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Home -ing in on domestic energy research: "House," "home," and the importance of ontology

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ABSTRACT

Domestic energy demand is a topical policy issue, with implications for climate change, energy vulnerability and security. Domestic energy demand varies considerably by country, climate, building type, and even when these factors are the same, occupancy patterns and inhabitant's lifestyles also create variation. However, clarifying understanding of the basic locus of analysis: the home, house, dwelling, or household has received little attention to date, despite its relevance to debates on energy demand. This paper explores the theoretical and methodological assumptions of investigating the 'house' compared to the 'home' and the implications for domestic energy researchers. We suggest that the ontological priority given to the 'home' results in scholarship which considers both social and physical aspects that shape demand. Conversely, research prioritising the 'house' is dominated by techno-economic thinking, and overlooks critical social considerations. Recognising this important distinction, we conclude with a plea for scholars to be cognisant of ontology and language, and provide some suggestions for a future research agenda.

1. Introduction

The housing sector is an important area in energy research, accounting for up to 45% of a nation's energy consumption [1]. Domestic energy demand varies considerably by country, climate, building type, and even when these factors are identical, occupancy patterns and inhabitant's lifestyles create a significant variation [2,3]. Domestic energy demand has thus long been an object of research for economists, engineers, and building scientists and in the past quarter century there has been a growth in contributions from social scientists, including psychologists, sociologists, geographers and historians [4,5]. This paper explores the theoretical and methodological assumptions underpinning these diverse contributions. In this paper we therefore argue that there is a lack of critical engagement with *what* is being investigated in domestic energy research, specifically the basic locus of analysis. Terms such as 'housing', 'household', 'home', 'house', 'domestic' and 'dwelling' appear to be used interchangeably. Whilst the meanings of, and distinction between, these terms has received attention elsewhere, they have not been fully explored within the context of domestic energy scholarship.

The main contention of this paper is that notions of home are instinctively linked to more than the house, and such understandings may be used to challenge the dominance of the mainstream techno-economic approach which focuses on improving design, technologies, or other physical aspects of domestic buildings. Accordingly, this paper brings insights from home scholarship: the widely agreed difference between house and home and significant social aspects of home (e.g. comfort, identity, security, privacy) to help progress domestic energy research. Energy demand is not solely dependent on the design and physical features of a building; social expectations and norms also shape everyday routines which has energy implications [6]. We recommend that energy research would benefit from adopting the home (and all the baggage the term comes with) as the focus for investigation, highlighting an appreciation for the socio-technical nature of domestic energy demand. The current techno-economic approach narrows strategies for intervention, whereas consideration of demand as the result of socio-technical systems presents broader range of strategies (e.g. targeting social conventions, meanings of comfort, fashion and clothing).

The paper begins by exploring the dominant approach to domestic energy research, that which prioritises the 'house'

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revealing its theoretical and methodological assumptions. Section 3 moves on to explore the literatures related to the 'home', highlighting and connecting key themes back to domestic energy research. Section 4 presents our novel conceptual framework demonstrating the implications of energy research which differently awards 'home' or 'house' ontological priority. Finally, we offer some possible directions for future research and policy recommendations as a result of adopting the home as the key locus of analysis.

2. Scholarship on the 'house' and energy

Domestic energy researchers are guilty of using house, home, housing, dwelling, and household interchangeably. In this section we use the term 'house' to signify a particular, dominant, way of approaching the topic of energy demand and suggest this reflects certain assumptions. We highlight these assumptions and demonstrate the implication of these in terms of methodological approaches, how householders are perceived, how 'success' is measured and intervention strategies.

A house is the physical building where people live (including flats/apartments in this sense), so research is concerned with material aspects, such as construction, energy supply, heating or cooling system, and appliances. Accordingly, studies of the house have been undertaken mainly by building scientists, engineers and architects [7] who typically employ quantitative and applied methods (e.g. large quantitative surveys, modelling and statistics). For example, modelling designs to improve efficiency or estimating energy demand based on building features and the local climate [8–10].

These contributions are important to regulation and development of policy instruments [11], making buildings, heating/cooling systems and appliances more efficient as well as reducing carbon emissions and inefficiencies in the supply system. Indeed, examples of improvements in energy efficiency are prolific. According to modelling of national energy consumption in the UK by Palmer and Cooper [12], the mean average energy use per home fell from 23,900 to 16,700 kWh between 1970 and 2011. Yet, what energy is used for has changed dramatically in the past 40 years with the heating of more rooms to higher temperatures, as well as an increase in the number and use of appliances. Further, developments in economics, law, public policy, business and urban planning have contributed to the development of mechanisms for the delivery and uptake of building improvements [5]. Again, this research is generally underpinned by quantitative methods, such as large-scale surveys and analysis of secondary data sets although qualitative post-occupancy evaluation is also used [13], albeit modestly.

By focusing on only physical elements, studies of the house are, at best, reliant on unsophisticated understandings of the role of occupants, and, at worst, assume that building users are passive. Typically, householders are recognised as contributing to the performance gap, but addressing this variance is seen as the responsibility of other disciplines [14]. In part, this may be explained because positivist methodologies may struggle to make sense of or account for these complexities. Evidence of householders being perceived as passive is derived from the expectation that householders ought to use the house as 'intended' or designed to be used [8]. If modelled demand does not match actual performance the response is to adapt design rather than engage householders. For instance, there is considerable literature on the importance of designing an appropriate level of control, on making sure interfaces are user-friendly, and in determining what level of control makes occupants most tolerant of their indoor climate [15,16]. Indeed, the intention of building performance models is to give a measure of energy efficiency which is independent from the influence of occupants' behaviours [8].

Building standards suggest that several criteria are needed in combination to achieve a comfortable indoor environment: air and radiant temperature, humidity, air movement, individual clothing and level of activity all play a part (e.g. ASHRAE and ISO standards[1]). Furthermore, there is a dominant focus on thermal comfort and temperature in particular; with comfort becoming commonly defined according to Fanger's [17] "comfort equation" which suggested that 21 °C is the optimal temperature for thermal comfort. While Fanger [17] clearly understood comfort as the result of complex interaction between multiple criteria, his work helped lead to the perception and acceptance of comfort as a definable condition and establishment of universal standards for the indoor environment [6].

By considering building users as passive and occupant satisfaction as a clearly defined standard, it follows that the strategy for intervention (for affordable, secure and low-carbon domestic energy) would be to target the house and pursue mechanical solutions. As Chappells and Shove argue "if comfort is thought of as a *definable* condition, the aim is to *design* indoor environments that deliver it" [78](11, emphasis added). Thus, studies of the house aim to make houses and energy provision more efficient. Part of this includes research on policy mechanisms or how to encourage uptake of insulation or micro-generation technologies but the target of intervention is still the house and 'house researchers' are not concerned with understanding how people use energy or what energy is for [18–20].

This section has set out the dominant approach to domestic energy research, and the implications of theoretical and methodological assumptions of positivist lines of enquiry that are focused on physical drivers of energy demand. These methodologies are undoubtedly valuable, for instance in modelling and evaluating policy instruments depending on technical, economic and regulatory factors [11,21,22]. Furthermore, in modelling, designing, and assessing new technologies and more efficient buildings these contributions from building scientists, engineers and architects are essential. However, a performance gap between modelled building performance and actual energy demand is widely recognised [8,23,24] and this approach is not suited to incorporating the complexity of social drivers of demand, for instance issues of rebound or increasingly energy-intensive expectations for indoor environments. Therefore, we are concerned with finding a locus of investigation that captures the complexity of interaction between both physical and social drivers of domestic energy demand, and turn to literature on the home to inform this conceptual development.[2]

[1] ASHRAE (American Society for Heating, Refrigeration and Air-Condition Engineers) and ISO (International Organisation for Standardisation) are both examples of organisations setting 'standards for thermal environmental conditions for human occupancy' [101] which are becoming increasingly recognised and adopted internationally (Nicol and Humphreys [102]).

[2] There is also a significant body of work on the notion of dwelling, which is in many ways complimentary to developments in literature on the home. For instance, philosopher Martin Heidegger's (1971) seminal article 'Building, Dwelling, Thinking' has sparked similar debates to the difference between home and house (e.g. critiquing conflation of terms, considering circular relation, critiqued by feminists, debates about home-making), but instead emphasises the distinction between dwelling and building. However, there is much debate surrounding definitions of housing, household, domestic, home, house and dwelling, and we do not aim to provide an exhaustive review of this multitude of concepts; hence why we focus only on the terms 'house' and 'home' as a framework to explore trends in domestic energy research.

3. Why the home matters

Researchers have increasingly recognised that there is more to housing than the material house and attention has shifted to the concept of home. Yet this transition remains implicit in domestic energy research, which we seek to redress.

3.1. Home literatures

The subject of home constitutes a considerable body of interdisciplinary academic work with contributions from researchers in architecture, geography, sociology, social-psychology, anthropology, history, philosophy, law, and housing studies. This section provides a brief discussion of key themes and debates related to home (for more comprehensive reviews of this work see Blunt and Dowling's [35] seminal book *Home* and Mallett [25]) to orient our audience. Briefly, Brickell [26] suggests that research on the home comprises three distinct periods. In the 1970s and 1980s, the home was presented as a place of privacy, security, control, independence and belonging in response to an increasingly alienating world. In reaction to this portrayal of 'home-as-haven' was a period of critique in the 1990s, particularly attacking the binaries (e.g. inside/outside, male/female, work/home, public/private and safe/unsafe) that had supported these optimistic notions of home. Finally, since the early 2000s research has stressed the ambiguity and multitude of co-existing meanings of home [26]. While this is an oversimplification of an immense and exponentially growing area of research Brickell's account can nonetheless be usefully interpreted as demonstrating two key elements of home research which are related to (1) the 'home-as-ideal' and (2) an agreement on the difference between house and home.

Firstly, positive connotations attached to home, as well as critique of this assumption, remain an underlying and important area of discussion [27–31]. Indeed, Rybczynski's [50] book *Home: a short history of an idea*, responsible for bringing the home to a much wider disciplinary audience, inextricably links comfort and home. Many studies problematise these understandings of ideal. For instance, linking home to something intangible; a nostalgic longing of a childhood home or pursuit of a future fantasy [32]. Others argue that the ideal home is often conflated with the nuclear family, excluding other household organisations as well as gay men and lesbians from common notions of home [28]. Furthermore, by regarding home as an ideal, Imrie [30] argues that planning and designing overlooks illness, impairment and disease as part of domestic living, resulting in homes that are places of exclusion and entrapment for some (e.g. the front step makes accessibility hard for wheelchair users, sometimes to the point of not being able to leave without assistance). Such studies indicate that representing the home as a positive concept may in fact exclude certain groups or ideas which are connected to home.

However, whilst assuming the home is positive, and that "home should offer to the individual rest, peace, quiet, comfort, health and that degree of personal expression" (Gilman, 1903, reprinted in 2002 [27: 3]); Gilman argues for criticism and questioning of the home as a way of improving and protecting it as an ideal. Moreover, several researchers [28,30,33,34] recommend that construction of 'home-as-ideal' is the result of the majority of research being relatively abstract; whereas, more empirical studies reveal the meaning and experience of home to be much more variable. Yet, considering the multiple dimensions of home, the notion of the 'home-as-ideal' is likely to continue to be a fundamental, and even instinctive, aspect of colloquial understandings (e.g. as an ideal future form that can be pursued, a present space of comfort or security, or as an idealised past perception of a childhood home).

Secondly, while there is a move away from strict definitions of home, there is wide agreement of the distinction between house and home as a starting point for further exploration and development [35,36]. Home is more than physical/material objects or artefacts; it is connected to emotions and relationships, as well as social and cultural expectations [25]. By contrast, the house is just physical; it's the 'brick and mortar' [36]. House and home stand in circular relation; interaction with physical elements, such as building, decorating, and 'home-making' are integral to attaining a sense of home [28,32,37], however, at times the house can be what is most important to feeling at home; as Parsell's [31] discussions with homeless people in Australia would suggest. One can live in a house and yet not feel 'at home', consider transitory accommodation such as prison, boarding school, hospital, and university [35]. Thus, "home is a series of feelings and attachments, some of which, some of the time, and in some places, become connected to a physical structure that provides shelter" ([35]: 10).

There are also temporal dimensions to home, it is not static and may be actively created/achieved (e.g. cooking is often connected to a sense of homeliness); it likely changes throughout an individual's life in relation to both physical (e.g. moving out of the parental home) and social (e.g. domestic violence, living with friends or strangers, marriage) circumstances. Importantly, work has considered at what point a house becomes a home: highlighting the utility of more attention to processes of home-making, often related to immigrants and refugees [38–40], and understanding how control, privacy, and ownership relate to belonging and feeling 'at home' [30]. There is clearly much to consider from such scholarship and the extent to which these ideas are incorporated into domestic energy research, as we now discuss.

3.2. The importance of home in relation to domestic energy research

This section unpacks and explores an alternative approach, distinct from the 'house' framework, to research domestic energy which aims to capture the relationship between both social and physical elements of energy demand. The term 'home' is employed to recognise greater complexity and socio-technical lines of enquiry.

As discussed in the preceding section, there is recognition that home is both a social and physical unit [35,41]. As a result domestic energy research which awards the ontological priority to home is concerned with material *and* social elements of domestic energy and the extent to which these are co-constructive. Sociologists, anthropologists, social-psychologists, geographers, designers and historians have all contributed to understanding of the home in multifaceted ways, often exploring how routines and everyday activities shape domestic demand [42,43], how occupant activities explain the performance gap [24,44] and how to shift unsustainable lifestyles [45]. Largely a range of qualitative (e.g. ethnographies, interviews, focus groups, participant observation, content analysis) and quantitative methods (e.g. modelling and large scale surveys) are employed to address these socio-technical topics.

In such scholarship, building users take on an active role. Householders are integral to the management of their home; their routines and expectations shape and create demand [6,46,47]. Everyday activities are not simply structured in order to uses appliances or building features as they are designed, how the home is managed is the result of complex social conventions. Householders are viewed as actively reproducing and transforming the norms of how the building and technologies in the home are used [48].

Research on the home does not take occupant satisfaction or comfort to be universally definable or measurable. Comfort is a complex and contested concept (for an in-depth review see [6]).

Table 1
Examples of domestic energy scholarship and swapping of key terms.

Source	Type of publication	Quote, emphasis added
Palmer and Cooper [103] (11)	UK Department of Energy and Climate Change, Energy Fact File	Carbon dioxide emissions from *housing* have fallen since 1990, even including the cold winter of 2010. This was despite increases in the number of *homes* and changing expectations about energy use in the *home*. [. . .] Rising costs for electricity hit poorer *households* with electric heating the hardest
Thormark [104]	Building and Environment, article	The indoor temperature in the *dwelling* has a minimum of 20 °C. [. . .] With the definition that a low energy *house* uses less than 70 kWh/m^2
Kavgic et al. [105] (1685, 1696)	Building and Environment, article	Building physics based modelling techniques generally include the consideration of a sample of *houses* representative of the national *housing* stock [. . .] Specifically this reflects our lack of knowledge of how different people consume energy in their *homes*, how they use *domestic* technologies, and how they react to changes in the *dwelling* as a result of energy performance measures
Rudge [106]	Energy Policy, article	It was found that in 20% of English *homes* the overall *dwelling* temperature, represented by a spot reading in the hall, fell below 12 °C indoors when the outside temperature was 0 °C. It appeared that the long held reputation abroad for English *houses* as draughty was still deserved
Lane and Gorman-Murray [107] (1, 3)	Material Geographies of Household Sustainability, book	It also entails many assumptions about the 'normal' practices of mundane *domestic* life and the motivations of *householders* for their behaviour and decisions.[. . .] The locus of the *household*, or the *home*, and issues of environmental sustainability are both centrally positioned in these broader demands

The dictionary definition is a state of physical and material well-being or satisfaction of bodily needs; and there is often recognition that comfort can be both mental and physical satisfaction [49]. Furthermore, comfort is often defined and better understood as a condition in which discomfort has been avoided [50]. Understanding comfort as a social construct raises a concern that "in determining what people 'need', the science of comfort has allowed designers to produce buildings and systems that meet and at the same time create expectations of comfort" ([6]: 34). Indeed, the increase in mechanical solutions often means that expectations of comfort are becoming increasingly energy demanding [51]. In relation to literature on the home, comfort is understood as a social phenomenon that varies historically and spatially [52] and much of this literature [53,54] advances adaptive strategies and how householders *make themselves* comfortable as an alternative discourse to thermal standards. The value of further research to find other ways of conceptualising comfort (e.g. including physical and psychological aspects) becomes readily apparent because it challenges the dominant perception of the 'comfort zone' and mechanical solutions which have led to more energy-intensive social practices world-wide.

By considering householders as active in shaping energy demand and comfort as contested, the range of intervention strategies increases because they are not just about targeting the physical aspects of a house. Instead of just trying to make the same process more efficient or do 'more with less,' strategies to reduce domestic energy demand include challenging social conventions and targeting unsustainable elements of activities. Modelling national energy and efficiency improvements is only part of the story, as for instance, it says nothing about growth in the housing stock or how energy is used in homes. The trend towards smaller households, which Palmer and Cooper [12] and Wilson and Boehland [55] both suggest is a driver of a rise in domestic energy demand in the UK and US, is an issue that is better understood in terms of the home. Simply improving the energy efficiency of the house perpetuates and encourages these sorts of trends because it sends the message that these are reasonable standards of living to expect [56]. A small house built to moderate energy performance standards generally requires less energy than a large house built to very high standards [55] and hence targeting these social norms and expectations could make huge reductions in domestic energy demand. Studies focusing on what energy is for try to find other ways to meet these expectations [57]; often highlighting historical activities that reduce the need for mechanical heating or cooling [58] or encouraging reflection on moments of disruption as opportunities for change [59]. In short, research on the home opens up a huge potential for a greater understanding of what drives energy demand.

4. Towards a new conceptual framework for domestic energy research

With the aim of offering a clear foundation for domestic energy research, the proceeding section introduces a conceptual framework to more systematically compare the 'house' and 'home' approaches. As highlighted earlier, the necessity for such an ontological 'tidy-up' stems from the relaxed way in which literature adopts and uses important terms. As can be seen in Table 1, the literature is confused and confusing, with some literature often using the same word differently, or using different words to mean the same thing.

Our framework, and this paper, seeks to challenge such problematic linguistics and attempts to clarify the different locus' of domestic energy research.

4.1. Introducing a framework comparing house and home

It is clear that the literature can be characterised as awarding ontological priority to either 'house' or 'home'. To understand the consequences of this difference in the context of domestic energy and how it is researched we introduce Fig. 1. This figure contains four axes which we have selected because they helpfully demarcate 'house' from 'home' in the context of domestic energy research. The first of these is the research approach. Starting with this is critical because it signals the theoretical and methodological assumptions of the researcher. In the interest of addressing the call for deeper examination of humans in energy systems [5] our second axis compares the role of building users, on a continuum of passive to active. We are also concerned with the resulting policy recommendations or intervention strategies, social or technical, hence this also forms an axis. The final axis is related to how 'success' is measured in relation to building occupants; in other

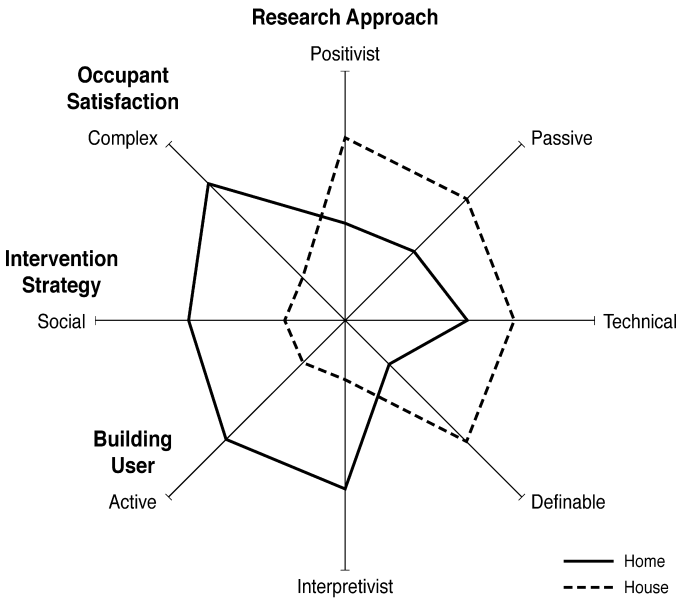

Fig. 1. Comparing house and home in domestic energy research.

words, whether occupant satisfaction is definable (e.g. comfort zone 18–21 °C) or recognised as complex (e.g. homeliness). Against these four axes we position two lines, one for 'house' and the other 'home' to demonstrate where we feel these bodies of scholarship contribute.

Mapping of 'house' and 'home' onto these four axes is supported by our discussions in the preceding sections. Of course, there are inevitably debates over labelling, and precise locations of the 'house' and 'home' lines on these axes are open to challenge; but what we have done is to begin to systematically unpack the different research agendas that emerge from focusing on the house or the home. It is important to make clear that while the axes represent continuums, the intention is not to set up binaries, instead Fig. 1 demonstrates that both 'house' and 'home' straddle different perspectives in domestic energy research. The primary purpose of this conceptual approach is thus as an heuristic device to explore the implications of a techno-economic dominance that encouraged focus on the house in domestic energy research and to demonstrate the importance of the home as a distinct locus of analysis; unpacking ways in which the two are similar and/or contradictory.

4.2. Research approach

A great deal can be understood from locating domestic energy research on a continuum of positivist to interpretivist because it helps distinguish disciplinary backgrounds and methodological approaches. The term positivist refers to a philosophy of science which maintains that natural science methods (e.g. hypothesis testing, experimental controls, falsifiability) are preferable for explaining social phenomena [60,61]. Whereas, the interpretivist approach maintains that the methods of natural science are not adequate to study the social world because social phenomena are fundamentally distinct from the physical reality studied by natural scientists [61]. Interpretivists stress that human experiences and explanations are subjective, requiring a different set of methods to interpret and make sense of this complexity, accordingly, reality is subjective, interpreted social action [62]. Like many other fields of research, domestic energy scholarship has a history of output and funding coming initially, and largely, from positivist, science, engineering, technology and mathematic backgrounds [63] which in part explains the dominance of this approach.

Several authors [4,5,7,64] characterise energy research, broadly defined, as adopting techno-economic thinking (e.g. rational choice theory or relying on modelling), which has remained based on the core theoretical assumptions of engineering and economics since the 1970s. There are increasing contributions from social scientists, but these remain relatively small. For instance, Sovacool [5] reviewed publications in three top energy journals (including *Energy Policy*) between 1993 and 2013 and found that only around a fifth of researchers reported training in social-sciences (primarily business, public policy and law) and that only 12.6% of articles used qualitative methods, with the majority favouring quantitative tools or relying entirely on secondary literature. While there is an affirmation for the value of interpretivist contributions (see the new journal *Energy Research and Social Science* or *Building Research and Information's* Special Issue on 'Challenges and Future Directions for Research on Energy and Buildings') Schweber and Leiringer [4: 490] suggest that understanding of social elements is relatively narrowly focused on "discrete technical innovation and atomised individual users."

These sorts of assertions underpin the arguments of many social scientists who suggest that current research frameworks of energy are too simplistic, and give little attention to important social and historical elements that shape demand [5,64,65]. While modelling can be made more accurate by including information about the way householders live in their home [66], the dominant approach, which relies on technical calculations based on physical features of the home and climate, struggles to address these complexities. Understanding these variations may be enhanced by contributions from researchers outside the dominant (positivist) techno-economic approach because they pursue a more holistic conceptualisations of domestic energy and offer alternative perspectives which highlight new lines of enquiry and gaps in current approaches.

4.3. Building user

How building users are perceived also appeared to be an important point of divergence in the domestic energy literature [67,68]. Essentially, questions about accessibility, rebound or details of consumption are regarded by building scientists and engineers as someone else's problem [3] and has essentially been delegated to other disciplines. Thus householders are represented as passive and explaining a performance gap as a failure in design [16,46] and householders are not included in calculations of building performance [8]. However, common amongst domestic energy scholarship is a recognition that a major gap exists between modelled or designed building performance and the actual energy demand from a home [8,23,24].

This performance gap is well-documented and has been explained by the rebound and prebound effect [44]. For instance, in colder climates, inhabitants generally adjust their standards to the efficiency of the building, accepting lower temperatures in inefficient homes and getting used to higher temperatures in efficient ones [44]. In general then, technical calculations overestimate the energy savings from new builds or energy improvements (rebound) and also overestimate the energy demand in older energy-inefficient homes (prebound) [44]. Furthermore, in studies by Gill et al. [2] and Gram-Hanssen [69] householders have been found to use two or three times more energy than their neighbour, while living in the exact same type of home with the same number of occupants. So there is also scholarship supporting and stressing the importance of householders as active and central to shaping energy demand [67,70,71].

Yet the perception of whether the building user is active or passive has implications for researchers recommendations for intervention, if householders are perceived as passive than strategies to reduce energy demand inherently turn to the building, ignoring social avenues of engagement.

4.4. Intervention strategy

Distinguishing between different strategies of intervention can usefully be represented by a continuum of social to technical. The far end of social interventions would include social-psychology or economics-informed behaviour change campaigns [45,72,73], whereas the technical end is more concerned with innovative technologies and designs such as renewable micro-generation or low-carbon house designs [74,75]. Closer to the middle of the social–technical continuum are strategies that to some extent combine social and technical considerations, such as post-occupancy evaluation which tries to incorporate householders experience to improve design [13,76] or considering how expectations of indoor climate co-evolve with changes to the material features of our homes [6,52]. For instance, the Japanese government reduced energy by not cooling office buildings below 28 °C in the summer, in response employees were able to remain comfortable and productive by adapting and wearing lighter-weight business attire [77]. This example is not about a change in technology or the indoor environment alone but is also accompanied (and dependent on) social changes that made working in warmer conditions more accepted or tolerable. Similarly in a domestic context, an increased acceptance in variability of temperature, daily and seasonally, may encourage activities and expectations that are less energy demanding; for instance, turning off central heating from April to May, working from home in a sleeping bag instead of having heating on during the day, or taking mental comfort from saving energy or being self-sufficient. By targeting the building in energy policies, the potential of altering cultural norms and ways of doing everyday activities is underestimated and may in fact justify and perpetuate increasingly energy-demanding expectations (e.g. narrow 'comfort zone' temperature: 18–21 °C).

The sort of intervention strategy that is encouraged by researchers is also linked to the goal of these strategies; more technical intervention assumes that occupant satisfaction is more or less definable in terms of being able to sufficiently control the indoor environment.

4.5. Occupant satisfaction

The final axis of comparison is related to how success is gauged. In domestic energy research, there is general acceptance that building performance is not only about energy but occupant satisfaction as well (e.g. reducing energy demand is not meant to come at the expense of being too cold). On one end success is (relatively) definable due to there being measurable targets (e.g. temperature, air quality, lighting, noise levels) [17]. On the other end, there is not a universally perceived goal; comfort is socially constructed and varies temporally and spatially meaning there are a wider range of potential goals (which are not the result of modelling or equations) [42,78]. A focus on the house has skewed debates away from bringing questions of demand into view. Since there is no such thing as an unlimited energy supply, more fundamental questions need to be asked about how much energy is enough and what establishing ways of living which require much less energy than we use today may really mean [79].

Comfort in the home cannot be narrowly defined; a point that is self-evident when one reflects on their own annual adaptations of shifting clothing, consumption of hot/cold food and beverages, and heating/cooling practices as seasons change. Yet our preoccupation with the house has made comfort a commodity [54], a perspective which (largely) ignores the interrelationships between meanings, materials and competencies of domestic energy demand. Overlooking this complexity has led to unintended consequences, partially explaining the performance gap and rebound.

To summarise, it is clear that there is undoubtedly overlap between 'house research' and 'home research'. Both acknowledge that householders influence domestic energy [14,23,66,80], yet those which prioritise 'house' generally do not go further than this and focus on material and mechanical solutions (e.g. designing a more efficient boiler or how to construct a tighter building fabric). Both approaches use a mix of quantitative methodologies, with 'home researchers' employing large quantitative surveys to track changing social phenomenon (e.g. household size and characteristics). However 'house research' broadly is concerned primarily with the physical building; supported by a more positivist approach, which pursues definable and easily measured criteria in order to design technical interventions and regarding the building user as relatively passive. Hence, the 'house' is skewed more to the right side of Fig. 1, whereas the 'home' approach favours the left side arguably to compensate for the positivist techno-economic dominance. The 'home research' broadly considers both social *and* physical aspects of demand and may stress the importance of social intervention strategies and building users as active because it is overlooked in the mainstream house approach. An interpretivist approach, which tends towards evaluating occupant satisfaction as complex and contextual, is more theoretically and methodologically suited to this line of enquiry.

Fig. 1 is an heuristic device to explore the theoretical and methodological assumptions of investigating the 'house' compared to the 'home', ultimately the distinction between the two hinges on whether a domestic energy researcher considers both social *and* physical aspects of demand. Importantly, and to re-iterate, our distinction is not made to declare one approach unnecessary; studies of the house (e.g. improvements in efficiency and design) are an important part of delivering high quality, affordable, and sustainable homes *but* this approach is not sufficient on its own [81]. Rather than focusing on improving the house the real challenge is to pursue understandings of domestic energy which combine both physical and social factors. In order to do this, a new research agenda is needed. The next section offers recommendations that clearly take home as the focus of analysis in domestic energy research.

5. Research agenda

After a preoccupation with the house and its physical components, and recognising that more attention is needed for social aspects (and the interaction between the two), we now offer three possible directions for future investigation which emerge from consideration of the axes in Fig. 1 – some of which are areas we are developing in our ongoing research on domestic energy.

5.1. Research approach and methodologies

Returning to our first axis on research approach, the dominance of the positivist 'house' approach means that there is an important opportunity for the development of innovative methodologies to capture both social and physical elements of domestic energy demand. For instance, in order to improve understanding of how occupants are influenced, and influence the physical make-up of their homes, data collection would benefit from taking place at participant's homes. House tours are not a new idea but there has been

little to no methodological reflection on employing this method for energy research (see Carpiano [82] on walking tours and Pink [83] on visual ethnographies for some related concepts). There are other methods which contribute to a more holistic understanding of home energy (e.g. life graphs, drawing ideal floor plan, talking about daily life instead of values) [51,84–86] or utilise other data sources that may offer insights into cultural conventions and how these are physically manifested (e.g. online discussions about heating and adaptation, customer review of products, Home Décor magazines) [42,87]. There are undoubtedly further areas of potential investigation, however the approach presented here suggests that the home is deserving of further research and development of methods appropriate to the task of studying home energy.

5.2. Perception of building users

The second axis highlights an opportunity to reflect on how building users are perceived and researched in the context of domestic energy. In particular, we suggest that a more robust investigation of building users would include consideration of the interaction between householders which has been overlooked by the dominance of house research. Primarily when households are researched, one member of the household acts as a representative. Yet it should not be a surprise to the readers of this paper to recognise that management of the home is generally the result of negotiation and compromise between household members (e.g. different preferences, ways of doing, and household hierarchy). While the suggestion that researchers need to pay more attention to processes of compromise and negotiation in order to gain a fuller understanding of how the household operates is nothing new [88,89] there is very little methodological reflection even within focus group and family studies to inform this sort of data collection [90,91]. Understanding these household dynamics is important to domestic energy research because it relates to how decisions that are of concern to energy researchers are agreed and carried out (e.g. when to turn the heating on or up, setting thermostats, or buying micro-generation technologies).

5.3. Intervention strategies and occupant satisfaction

We combine our final two axes because intervention strategies largely depend on how success is understood and gaged. If occupant satisfaction is not perceived to be universal or broken down into quantifiable segments, intervention strategies are unable to remain focused on the house and have to consider the implications of more complex understandings of occupant satisfaction or comfort. Research on home energy contributes to a growing body of literature that analyses energy consumption in the context of daily life and changing expectations in relation to different standards of living. Part of this is developing a greater understanding of comfort in terms of teasing out social expectations and adaptive strategies. While there is academic literature that explores how understandings of comfort have evolved and offers comfort as an explanatory variable for increasing energy consumption (e.g. [92]), we suggest that the idea of comfort would benefit from more empirical exploration (e.g. its meaning/experience to different groups and in different contexts/cultures). Empirical studies on home, home-making and comfort may be illuminating for developing energy reduction interventions because they offer insight into what shapes everyday practices and expectations which impact domestic energy demand. For example, there may be changing perceptions of comfort as new technologies become available and more common: more exposure to under-floor heating may lead some householders to move away from radiators which are common in the UK because warm feet are very important to their comfort and feeling 'at home'. These sorts of changes in comfort tastes have implications for the physical infrastructure of our homes, the indoor climate and also perceptions of homeliness and expectations of comfort. This type of shift has much less to do with efficiency or temperature of the room but the interaction between a specific technology and shifting comfort conventions. A better grasp on what comfort means to different groups and in different contexts is needed in order to track, explain and target escalating expectations [51,93] and develop effective intervention strategies.

6. Conclusions

This paper sought to offer a clearer foundation for the locus of domestic energy research. It is the contention of this paper that current failures in reduction of domestic energy is indicative of a research and policy focus on improving energy efficiency in the house, which does not support a full understanding of what drives energy demand. Despite several decades of a dominance of research on the house, these methods have failed to adequately explain variation across populations and reduce energy demand, making the utility of studying the interaction between social and physical elements of the home increasingly apparent. Although many research studies have argued that techno-economic thinking dominates energy scholarship, we argue this has, in part, arisen because of a lack of clarity about the difference between house and home. By exploring the 'doing' of domestic energy research, we have demonstrated that the house and the home are distinct units of analysis attached to different research approaches and assumptions, different perceptions of householders and strategies of intervention, as well as different understandings of occupant satisfaction. We have thus argued that the broader scholarship on the home brings interesting insights and discussions and may enable others to enhance understandings of domestic energy demand. For instance, an acknowledged difference between house and home, the multidimensional meanings of home and home-as-ideal, may be useful to pursue since these may influence energy demand. The depth of scholarship on the concept of home, as compared to the house, is significant for domestic energy because it helps researchers understand the complex social expectations (beyond control of temperature, air quality and lighting for instance) that are attached to everyday activities and to what energy is used for. Therefore, we conclude that the home should be prioritised as the basic locus of analysis in domestic energy research, or at the very least the importance of home should not be ignored or underestimated.

Many of the publications in *Energy Research and Social Science*, to date, contribute broadly to this 'home' approach to energy research because as Stern [94: 41] suggests this journal provides a space for "an integrated, trans-disciplinary science of human–energy interactions". Indeed, the papers focused on domestic energy by Royston [87] and Wallenborn and Wilhite [65] already adopt 'home' as their focus exploring both social and physical elements of energy demand. However, some contributors to the journal went arguably too far away from considering the 'house' and have forgotten to consider physical elements as well as social aspects which shape demand so are not adopting a 'home' approach because they are primarily concerned with occupants and behaviour [95–97]. The majority of contributions are not necessarily focused on domestic energy, but nonetheless similarly recognise that "good policy requires deliberation of the social dimensions of energy systems" [98: 107]. Both Ryan et al. [99] and Hirsh and Jones [98] offer excellent examples of the contributions (and challenges) of social scientists in energy research. Furthermore, Walker et al. [100: 1] provide an exemplar of how social scientists can offer new insights

and practical recommendations for topics generally addressed by natural and building scientists (i.e. spread of air-conditioning).

Given an appreciation that more attention is needed for socio-technical aspects of domestic energy demand, this paper offers some possible directions for future research. Firstly, there is a need for greater understanding of comfort in terms of teasing out social expectations and adaptive strategies, moving away from reliance on a universal standards or research concerned with comfort in relation to productivity. Secondly, we suggest that there is a need for research on negotiation between household members as the majority of energy research perceives households as homogenous and overlooks interaction that is part of home management. Thirdly, and to achieve this, it will be necessary to develop methodologies that can capture both physical and social aspects of daily life at home. It is clear that we need to home-in on domestic energy research.

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