Social identity and relations: implications for home energy demand and the peak load reduction in the UK

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Abstract: This paper explores how social relations and social identities shape home energy management practices at individual and collective levels. While emerging research has signalled the importance of social relations in shaping energy demand, there have been no empirical accounts to date. In addition, there have been few theoretical advances in the study of interconnected phenomena involved between social context and energy demand and between scales of the home and neighbourhood, with a dominant focus placed on individual homes and descriptive approaches. Social identities and relations shape both individual and collective actions, decisions, and experiences. Identities manifest in diverse routines, habits, and daily rhythms in and beyond the home. A deeper understanding of the ways they manifest could have significant implications for developing electrification and distributed energy transitions and understanding residents' roles within future interventions in energy demand and use, adoption, and peak load reduction.

The approach of this study draws on novel conceptual grounds combining social identity theory, social practice theory and rhythm analysis to examine the characterisation of social relations and identities, alongside household energy demand practices. The methods include ethno-visual surveys involving 617 participants and 11 interviews with residents living in the Glasgow and Bristol regions in the UK. The findings enable new understandings of how social relations and identities can shape energy demand practices and the socio-spatial and technical implications this has on future peak load reduction and smart grids. The implications of the findings are twofold. First, the study shows how focusing on social relations and identities can lead to new forms of interventions in smart grid and energy systems transitions and the roles energy customers, the community and neighbourhoods may play. Second, there are policy implications for the planning of future automated demand management, through new socio-spatial insights into how different social identities and relations can contribute to just transitions and equitable energy futures in the UK.

Keywords: *Social Relations, Social Identity, Collective Energy Demand, Rhythms, Home Energy Demand Management, Peak load reduction*

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1. INTRODUCTION

UK decarbonisation targets rely significantly on addressing peak load reduction and energy demand of the domestic sector [1]. Whilst increasing efforts are being placed on accelerating the modelling and design of smart energy systems such as smart grids to help coordinate and automate the energy demand to reduce peak loads [2], they have so far not included the social context of home energy use. The social context of home energy use, specifically social relations within and beyond it are known to have a potentially critical impact on how peak load reduction may evolve [3]. There is increasing evidence that time of use, and peak loads vary across different homes not only in relation to the typology of the home [4, 5], demography of

occupants [6-8], appliance numbers and use [8-10] but also more recently their wider social context such as social identity and social relations [11].

The domestic social context of energy use and demand management has been well documented across established social science literature at both individual and collective scales. Most of these studies approach energy use in terms of broader considerations of energy behaviours and attitudes, focusing on how these impact energy use. The domestic context is argued to be a critical area for addressing increasing energy demand and reducing carbon emissions in the decarbonisation transition [12-14]. Specifically, with increased efforts placed on simulating the coordination and operation of smart energy systems such as smart grids in likely peak load scenarios in a fully electrified energy system, the reliance and involvement of residents become critical in the domestic context [4]. Consequently, emerging calls argue for a better understanding of the social dimensions of domestic contexts and the role of individuals and households in these simulated future energy demand scenarios and smart energy systems [15, 16].

It has been well established in the social science literature, that social relations both individually and collectively can shape home energy management (HEM) practices and time of energy use [3]. At an individual scale, within the home itself, social relations in the home can impact consumption patterns in various ways, such as influencing energy usage habits and shaping decision-making processes related to sustainable practices. In addition, social relations within the home can affect the adoption of energy-efficient technologies and the willingness to participate in energy-saving behaviours and energy management. Moroşanu [17] discusses social practices, including shared values, attitudes, behaviours, routines, and decision-making processes among household members that contribute to energy consumption patterns and time of energy use. These, in turn, shape collective energy usage habits, influencing household routines, and impacting choices related to energy-saving measures and technologies. Frederiks et al, [18] highlight behavioural interventions such as cognitive biases, and motivational factors (social influence, personal values, and identity), tailored to individual characteristics, to effectively promote home energy demand management.

A rich body of evidence demonstrates how social relations, gendered practices, and home structures significantly influence household energy management (HEM) practices [3, 19-22]. Oliveira et al. [22] discuss that collective context shapes energy use patterns, including time of use, by acknowledging the intricate interplay between individual energy behaviours within households and the broader socio-spatial dynamics of the community. This recognition emphasises the need to move beyond isolated, individual-level energy management strategies and to develop a more holistic approach that considers the shared resources, social interactions, and spatial configurations influencing energy consumption patterns across the community. Beyond the scale of an individual home, Hui and Walker [23] emphasise the importance of considering relations both within and outside the home. Interactions with neighbours, communities, and energy providers all contribute to shaping energy behaviours and practices including time of energy use. Du et al. [21] discuss the significant role played by these external relationships in influencing energy behaviours. Hargreaves et al, [3] highlight that social norms and practices within social networks, such as family, friends, and colleagues, can shape both individual and collective energy demand patterns. The authors suggest that observing others' behaviours and experiences within social circles can drive certain energy practices. Padovan et al. [16] stress the importance of adopting a collective perspective at the household and neighbourhood scales to comprehend the dynamics of social practices, including those associated with home energy management.

While the research discussed above has provided valuable insights at both individual and collective scales, understanding the interconnections between the home and its external social context remains limited. Many scholars have called for a greater understanding of interfaces between individual and collective approaches and the roles households may play within smart energy systems such as smart grids [16, 24-26]. It is important to explore the intricate dynamics between home energy management, the broader social context,

and the role of smart energy systems and collective approaches in order to design effective interventions and policies that foster sustainable energy practices and contribute to decarbonisation and future energy goals. Biresselioglu et al. [27] discuss the significance of smart energy systems and collective approaches in the pursuit of decarbonisation, suggesting that collaboration among households, communities, businesses, and governments plays a vital role in achieving decarbonisation goals. Similarly, Hanssen et al, [28] argue that the successful implementation of smart systems for decarbonisation requires a holistic approach that considers the social dimensions of homes, including social norms, practices, and collective behaviours. Furthermore, Du et al. [21] underscore the importance of social networks as impactful social connectivity in managing energy demand, finding that energy-saving behaviours within social networks can lead to a domino effect, inspiring and influencing others in the network to adopt similar practices. This interconnected knowledge sheds light on how social networks, social norms, and collective behaviours influence energy demand patterns, enabling the identification of strategies to promote energy-saving behaviours and reduce peak loads. Nevertheless, there remains a paucity of both empirical accounts and theoretical advances.

The purpose of this paper is to discuss new empirical insights into the collective capabilities of individual homes to manage energy demand in peak load scenarios in the UK. The research draws on an EPSRC-funded project carried out in the cities of Glasgow and Bristol, employing a combination of ethno-visual surveys and interviews to understand how social relations in different domestic contexts may impact and shape responses to peak load scenarios in the UK. The following section provides a review of the literature on social identities and social relations in the context of energy demand management. This is followed by a discussion on the applicability of social identities and relations in the context of the research focus being addressed and an outline of the empirical setting and methodology. The final sections outline the findings and conclude with contributions and areas for future research.

2. REVIEW OF LITERATURE

There has been a growing interest in understanding how social relations and identities impact energy demand through smart energy systems such as smart grids [3, 15, 29-33]. In this domain of research, social relations have been studied mainly by focusing on perceptions and attitudes towards smart energy systems, the need for integrating social relations into the modelling of smart systems as well as the potential governance arrangements and implications of collective coordination within these systems.

Research [3, 34-36] has highlighted that households' attitudes and perceptions towards energy demand and practices are strongly influenced by their social identities and relationships with others, both within their homes and within their communities. Hargreaves et al, [3] discuss perceptions and attitudes of households within their social relations as influential factors in energy demand. The authors highlight three key factors i) family and friends' networks which individuals often observe and learn from the energy-related behaviours of their close ones, ii) various agencies such as government bodies and energy service providers that have the potential to influence energy demand through social relations, and iii) social identities such as gender, occupation, and cultural background in shaping energy demand. They stress the significance of these factors that intersect and play vital roles in shaping people's engagement with and use of energy and energy demand management. Burningham and Venn [34] discuss the dynamic relationship among social relations, transitions, and everyday consumption. The authors highlight that shared identities, norms, and practices within households and social networks can shape household behaviours and decision-making regarding energy use patterns and energy demand management.

Different identities impact individuals' responses to energy interventions and their adoption of energy-efficient behaviours for example, individuals who identify as thrifty may have a strong focus on cost savings and financial efficiency and individuals in the disability category, may face additional challenges and

barriers that affect their ability to adopt energy-efficient behaviours [37, 38]. Moreover, societal norms and roles associated with gender, generation, and social class within family and community relationships further shape energy demand patterns and influence responses to interventions [39, 40]. Traditional gender roles often assign the responsibility for household chores and energy management to women, impacting the division of labour within households and leading to disparities in energy use and conservation behaviours [41]. Furthermore, different generations exhibit varying attitudes, values, and behaviours toward energy use, with younger generations being more environmentally conscious and likely to embrace energy-efficient technologies and practices [42, 43]. Additionally, social practices play a significant role in shaping energy demand patterns and responses to interventions, as individuals from diverse social contexts possess different levels of access to resources, energy-efficient technologies, as well as information [44].

The integration of social relations into the modelling and development of smart energy systems and transitions more broadly is recognised as critical to a holistic understanding of how peak load reduction may function in smart grids. Savelli et al., [32] discuss the concept of smart energy neighbourhoods, emphasising the incorporation of social factors such as social relations into the modelling of smart energy systems for designing effective interventions and policies that promote energy efficiency and demand management. In addition, Hargreaves et al. [30] highlight the importance of social smartness in the modelling of smart energy systems such as smart grids by emphasising the significance of considering distributed perspectives, social interactions, and societal values in shaping the design, implementation, and functioning of smart energy systems.

In addition, researchers have delved into the potential governance considerations for coordinating social relations and identities in the context of energy demand management [34-36]. These studies have focused on specific contexts, such as community energy projects, to examine how networks, community structures, and social interactions can facilitate collective action and cooperative behaviour in the energy domain. By investigating the role of social relations and identities in promoting collaborative efforts, researchers identify effective strategies for engaging communities, fostering energy-saving behaviours, and implementing sustainable energy initiatives. For example, Miller et al. [45] emphasise the importance of incorporating various social governance dimensions into energy policy, highlighting the need to integrate individual relations and behaviours, advance knowledge and expertise in socio-energy systems, and address social justice issues within energy transitions. Additionally, Creamer et al. [35] discuss the governance of social relations specifically in the context of community energy projects. They emphasise that the governance of social relations in these projects involves the active involvement and interplay of multiple actors, including governments and institutions operating at different scales, such as the local and regional/national levels. However, despite the existing research highlighting the importance of social relations, there is a need for more empirical evidence on how social dimensions in relations manifest or how they shape energy demand practices and identities. Social identities and rhythms offer valuable insights into how households and communities navigate energy-related issues across different scales and spaces. For instance, social identities create a sense of belonging, linking individuals to specific groups or communities associated with particular scales and spaces [46, 47]. This sense of belonging and the corresponding group dynamics and cultural norms profoundly shape how households perceive and interact with their environment, influencing their energy-related behaviour and practices [3]. Furthermore, shared identities within specific scales and spaces are often associated with shared social norms and practices [48]. These norms guide individuals' behaviours and expectations regarding energy consumption, conservation, and management [49, 50]. Meij et al, [51] discuss that shared identities and rhythms shape social interactions and networks within different socio-spatial scales. The authors also highlight that aligning spatial arrangements and temporal orderings can promote social interactions and contribute to the development of social networks within a neighbourhood context.

Wilson et al, [52] discuss identities and rhythms that interact with contextual factors such as cultural, economic, and political aspects within different scales. These factors collectively shape how households

perceive their role in the broader societal and environmental context and how they interact with their surroundings. Cultural influences, reflecting societal values and norms, affect how energy is used and valued within households. Economic considerations, including income levels and costs, influence decisions regarding energy consumption and investments in energy-efficient technologies. Political dynamics, encompassing policies and regulations, shape the incentives and opportunities available for adopting energy management practices. These multifaceted interactions shape households' overall awareness, attitudes, and behaviours related to energy use, thereby significantly influencing their energy-related behaviour and practices [3]. Furthermore, shared identities within specific scales and spaces are often associated with shared social norms and practices [48]. These norms guide individuals' behaviours and expectations regarding energy consumption, conservation, and management [49, 50]. Meij et al, [51] discuss that shared identities and rhythms shape social interactions and networks within different socio-spatial scales. The authors also highlight that aligning spatial arrangements and temporal orderings can promote social interactions and contribute to the development of social networks within a neighbourhood context.

Collective actions in the context of energy demand are also influenced by social identities, particularly group identities which are tied to social and energy practices. Researchers discuss that social identities tied to social, cultural, or regional groups can influence energy-related practices, behaviours, and conservation [53-55]. For instance, individuals who identify strongly with environmental or sustainability movements may be more likely to engage in collective actions aimed at reducing energy consumption and management [25]. In addition, group identities can form norms, values, and attitudes towards energy demand, influencing collective behaviours [56, 57].

By leveraging social identities and relations in the context of energy demand, significant advancements in home energy management can be achieved. The understanding that households' attitudes and behaviours towards energy consumption are strongly influenced by their social relations and connections opens up opportunities for targeted interventions and tailored approaches. By harnessing social identities and relations, strategies can be developed to promote energy-saving behaviours, foster social norms that encourage sustainable energy practices, and facilitate collective actions within communities. Moreover, incorporating social factors into energy transition modelling and governance frameworks can lead to more effective interventions, policies, and community engagement initiatives, ultimately driving the adoption of energy-efficient technologies and shaping a more sustainable energy future.

3. EMPIRICAL SETTING AND METHODS

This research employed a mixed-method experimental approach [58] that integrates various data sources, including surveys, photographs, smart meter data, and interviews with residents in Glasgow and Bristol, UK. The selection of these cities as research settings was guided by their distinct climatic conditions, neighbourhood characteristics, and social and spatial factors, while still sharing similarities in local energy policy. By utilising a mixed-method experimental design and embracing the iterative thematic inquiry (ITI) approach [59], we were able to gather a comprehensive range of socio-technical identity and social relations data. Rather than presenting a comprehensive overview of the entire project, this paper specifically focuses on the analysis and presentation of data related to social relations and identities in the context of home energy demand, particularly derived from survey and interview responses.

The data collection and analysis proceeded through multiple stages. In the initial stage, a survey was distributed using Qualtrics, with a total of 1427 participants taking part. After filtering out incomplete and duplicate responses, the final sample consisted of 617 participants, comprising 231 participants from Bristol and 386 participants from Glasgow. The survey was designed to explore four key categories aligned with the project's overarching conceptual approach [60]. These categories included: i) participants' home spatial and social characteristics, ii) home energy management approaches, iii) neighbourhood approaches to

energy and social dynamics, and iv) home daily and weekly energy use and management routines. As part of the survey, participants were also invited to submit photographs depicting their typical evening routine, along with a free-text description to capture any additional thoughts or insights not covered by the survey questions. The evening routine was specifically chosen due to its significance in addressing the challenge of the peak load reduction [4, 15]. The utilisation of photographs was found to be effective in conveying both the social and spatial context that might otherwise be overlooked [61]. Moving to the next stage, interviews were conducted with participants from both Glasgow and Bristol, with a total of 11 interviews completed thus far.

In this paper, the focus of the discussion centres on the survey and interview data. The survey responses were initially categorised and organised into analytical categories, drawing upon empirical context, social identity theory, social practice theory, and rhythm analytical dimensions in line with the project's conceptual approach. Subsequently, the responses were further grouped based on significant parameters identified as crucial in the context of home energy management and peak load reduction scenarios within each category. Four themes emerged from the initial survey analysis – these were then grouped into archetypes. All interview transcripts were thoroughly read and grouped into the corresponding Archetype groups (1 to 4). Descriptive memos were prepared following the protocol sequence to capture the key aspects of each interview. In the second phase of analysis, these memos were analysed in conjunction with insights obtained from the survey data. This allowed for a deeper exploration of key thematic details in each archetype, further enhancing, and expanding upon the findings derived from the survey.

4. FINDINGS

The analysis revealed four distinct themes, referred to as archetypes characterised by different social identities and rhythms of energy management practices. The four themes are as follows: Theme 1 (Archetype 1-Generous Belongers); Theme 2 (Archetype 2-Aware Belongers); Theme 3 (Archetype 3-Distributed Belongers); Theme 4 (Archetype 4-Disengaged Belongers).

Theme 1 denoted as Archetype 1 (*Generous Belongers*), comprises 114 households that exhibit a *very high level of social identity and community ties*. They demonstrate very high social reach, engaging with 7-10 neighbours on a regular basis (daily). These households suggest that they actively assist their neighbours and share energy-related information on a very frequent basis. They convey a preference for taking individual responsibility for their energy management, with a majority of participants (82%) actively engaging in energy management practices such as monitoring and adjusting their usage (78%). Their energy adjustments are suggested to also be very regular, with a preference for daily and frequent actions. Theme 2 referred to as Archetype 2 (*Aware Belongers*), consists of 80 households who exhibit a *high level of social identity and community ties.* They maintain a high social reach, engaging with 5-7 neighbours on a few days a week, somewhat less frequently than Archetype 1. These households also suggest a frequent engagement in supporting neighbours and somewhat less frequently (than Archetype 1) sharing energy-related information. The households also indicate a preference for taking individual responsibility for their energy management, with a significant proportion (75%) actively engaging in energy management practices, frequently and regularly monitoring their energy use and adjusting their usage (71%). Their energy adjustments are carried out regularly, with a preference for a few days a week with less frequent actions than Archetype 1. The heightened social reach and strong community ties indicate a strong commitment to managing energy in a regular, frequent, and repeated consistent pattern. This is consistent with Social Identity Theory [46] and suggests participants who may fall under Archetypes 1 and 2 may be inclined to adjust their usage in peak load scenarios in a regular and frequent pattern. This is in contrast to archetypes 3 and 4 as conveyed in the following paragraphs.

Theme 3 designated as Archetype 3 (*Distributed Belongers*), comprises 120 households characterised by a *moderate level of social identity and community ties*. They maintain a moderate level of social reach, engaging with 3-5 neighbours, on a weekly basis. These households indicate a preference for taking somewhat less individual responsibility for their energy management, compared to Archetypes 1 and 2, engaging in energy management practices, occasionally and irregularly (53%). Theme 4 denoted as Archetype 4 (*Disengaged Belongers*), encompasses 313 households that exhibit a *low level of social identity and community ties*. They have a low social reach, engaging with 0-3 neighbours, on a monthly basis. Households in this archetype occasionally assist their neighbours and have a low frequency of sharing energy-related information. The households in this theme demonstrate a tendency to take less individual responsibility for their energy management (52%). They are not engaged in energy management practices, and infrequently and irregularly monitor their energy use (52%).

In summary, the heightened social reach evidenced in Archetypes 1 and 2 denotes a greater involvement, regularity and frequency in carrying out energy management practices such as adjusting and monitoring (See also Figures 1 and 2).

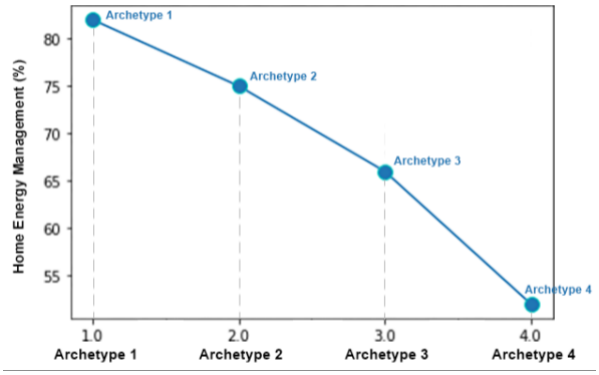

Fig1: Percentages of individual responsibility for home energy management in Archetypes 1 to 4.

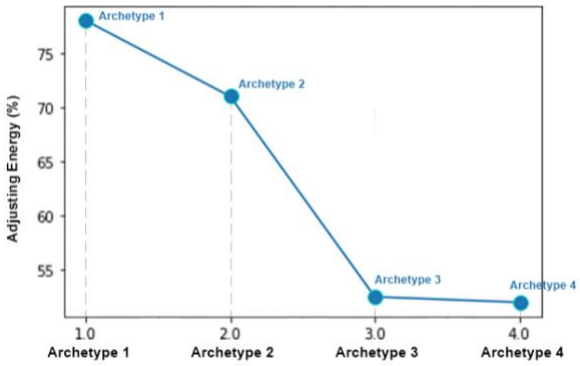

Fig2: Percentages of individual responsibility for adjusting energy (heating) in Archetypes 1 to 4.

By taking social reach and identity into account, new behavioural insights can be accounted for in the context of peak load reductions, enabling for instance tailored interventions in different neighbourhood contexts. For example, based on concepts drawn out of the Social Identity Theory in the context of a peak load reduction, archetypes 1 and 2 are more likely to be adjusting their usage on a regular and frequent pattern, with archetypes 3 and 4 on an irregular and infrequent pattern. Whilst prior work has suggested importance needs to be placed on home typologies, social and employment demographics [62, 63], in this study social characteristics, employment profiles as well as age did not impact archetype characteristics, with most households made up of owner-occupiers in full-time employment and aged 25 to 34. In addition, there was no variation reported in patterns of energy management between different home types with most being bungalows and maisonettes, and the majority of households reporting electricity and gas supply, with most having a high number of appliances (20 appliances or more).

5. CONCLUSION

The benefits from insights gained in this study are twofold. First, the new multidimensional empirical evidence based on two city contexts (Glasgow and Bristol), provides an emerging new understanding of

the ways social relations and identities characterise the rhythms of energy management within households. The combining of identity, practice and rhythm data enables a nuanced understanding of the potential implications social relations can have on households' engagement in energy crisis scenarios such as peak load reduction. Whilst consistent with findings by Burningham and Venn [34], the four archetypes denote the characteristics and rhythmic impact of shared identities and practices within households and social networks, showcasing their capacity to shape household behaviours and influence the decision-making processes related to energy use patterns and the management of energy demand. Insights also expand recent work by Hargreaves et al, [30] as well as Hargreaves and Middlemiss [3] by providing both empirical evidence and a new conceptual lens into the study of social relations implications of the energy crisis. By incorporating a range of social identity factors such as social reach, community ties, and engagement frequency, this research contributes to expanding the analytical ground of theoretical approaches that connect social identities with energy-related behaviours [64].

Second, there are significant implications considering the development of smart energy systems policies [65] and the establishment of flexible energy frameworks in the UK [66] and elsewhere. Future work could expand insights from this paper and consider the development of a new type of 'community energy social practice' role that holds the potential to provide valuable assistance to local authorities in their pursuit of de-centralised and localised approaches, aligning with overarching national energy transition objectives. This endeavour would facilitate the cultivation of local-led insights into the determinants of drive peak load demand, promote community resilience during sudden blackouts, collective responsiveness to emergent events or even facilitate energy sharing during unstable supply due to unstable energy sources. Furthermore, insights from the four archetypes offer robust support for a greater evidence base of the social and spatial characterisations associated with energy consumption patterns. The identified energy practice rhythms in this study reveal how energy is managed across varying socio-spatial contexts. Understanding these patterns further with a greater sample and diversity of participants and contexts [51] could help identify areas where energy demand is high or inefficient, allowing for targeted interventions to reduce or shift peak load. By identifying the archetypes with regular and consistent energy usage adjustments, policymakers and system operators could then better support governance approaches in demand response programs. This can help reduce peak energy demand, optimise grid operation, and facilitate the integration of renewable energy sources, thereby supporting decarbonisation efforts.

Currently, there is a lack of empirical investigation into the socio-technical and spatial characterisation underlying the utilisation of Home Energy Management (HEM) and broader Consumer Energy Resource (CER) technologies. In order to establish a more definitive end vision, it becomes imperative to undertake evidence-based research using a diverse array of mixed methods, including large-scale field studies across a spectrum of socio-economic and geographic contexts within the UK. While this study contributes towards this evidence base, there is a need to expand data collection and analysis with a greater sample base, across a broader social and physical set of characteristics. Future research could examine how shared identities and rhythms shape social interactions and networks across diverse socio-spatial scales. This exploration could be enriched by taking into account contextual factors such as cultural, economic, and political aspects that operate within varying scales. By delving into these dimensions, a more comprehensive understanding could emerge, contributing to a better understanding of how identities, rhythms, and contextual factors collectively shape and are shaped by energy management behaviours, practices and societal dynamics, particularly in energy crisis events.

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