices, and people's spatial and temporal rhythms and routines are shaped by factors such as work, family, and social obligations as well as identities. Walker [18] examines the concept of rhythm as a tool for understanding energy demand and consumption patterns, suggesting that by analysing temporal rhythms in everyday social practices, such as when people use energy in their homes, we can gain insight into the social and cultural factors that influence energy use. Blue et al. [19] argue that temporal rhythms play a crucial role in shaping people's energy-related practices and that understanding these rhythms is necessary to effectively design and implement flexible energy systems. They highlight the importance of considering both the spatial and temporal structure of practices (i.e., how frequently and regularly they occur) and the spatial arrangement of practices (i.e., how they are sequenced throughout the day across spatial scales) in order to effectively intervene in energy use. They suggest that a focus on temporal rhythms can challenge dominant representations of time and society in the energy sector, which tend to prioritize linear and predictable models of energy consumption and production. Oppermann et al. [42] propose a thermal rhythm-analysis that takes into account the multiple temporalities that shape energy use and heat stress. This involves examining the rhythms of energy demand and use, the rhythms of social and cultural practices that shape how people interact with energy and heat. Torriti [43] notes that time-use data can help us understand the timing of energy demand and how it is related to social practices, providing a useful starting point for developing policies and interventions aimed at promoting more sustainable energy consumption practices.

The study of rhythms as both spatial (and temporal) patterns of energy use and demand has been empirically mainly drawing upon large-scale time-use data sets [43–47]. Such studies view energy use as embedded in an activity at different scales of rhythms in practice. Each of these scales of rhythms in practices – daily, weekly, seasonal – and their interaction, are generative of the rhythmic patterns of energy demand. These 'energy rhythms' can then be observed within different bounded spaces or categories of the spatial unit. A given household, for example, will have rhythms in its energy demand, following patterns of home-based practices over the course of the day and week, overlain then by seasonal patterns that cycle over the year. Understanding energy use (over days, weeks, and seasons) involves engaging with rhythmic repetition, sequencing, and synchronisation of energy-using practices in everyday life – scaled up to a collective level – such studies can tell us something about the dynamics of demand in the aggregate as well as about making of rhythmic peaks of demand. The need to not just sustain functionality but to transition rhythms into new shapes, patterns and interrelations is key to forging a new equitable relationship with energy.

3. A novel SPT, SIT and Rhythm-analysis approach

Our approach rests on the notion that energy use and engagement in collective energy systems is a socio-spatial, identity, technical, and temporal practice. While this is well known, the compositional conceptualisation of multidimensional dynamics is not well explored to date. SPT studies offer rich insights into practices enacted by individuals and their shaping of and by broader societal structures and norms both at the micro-scale of the home and macro scales of cities. Rhythm-analysis has offered helpful insights into individuals' temporal dynamics of energy use, however often with insufficient engagement with their collective socio-technical context. SIT has been extensively applied in the context of collective behaviours and the effects of social relations and identities on collective action.

Building upon the above discussion, our proposed approach (see Fig. 1) embraces analytical strengths in SPT and SIT as well as rhythmic analysis as proposed by Walker [48] in order to enable theoretical study into complex interrelated multidimensional (individual and collective) (micro and macro spatial) of energy use in domestic sectors and more widely.

Fig. 1 illustrates an abstract representation of the entangled character of social, spatial, identity and technical dimensions of home energy

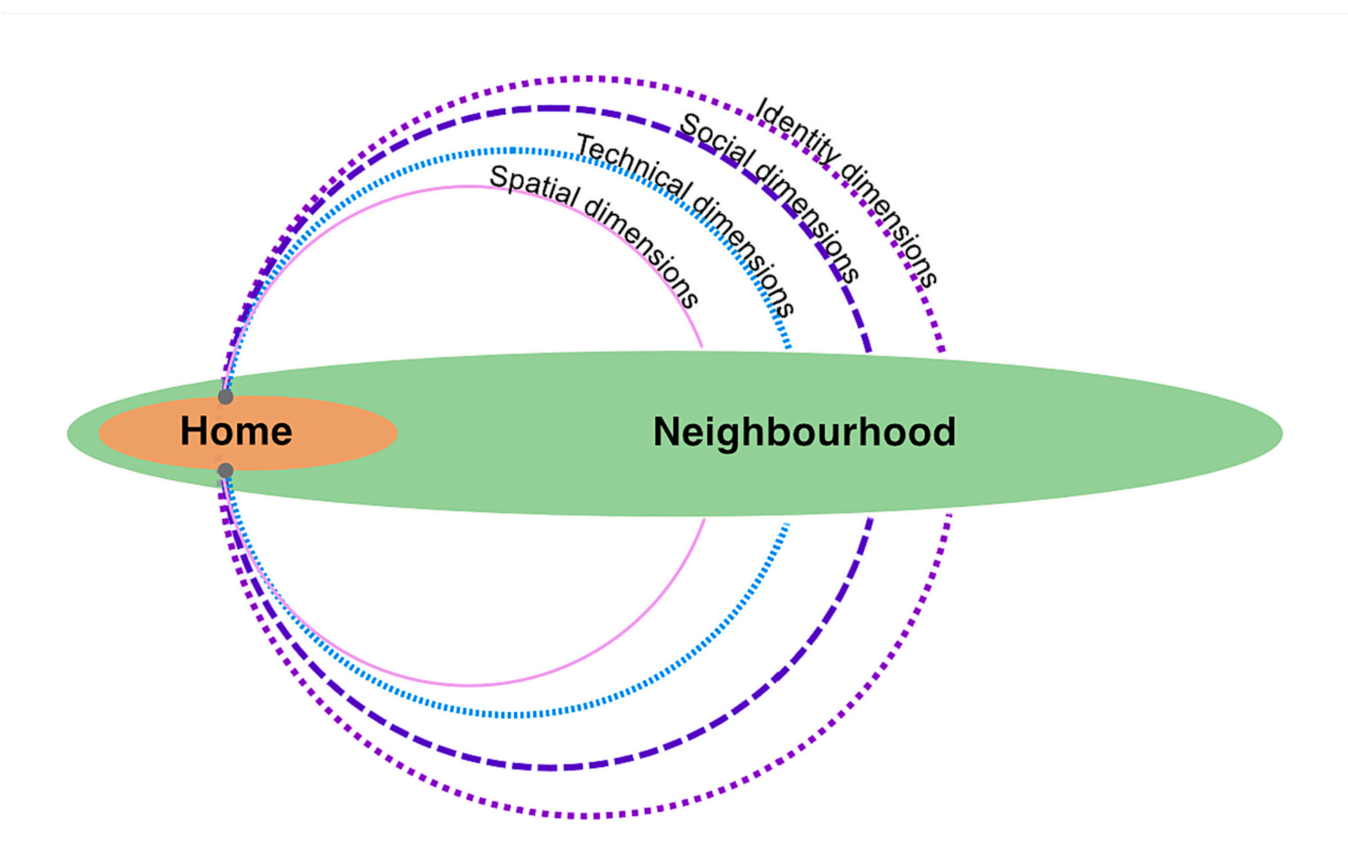

Fig. 1. Illustration of conceptual framework.

use that manifest at multiple spatial scales — in this instance the home and neighbourhood. We argue that social dimensions in the figure can be observed and studied through an SPT lens as materials, meaning and competencies, with technical dimensions seen here as frequency and intensity of energy use. Spatial dimensions of those practices can be viewed through the lens of rhythms as suggested by Lefebvre's characterisations of spatial and temporal patterns [14] of energy use with identity relational dynamics viewed through SIT. They all interact and entangle across the scale of home and neighbourhood on a continual basis. An empirical example may be a study of households and their dynamics within neighbourhoods through both their social practices of energy use within the home, the spatiotemporal rhythms of that use and the relational dynamics with neighbours in the neighbourhood — such multidimensional empirical studies could help advance understanding of spatial-social dynamics for collective energy systems.

4. Discussion and conclusion

Collective action energy projects have gained traction in EU and UK policies as effective means of decarbonization and empowering citizens while fostering sustainable energy behaviours, energy justice, and democracy [33]. However, the UK has shifted its policy focus from citizen-led community energy to a model favouring private investments and institutional partnerships [49]. Although there have been efforts to engage energy users through various strategies, such as group identity formation and incentivization, little attention has been given to the broader energy systems and social practices across scales [50]. While there have been calls for collective action and studies supporting such research, the emphasis has been primarily on ways of engaging energy users via strategies such as information provision, goal setting, group identity, peer influence/social comparison, social modelling, feedback/monitoring, incentives/penalties, and gamification. Much effort has been placed into ways to formulate group identities within neighbourhoods and cities, encouraging pro-environmental behaviours at an individual scale [50] or expanding the remit of bounded energy communities [51]. Less effort has gone, however, into characterising or understanding how such identities are shaped, become enacted and are reinforced spatially and socially.

There has been growing work that has started to explore the ways smart grids and similar "socially" smart energy systems could evolve collective intelligence on social relations to energy and how this may inform how home energy demand is managed taking social and spatial context into account. McKenna et al. [52] have linked the use of household energy data from smart meters to contextual information (such as weather, building thermal qualities and survey data) to highlight how daily energy consumption is influenced by building size, age, and occupancy. However, there is limited discussion on how such qualities are linked to broader energy systems, practices, and social identities.

The multidimensional dynamic of collective engagement in socially smart energy systems demands a novel conceptual approach. The proposed conceptual framework has multiple theoretical and empirical benefits. From a theoretical perspective, the use of the approach would enable the analytical study of energy users as actively engaging within and across energy systems, holding the capacity for both social relations and context (drawing on SPT and SIT), as well as spatial rationalisation (drawing on rhythm-analysis). From an empirical perspective, this novel approach to studying the collective capabilities of socially smart energy systems, would for the first time transform policy and industry understanding not only governance mechanisms [53]. This in turn can further expand to the engineering requirements and characteristics of a wide spectrum of energy systems from smart grids, and energy communities to smart devices, HEM and district heating systems or similar neighbourhood energy strategies. This approach holds the potential to reveal new social, spatial as well as engineering and design requirements that could enable an empirically informed responsive and dynamic way to manage and distribute energy, going beyond current approaches favouring monitoring and information provision. Meeting the challenges of future socially smart energy systems requires bold conceptual experimentation and development alongside enhanced multidimensional data collection and analysis. These are crucial to enable an understanding of individual responsiveness and collective outcomes along with possibilities for the energy system that are not yet fully understood. This work offers a novel approach that has the potential to advance energy systems research integrating both individual and collective social, spatial, and technical dimensions. By incorporating diverse perspectives this approach aims to deepen our understanding of the implications of the energy systems and provide insights to inform future policy decisions.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Sonja Oliveira reports financial support was provided by Engineering and Physical Sciences Research Council (grant number EP/V041770/1).

Data availability

No data was used for the research described in the article.

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