Energy Research & Social Science 7 (2015) 12–22

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Original research article

Why do homeowners renovate energy efficiently? Contrasting perspectives and implications for policy

C. Wilson [a,*], L. Crane [a], G. Chryssochoidis [b]

[a] Tyndall Centre for Climate Change Research, University of East Anglia, Norwich NR4 7TJ, UK
[b] Norwich Business School, University of East Anglia, Norwich NR4 7TJ, UK

ARTICLE INFO

Article history:
Received 6 October 2014
Received in revised form 1 March 2015
Accepted 2 March 2015

Keywords:
Home
Renovation
Energy efficiency
Policy
Decision making

ABSTRACT

This paper contrasts two perspectives on energy efficient home renovations from applied behavioural research on energy efficiency and from sociological research on homes and domestic life. Applied behavioural research characterises drivers and barriers to cost-effective renovations, and identifies personal and contextual influences on homeowners' renovation decisions. Research findings inform policies to promote energy efficiency by removing barriers or strengthening decision influences. Sociological research on domestic life points to limitations in this understanding of renovation decision making that emphasises houses but not homes, energy efficiency but not home improvements, the one-off but not the everyday, and renovations but not renovating. The paper proposes a situated approach in response to this critique. A situated approach retains a focus on renovation decision making, but conceptualises decisions as processes that emerge from the conditions of everyday domestic life and are subject to different levels of influence. This situated approach is tractable for energy efficiency policy while recognising the ultimate influences that explain why homeowners decide to renovate.

1. Introduction

Efforts to promote energy efficiency in the home have waxed and waned over the decades since the oil shocks in the 1970s sharply increased the financial incentive for reducing energy use. Policy concerns about energy efficiency are again ascendant, spurred by climate mitigation and energy security goals. Renovating existing buildings to improve their efficiency is an important element of climate policy [1]. In the UK, for example, long-term emission-reduction targets imply "*one building would need to be retrofitted every minute for the next 40 years at an estimated cost of £85 billion for homes alone*" (p. 500, [2]).

The majority of homes are owner-occupied: 70% on average across the EU, and 67% in the US and the UK [3]. In owner-occupied homes, renovations are necessarily preceded by homeowners' decisions to renovate. Energy efficiency policy seeks to influence those decisions. As noted in a recent global review, "*retrofitting existing buildings is a discretionary investment . . . building owners . . . need to be persuaded not only of the merits of energy investment, but to finance it and bear whatever disruption it entails*" (p. 734, [4]).

Policies for encouraging and supporting energy efficient renovation decisions by homeowners are widespread. They include: energy audits and assessments; energy performance certificates or ratings at the point of sale; financial incentives and capital support including grants, subsidies, tax credits, low interest loans, and third party financing; certification and training of contractors; community or neighbourhood renovation schemes (collective procurement, support for vulnerable or low income households); marketing and information campaigns. Although they vary considerably in design and implementation, these types of policy characterise efforts to promote energy efficient renovation decisions in the UK [5], in the EU [6], in North America [7,8], in China [9], and in other markets worldwide [10,11].

The common premise of all such policies is that homeowners are motivated to renovate to save energy and money, but are prevented from doing so by capital constraints and uncertainties about energy savings, financial returns, and contractors' quality and reliability. This premise is supported by a large body of 'applied behavioural research on energy efficiency'. We use this label to characterise a body of research concerned foremost with empirical findings on behaviour and decision making, particularly in a domestic context, and with how these findings can be applied in policy or intervention design. Applied behavioural research on energy efficiency draws on microeconomics, social psychology and technology

* Corresponding author. Tel.: +44 01603 591386.
E-mail address: charlie.wilson@uea.ac.uk (C. Wilson).

http://dx.doi.org/10.1016/j.erss.2015.03.002

Box 1: Definitions and terms.
We use the term 'renovations' to mean major structural improvement work to a domestic property, i.e., "*substantive physical changes to a building*" (p. 499, [2]). Renovations have high time, cost, and skill requirements, and are typically carried out by professional contractors with appropriate technical expertise [17].
'Energy efficient renovations' typically involve changes or upgrades to the building envelope – windows, doors, cavity or loft insulation – or the heating and hot water systems [122]. In contrast, we use the term 'amenity renovations' to describe changes to kitchens, living areas, bathrooms, and so on. These are not primarily energy-related although may include some efficiency measures.

adoption research (e.g., [12,13]), as well as grey literature on consumer behaviour and marketing (e.g., [14]). It enshrines "*a more intense and narrower interest in instrumentally mobilizing people to achieve . . . energy use reduction*" (p. 33, [15]). This is in contrast to research that advances theory, engages with social or cultural issues such as status and power, or reflects critically on policy rationales and how research problems are framed [16].

Applied behavioural research on energy efficiency represents individual homeowners making reasoned decisions, subject to personal and contextual influences, in order to achieve certain outcomes which can be analysed in isolation from domestic life.

Maller and Horne [17] argue that this depiction of reasoned, goal-oriented and isolable decisions are part of a 'rationalisation discourse' in energy efficiency research that highlights individual choice and rationality. This fails to address "*the conventions and practices of households . . . which have remained largely in the shadows*" (p. 61, [17]). Several decades of sociological research into these conventions and practices have established a rich and compelling critique of applied behavioural research on energy efficiency (e.g., [18,19,20]). This critique rejects individuals and their cognitive or decision-making processes as the central objects of enquiry. It understands renovations through the lens of the routine, everyday, and socially shared practices that constitute life at home.

The aim of this paper is to show how situating applied behavioural research on energy efficiency within a broader conceptualisation of renovating, homes and households can enrich and strengthen an instrumental understanding of why homeowners decide to renovate energy efficiently. This in turn can broaden the evidence base for energy efficiency policy. By 'situated' we mean making descriptively realistic renovation decision processes endogenous to the dynamics of life at home.

The paper is structured in three parts. First, we synthesise the key approaches and findings of applied behavioural research relevant to energy efficient home renovations, and show how it informs energy efficiency policies. Second, we develop a systematic critique of this body of applied research along conceptual, empirical and methodological lines. Third, we set out a situated approach to renovation decision making that conceptualises renovation decisions as processes emerging from the conditions of everyday domestic life, subject to different levels of influence. We draw implications for energy efficiency policy from this situated approach. These include supporting efficiency measures as part of broader amenity home improvements. Box 1 defines key terms used throughout this paper.

Our paper contributes to this journal's engagement in ongoing debates about energy efficiency research and the effectiveness of policy. Stern [21] notes a specific lack of cross-disciplinary studies needed to explain the complexities of individual and household decision making processes related to energy. Lutzenhiser [16] goes further in characterising the "*singularly narrow theoretical and policy model of energy use and energy savings that governs energy efficiency activities*" (p. 141). He argues that this model or way of thinking is enshrined in an "*energy efficiency institutional complex*" that coordinates the actions of policymakers, utilities, and service providers, and squeezes out any receptiveness to critical social science. Moezzi and Janda [15] call for a scope of action on energy efficiency that moves beyond individual decisions and actions in the home and emphasises the social nature of energy use. Wallenborn and Wilhite [22] point to a different under-researched aspect of domestic energy use: its physicality. They argue that an emphasis on "*rational choice and methodological individualism*" (p. 58) for understanding energy consumption has ignored the importance of sensory and physical experiences, and the knowledge embodied in such experiences. Providing a specific example, Royston [23] focuses on how physically experiencing heat flows generates various forms of know-how or practical knowledge that conditions energy use in homes.

Improving thermal comfort is frequently cited by homeowners as a motivation for renovating, but applied behavioural research on energy efficiency pays scant attention to the physicality of domestic life and the mundane skills and competences used in heating homes. This shortcoming is picked up in the situated approach to renovation decisions proposed in this paper in an effort to show how social science research can explain how and why homeowners decide to renovate energy efficiently.

2. Applied behavioural research on energy efficiency

This section synthesises a large body of applied behavioural research on energy efficiency with relevance to home renovations. It sets up the dominant 'drivers and barriers' framing of renovation decision making, and shows how formal models of renovation decisions overwhelmingly emphasise financial attributes. It considers a range of personal and contextual influences on decisions, and gives examples of how research informs policy design.

2.1. Drivers, barriers, and the energy efficiency gap

Cost savings from efficiency improvements can provide short payback periods on capital invested [24,25], as well as a host of co-benefits such as improved thermal comfort, reduced draughts and condensation, and increased property value [26]. Consumer behaviour studies commonly find households report positive attitudes and strong intentions towards energy efficient renovations [27,28,14].

Yet installation rates of efficiency measures are stubbornly slower than instrumental drivers of renovation decisions would suggest. The 'energy efficiency gap' between technical and economic potential on the one hand, and actual market adoption on the other, has long been documented [29]. Explanations tend to invoke barriers to otherwise cost-effective technology adoption decisions: "*If there are profits to be made, why do markets not capture these potentials? Certain characteristics of markets, technologies and end-users can inhibit rational, energy-saving choices. . .*" (p. 418, [30]).

Commonly identified barriers to energy efficient renovations in owner-occupied homes relate to finances, information and decision making. Financial barriers include capital availability and strong aversion to delayed gains [31]. Information barriers include a perceived lack of credible and available information on efficiency measures [32], low salience or misperceptions of energy costs [33], and uncertainties about contractor reliability and cost-saving outcomes [34]. Decision-making barriers include the cognitive burden (or transaction costs) of making complex and irreversible decisions

[35], and the anticipated 'hassle factor' of having home life disrupted while the renovations take place [36]. These barriers are repeatedly emphasised in applied behavioural research on energy efficiency in the UK [24,25], in Europe [37], in the US [38], and globally [4].

2.2. Models of renovation decisions

Motivations (drivers) and constraints (barriers) are formalised in quantitative models of energy efficient renovation decisions. In particular, discrete choice models have been widely used to express households' preferences for the attributes of energy efficient renovations. As an example, Jaccard and Dennis [12] use a choice experiment on a sample of Canadian homeowners to elicit preferences for efficient or non-efficient home renovations. Each renovation alternative is described by four attributes (capital cost, annual heating costs, purchase subsidy, comfort level) which are varied over two to four levels (e.g., purchase subsidy could be either $0, $500, or $1500). The selection of attributes emphasises the overtly financial framing of the renovation decision. Only one of the four attributes is non-financial: 'comfort level' measured as 'high' or 'low' air quality.

Financial attributes are similarly dominant in the renovation decision models estimated by nine other studies using choice experiments. Specific renovation measures varied from insulation and draught-proofing to windows and heating systems across a range of national contexts: the UK [39,40,41], Switzerland [42], Germany [43], Finland [44], New Zealand [35], and Korea [45]. For a comparison of all the decision attributes used in these studies, see Table 2 in [46].

These renovation decision models (and microeconomic research more generally) are used to quantify the marginal effect of financial or other policy incentives [43,41], consumers' willingness-to-pay for efficiency measures [42,35], and implied rates of time preference or discount rates for future energy cost savings [12]. The application of these models thus further emphasises financial influences on energy efficient renovation decisions.

Another widely used analytical framework examines how innovations spread or 'diffuse' through a population of potential adopters who value certain attributes of innovations. Cost savings and thermal comfort associated with efficiency measures are an example of the 'relative advantage' attribute. Potential adopters of renewable heating systems in Germany reported convenience and comfort rather than cost as more influential sources of relative advantage [47]. But four other attributes are also important in diffusion research: compatibility, simplicity, observability and trialability [48]. Energy efficiency measures are only weakly observable and trialable as they have low visibility or visual salience, and are irreversible once installed [36,37].

Homeowner or household preferences for energy efficient renovations based on national surveys or market data can also be used to model renovation decisions. Such studies similarly focus on financial attributes of renovation decisions (e.g., [28]), but also include a wider range of explanatory or control variables. Poortinga et al. [49] controlled for socioeconomic variables and environmental attitudes in their conjoint analysis of UK household preferences for efficient heating systems and insulation measures. Jakob [50] and Grosche and Vance [51] tested the influence of household and property characteristics on the adoption of home efficiency measures in Switzerland and Germany respectively. Braun (2010) [121] similarly modelled heating system purchase decisions as a function of property and household characteristics, but included location and home tenure as controls. Michelsen and Madlener [52] include technology attributes as well as home and spatial characteristics in their modelling of renewable heating system choices in Germany.

The inclusion of these additional variables extends the scope of decision influences beyond a narrow set of financial attributes to include certain characteristics of renovation decision makers and certain features of the contexts in which decisions are made. These two categories of exogenous influence on the decision correspond to the distinction in social psychology between personal and contextual influences [53].

2.3. Personal and contextual influences

Variables describing personal influences include attitudes towards energy use or efficiency, and beliefs about the impact of energy use on the environment [53]. These are expressed towards energy efficient renovations or energy-environment linkages more generally, rather than towards homes or domestic life (e.g., [54]). Diffusion researchers highlight the importance of households' social communication behaviour as a particular type of personal influence [48]. Exchanging information on energy through social interactions helps explain households' propensities to renovate [55]. Information sought through personal contacts in social networks is more influential than expert advice or energy audits, increasing the likelihood of adopting efficiency measures by a factor of four [56].

Variables describing contextual influences can be grouped into four main types: household characteristics (size, lifecycle, socio-demographics), home tenure (ownership, duration), property characteristics (size, age, type), and policy inducements to improve the financial outcomes of renovating (incentives, subsidies).

A fifth type of contextual influence on renovation decisions emphasised more recently in applied behavioural research on energy efficiency relates to salient events (e.g., a boiler breaking down) or periods of transition in the household lifecycle (e.g., moving house, retiring, having a child) [57,58,41]. Salient events can serve as 'trigger points' for energy efficient renovations [28] or home improvements more generally [24,25]. Using UK panel data, Coulter et al. [59] found decisions about moving home could similarly be externally triggered, as well as gradually reinforced over a period of time by both expectations (being able to move) and desires (wanting to move due to dissatisfactions with home or neighbourhood).

2.4. Applied behavioural research and energy efficiency policy

Table 1 summarises the full scope of renovation decision influences identified in applied behavioural research on energy efficiency.

The decision influences summarised in Table 1 are of direct relevance for energy efficiency policy. Policies are designed to reinforce drivers, lower barriers, and support positive influences (Table 10.20 in [4]).

Policies to lower financial barriers include grants, subsidies, low interest loans, and third party financing. In the UK, the Green Deal offers third party financing to be repaid through a charge on electricity bills [60]. In Germany, low interest loans are available for renovations that improve energy performance 30% more than the legal minimum [61]. In the US, there are more than 30 different on-bill financing programmes [38], as well as many different kinds of federal and state-level grants and subsidies [62].

Policies to lower information barriers include home energy audits, assessments, and certificates [63,64], contractor training, skills development, and quality assurance [34], better estimates

Table 1
Influences on homeowners' renovation decisions in applied behavioural research on energy efficiency.

		Commonly identified	Occasionally identified
Drivers (also: motivations)		Cost savings Thermal comfort Environmental benefits	Draughts, condensation, air quality, health Property value Aesthetics, appearance
Barriers (also: constraints)	Finances	Capital availability, interest rates Delayed gains	Irreversibility
	Information	Uncertain cost savings Contractor reliability & quality	Uncertain comfort or health outcomes Low salience of energy, misperceptions of energy use
	Decision making	Disruption, hassle	Cognitive burden, transaction costs, information search costs
Attributes of efficiency renovations	Technical	Energy savings	Complexity
	Financial	Capital cost, cost savings, payback period Relative advantage	Financing mechanisms
	Other	Comfort	Compatibility, observability, trialability
Personal influences	Information & awareness	Expert advice or recommendations, energy audits or assessments Expected cost savings	Availability and credibility of information sources Peer (interpersonal) advice, communication Behaviour, social learning
	Attitudes & beliefs	Beliefs and understanding of energy-environment issues Attitudes towards specific energy-environment issues	Future energy prices Implicit rates of time preference Attitudes towards renovating and homes
	Experience, skills		DIY, technical skills, know-how Past experience with renovating or efficiency measures
Contextual influences	Household characteristics	Size, composition, lifecycle (e.g., number of children)	Gender, decision making roles Routines, habits Room occupancy profiles
	Socio-demographics	Age, education, income, employment	Location (e.g., urban–rural)
	Home tenure	Status (own, mortgage)	Duration (current, expected)
	Property characteristics	Size, age heating system, insulation	Number of different types of room Infrastructure availability (e.g., gas network)
	Salient events	Moving home	Triggers or disruptions to routine (e.g., boiler breaking down, tenants moving in or out)
	Policy incentives	Amount	Ease of access, timing, salience

Table references: see text for details, and: [49,119,50,36,120,27,51,28,121,32], [24], [54], [57], [58], [14,13,47,21].

of the multiple benefits of renovating [26], and real-time energy feedback [65].

Policies to lower decision-making barriers include the use of trigger points to implement efficiency measures [28], one-stop shops for home renovations [35], and loft clearance schemes as part of a whole home renovation service [31]. For a full set of barriers and related policies, see Table 1 in [46].

The drivers and barriers in Table 1 cross cut through the attributes of, and influences on, renovation decisions. Many barrier-removal policies are also designed to support positive decision influences. Home energy assessments and expert advice reduce the uncertainty of expected cost savings and reinforce positive attitudes towards energy saving outcomes. Quality assurance and certification schemes improve trust in contractors. Grants and low cost loans increase expected financial returns.

Energy efficiency policies also use household and property characteristics to identify market segments with a high propensity to renovate or with particular needs or vulnerabilities. As examples, buying a home as a salient event is targeted by energy performance certificates, and financial incentives or support are directed towards old 'hard-to-treat' properties or low income neighbourhoods.

Attractive attributes of renovation measures can also be reinforced by policies. Examples include comparative billing to increase the 'observability' of household energy consumption [66], energy service companies to manage the 'complexity' and cognitive burden of renovation decisions [67], and neighbourhood and community programmes, as well as open house schemes, to support social communication on energy efficiency [68].

These examples show how applied behavioural research on energy efficiency offers a clear analytical framework for understanding homeowners' renovation decisions and designing financial and information-based policies to remove barriers and strengthen positive influences. But this tractable route from applied research into policymaking has its detractors.

3. Limitations of applied behavioural research on energy efficiency

A fundamental critique of applied behavioural research on energy efficiency is that it misdiagnoses the problem. Shove [18] argued that a 'drivers and barriers' framing reduces social science to explaining and filling the energy efficiency gap identified by technical analysis under assumptions of psychologically motivated individual decision makers. Applied behavioural research on energy efficiency enshrines this limited gap-filling role [69,70]. Its scope of enquiry is limited to decision makers not differentiated households, energy efficiency not amenity renovations, the extra-ordinary not the everyday, renovations not renovating, and houses not homes.

This critique draws mainly on sociological research on everyday life and social practices. A common observation relevant to both fields is that individuals do not consume energy. Rather, energy

provides useful services that enable normal and socially acceptable activities to be carried out as part of domestic life. For decades, this has been a 'blind spot' in energy efficiency research and policy [71,72]. It is the 'doings' or activities of everyday life that have consequences for energy and material consumption [73]. Most energy-intensive activities in homes are quite mundane: heating rooms, heating water for washing, running appliances to freeze food or dry clothes. Comfort, convenience, and cleanliness have become normalised expectations embedded in such activities, with significant consequences for energy use [74].

Walker [75] explain "*how the use of energy is an 'ingredient' of the doing or performing of social practices*" (p. 49). Social practices are bundles of 'sayings and doings' that are enacted or performed and so reproduced through time and space, as well as socially [76]. Practices such as cooking, washing, or DIY (do-it-yourself), are the relevant objects of enquiry in this line of research; people are 'recruited' by such practices as part of their reproduction. Shove and Pantzar [77] argued that practices are constituted by three elements and their inter-relationships. These three elements are competences, meanings, and products. Gram-Hanssen [76] included institutionalised knowledge and explicit rules as a fourth element of practice. These elements of practice have been applied in empirical studies of renovating and how it intersects with everyday life at home [78,79,80]. Judson and Maller [81], for example, find that energy efficient aspects of renovation are considered by households in relation to other practices performed in daily routines, such as dining, socialising and entertaining.

We build on these insights into everyday life, practices, and homes to argue that applied behavioural research on energy efficiency has five conceptual and empirical limitations. We also include two methodological limitations related to framing and sampling bias.

3.1. Limitations (1): priming biases and financial variables

Research designs in applied behavioural research on energy efficiency that frame the problem in terms of 'drivers and barriers' strongly prime attention to the financial characteristics of renovations. Closed-ended survey methods invariably solicit perceptions or understandings of cost, cost savings, energy prices, payback periods and rates of time preference [54,57,58,14]. Directly asking about specific barriers strongly increases the likelihood that these barriers will be identified as influential.

Open-ended research helps draw out a much wider set of considerations in renovation decisions (e.g., [28,37]). But qualitative factors are often then lost in quantitative decision models or reduced to terms shorn of meaning and context, as in the use of air quality as a measure of comfort [12].

As a further example, the importance of building appearance or home aesthetics as influences on renovation decisions has been found in studies designed to test for it [82,83]. Yet aesthetics are infrequently included in closed-ended research instruments. In their extensive review of energy-related behaviours, Whitmarsh et al. [13] conclude: "When people refurbish their homes they invariably want to *see* the results of their *investments*" (p. 105, *our emphasis*). Even here though, renovations are still framed as investments and so overtly financial.

3.2. Limitations (2): sampling biases and decisions as events

Applied behavioural research on energy efficiency represents renovation decisions statically as a discrete event or point in time with a characteristic set of influences (see Table 1). Treating decisions as singular moments, undertaken by an individual or discrete set of actors, is also common in research on homes and housing more generally [84,85].

Energy efficient renovation decisions are often protracted [86]. Renovations are more commonly a periodic or ongoing feature of domestic life rather than a one-off event [87]. Decision influences and perceived barriers change as renovation intentions strengthen and are ultimately realised [82]. This means that survey or interview research findings will be influenced by *when* during the decision process households are sampled, particularly when comparing pre-renovation expectations with post-renovation experiences [88]. As an example, homeowners are more likely to cite building appearance as an important motivation prior to renovating, but retrospectively emphasise thermal comfort and energy savings [83]. Renovation decisions have a tendency to be rationalised after the fact (see [89] for a broader discussion of post hoc rationalisation).

Sampling design therefore influences research findings. Applied behavioural research that draws on self-selecting samples of would-be renovators or successfully completed renovators is particularly susceptible to bias (e.g., [90,34]). This includes studies of households participating in incentivised renovation programmes or policy trials (e.g., [91,47]). Including a 'control group' of non-renovators for comparison is a simple methodological remedy yet is uncommon in research designs.

3.3. Limitations (3): decision makers or individuals not households

The household has been recognised as an important scale of enquiry for examining environmental behaviour [92] and, more broadly, the transformation of cities and the built environment [93]. Observed renovation behaviour in markets, field trials, or intervention studies directly measures household-level decision outcomes. As the subjects of a decision process, households are seen as functional, operational units [94]. The UK Government's statistical service defines a household primarily as a bounded physical construction: "*one person living alone or a group of people (not necessarily related) living at the same address who share cooking facilities and share a living room or sitting room or dining area*" [95].

Applied behavioural research on energy efficiency frequently uses the term 'household', but households are neither defined nor identified empirically in a consistent way [96]. Renovation decision makers subject to personal influences tend to be individuals, albeit in a household context (see Table 1). Self-report data from individual household members are commonly generalised to the household as a whole. Even approaches that explicitly characterise decision-making differences between households recognise that a household may itself comprise more than one type of decision maker with distinct goals and aspirations [97].

Decision making can be interpreted at the household level measured through proxy variables such as household lifecycle or size. The number, age, gender, income and relationships of household occupants can also be used to create meaningful socio-cultural units for analysis [98]. Applied behavioural research rarely accounts for the possibility of distinctive households nor differentiated roles within the household [99].

3.4. Limitations (4): efficiency measures not home improvements

Applied behavioural research on energy efficiency generally excludes amenity renovations (e.g., kitchens, bathrooms) and other types of home improvement including DIY that may be carried out together with efficiency measures. Energy efficient renovation decisions are treated as distinctive, with their own characteristic set of drivers, barriers and influences (Table 1), and unrelated

to other decisions households might make with respect to their homes.

Yet seeing efficiency renovations as distinctive serves to decontextualize them. In the UK, efficiency measures are three times more likely to be included as part of broader amenity-based home improvement projects than considered alone; only one in ten would-be renovators are considering only efficiency measures [86]. In the US, renovation expenditure on amenity features of the home, particularly kitchens, is over five times that spent on energy-related measures [100]. Judson and Maller [81] found that efficiency measures in one part of the home often went hand-in-hand with expansions or intensifications of other parts of the home (e.g., additional bathrooms). Mainstream marketing messages on home renovations promote amenity not efficiency measures [101].

3.5. Limitations (5): extra-ordinary events not everyday domestic life

Analysing efficiency renovations as one-off, extra-ordinary events detaches decisions from everyday domestic life and weakens links to households' lived experience (p. 217, [72]). Thermally insulated walls and windows, and efficient heating systems, provide a range of useful services that enable everyday activities to be carried out in the home. Households' needs and expectations for these services evolve. Moving home is one way of adapting homes to households' evolving needs [59]. Renovating energy efficiently is another way.

Consequently, renovation decisions need to be understood "*in the context of the relations between everyday practices and the environments within which these practices unfold*" (p. 2802, [85]). Features of these decision environments, such as household and property characteristics, should not be treated as exogenous influences on renovation decisions but part of them. Renovation activity is situated in the home; decisions to renovate unfold as part of life at home [102]. The ultimate reasons why people might decide to redesign or structurally change a particular part of their domestic environment lies in these conditions of everyday domestic life. Energy efficient renovations are "*not an activity of changing a house . . . from poor energy performance to exceptional energy performance, but an intervention into the rhythms of domestic habitation*." (p. 569, [78]). These rhythms of domestic habitation are not adequately captured by the decision influences shown in Table 1.

3.6. Limitations (6): renovations not renovating

Energy efficient renovations support policy objectives to reduce household energy use and its adverse consequences. Homeowners' renovation decisions are the necessary precursor to the installation of efficiency measures, and so are of interest to applied behavioural researchers. This instrumental emphasis on cognition and physical change glosses over important relationships between the objects, skills and actions of renovating.

Renovation measures – energy efficient or otherwise – are objects that facilitate and constitute particular ways of living [103]. Kitchen renovations that result in 'having' a new kitchen are part of the shifting materiality of the kitchen space with its changed cupboards, sink and spice racks [104]. DIY (do-it-yourself) activities are an integral part of renovation processes, and clearly involve skills as well as objects. Even mundane objects such as a hammer enable particular 'doings' when used by a skilled practitioner [105]. Without object, skill, and practitioner, there would be no renovation activity.

Examining objects and skills in motion – the 'havings' and 'doings' of renovating households – diffuses a narrow focus on the specifics of renovat*ions* into an exploration of renovat*ing* as an everyday, even routine activity [103]. Renovating can thus be understood as a social practice constituted by four elements: skills, materials, rules, and shared understandings [76,81]. These elements interact through the reproduction of renovating as practice. Home improvement activities to change the structural features of a home involve skills and objects in processes of replication, continuation, and alteration – what's been done before, how that is ongoing, and how that is tinkered with or adapted [106]. Through this lens, discrete renovat*ions* need to be examined as part of renovat*ing*.

3.7. Limitations (7): houses not homes

Applied behavioural research on energy efficiency emphasises physical and structural changes to the fabric or energy systems of a property, house or dwelling. But the notion of 'home' extends far beyond the physicality of the house. House and household are certainly components of home, but so too are more complex social and emotional relationships [107]. Homes are both a physical space and an imaginary place which is not a static construct or representation but a dynamic expression of household members' feeling towards it (p. 230, [108]).

Household members ascribe meanings to their homes when thinking through changes made to the physical house. Aune [109] identifies three clusters of meaning relevant to energy efficient renovations: 'home as a project'; 'home as a haven'; and 'home as an arena for activities'. These various meanings are neither exclusive nor fixed. Rather they emphasise how households' emotional and symbolic connections with their homes impact on their expectations of comfort and associated homemaking activities.

The home is not therefore a neutral backdrop against which the enactment of domestic life can be examined. Spaces in the home like the kitchen, which are a locus or focus of household activity, can be strongly differentiated, associated with different meanings and roles by different household members [110]. Household typically defines the number and type of people in the physically bounded space, but home is a broader term that also describes emotional and social connections with its differentiated places.

4. Situating renovation decisions within domestic life

In summary, applied behavioural research on energy efficient renovations, which supports and informs energy efficiency policy, is limited by its interest in:

i. *renovation decisions*, but not the processes preceding them nor the domestic context from which they emerge;
ii. *financial drivers and barriers*, but not other salient attributes of home renovations;
iii. *energy efficiency measures*, but not other types of amenity renovation and improvements to the home;
iv. *households as discrete units of measurement and function*, but not differentiated entities with multiple decision makers;
v. *houses as physical structures*, but not homes with different spaces imbued with meaning and emotional significance; and
vi. *renovations as physical changes*, but not as enactments of renovating, an everyday activity involving objects, skills, and shared understandings.

These limitations of applied behavioural research on energy efficiency result in a narrowly defined problem and so a restricted set of explanations and influences for energy efficiency policy to act on (see Table 1). Yet an explicit representation of renovation decisions

is important because they are the direct antecedent to efficiency improvements in owner-occupied homes.

Situating an applied understanding of renovation decisions within a broader conceptualisation of homes, households and domestic life would help address some of the limitations of applied behavioural research while retaining its tractability.

A situated approach to renovation decision making has three key features. First, renovation decisions are processes. Second, these decision processes emerge from, and take place within, the conditions of everyday domestic life. Third, influences on renovation decision processes vary in their immediacy.

Situating decision processes within the conditions of domestic life emphasises the ultimate influences that originate and shape the decision process in its entirety. Guy and Shove [19] argue that "*more or less energy efficient choices are made in response to changing opportunities and pressures . . . knowledgeable actors creatively adopt and adapt strategies and practices that suit their changing circumstances*" (p. 133). Renovating is a way for households to resolve pressures, tensions or imbalances as well as to seize opportunities, pursue goals, or follow aspirations. Certain conditions of domestic life describe these deeper antecedents to isolable renovation decisions. As examples, renovation decisions may originate: (1) in household members' competing needs for the use of different spaces within the home; (2) in current or anticipated difficulties in the physicality of life at home; (3) in a mismatch between the meaning of a home for its inhabitants and the social identity conveyed by the house's arrangement and design. Deciding to renovate is rooted in, and endogenous to, such conditions of domestic life.

A situated approach thus retains renovation decisions as the central object of enquiry, but makes an important distinction between exogenous, isolable influences (both personal and contextual) from those influences which are deeper, constitutive elements of renovating.

This distinction helps navigate between the polarised perspectives of applied behavioural research on energy efficiency and its sociological critique. The former is more focused on immediate and proximate influences, the latter on ultimate influences (though neither exclusively so). Distinguishing levels of influence and causation in this way is common in both behavioural and sociological research (see Box 2).

For energy efficient renovation decisions, proximate influences explain what renovation decisions are made and how (e.g., with what products, at what cost, with which contractor). Ultimate influences explain why homeowners are deciding about renovating in the first place. Proximate influences act on renovation intentions once formed; ultimate influences explain the initial formation of intentions.

A boiler breakdown is an example of a proximate influence on a renovation decision. The recommended models and costs of replacement boilers offered by an emergency callout contractor are corresponding examples of immediate influences. The role of the boiler in providing thermal comfort, differentiating the use of rooms and spaces, and enabling patterns of social activity in the home, are all examples of ultimate influences.

Table 2 provides further illustrative examples of immediate, proximate, and ultimate influences on renovation decisions. The upper rows draw on applied behavioural research on energy efficiency (Section 2) and more strongly characterise immediate and proximate influences (though not exclusively so). Drivers and barriers from Table 1 are related to the attributes, personal influences and contextual influences shown in Table 2. Taking 'Personal Influences' as an example, energy-saving motivations influence the final selection of renovation products, and beliefs and awareness of environmental issues orients renovation decisions towards efficiency measures. But previous experiences, embedded in the skills and knowledge of householders, may increase the salience of efficiency renovations as a potential way to meet aspirational goals.

Box 2: Proximate and ultimate influences.

Proximate influences are closer to an observable outcome; immediate influences are closer still, e.g., at the point of decision. Ultimate influences characterise the underlying reasons why the outcome was observable.

The distinction between proximate and ultimate causation was first developed in evolutionary biology [123]. Ultimate causes explain observable behavioural traits in terms of evolutionary forces whereas proximate causes explain traits in terms of physiological or environmental conditions. Explanations of altruism, for example, draw on both proximate influences (e.g., empathy) and their deeper ultimate influences (e.g., kinship and natural selection) [124,125].

The same basic distinction between ultimate and proximate influences has been applied in psychology [126], public health [127] as well as sociology, albeit using different terminology. In sociology, proximal and distal causation distinguish individual-level or interpersonal influences on human behaviour from influences which are written in to the broader context in which behaviour is observed (e.g., [128]). Using a social practices perspective on renovating as an example, the ultimate (or distal) influences on renovation decisions are inscribed into the relationships between competences, meanings, products, and rules which constitute renovating practices.

The lower rows of Table 2 draw on the sociology of everyday domestic life (Section 3) and more strongly characterise ultimate influences (though not exclusively so). Taking 'Homes as Emotional and Social Places' as an example, renovating is an adaptive response to perceived misalignments between the physical characteristics of a house and the meanings of a home to its inhabitants. But these meanings may also be articulated in specific, measurable objectives for improving thermal comfort (shaping discussions over what to renovate) as well as in aesthetic criteria for selecting renovation products.

5. From research into energy efficiency policy

Ex post evaluations of energy efficiency policies tend to show very mixed evidence about their effectiveness [111]. Thirty years of experience in the US has provided only limited evidence that homeowners can be reliably motivated to renovate [62]. Energy saving potentials that have been touted for decades have not been delivered.

Financial incentives tend to be attractive to homeowners only once they are already committed to renovating [112,113]. Uptake of capital financing mechanisms is often low [38]. This has certainly been the case for the Green Deal scheme introduced recently in the UK. In the period January 2013 to October 2014, only 7200 households had third party financing plans offered or accepted, although 390,000 households had received a Green Deal energy assessment [114].

Energy assessments or audits do not necessarily lead to renovation decisions. Audit recommendations are often ignored as they mainly confirm what households already know, and homeowners consider their homes to be adequately efficient already [115,64]. Dropout rates from both audit and financing programmes can be high, even if financial incentives are sizeable [5].

Even in Germany, considered a market leader, a combination of regulation, subsidy programmes, and information instruments for motivating homeowners to renovate energy efficiently have delivered annual renovation rates that are only half those expected in

Table 2
Examples of immediate, proximate and ultimate influences on energy efficient renovation decisions.

	Immediate influences (informing or influencing point of decision – e.g., *which renovation products?*)	Proximate influences (strengthening or shaping decision intentions – e.g., *how and what to renovate?*)	Ultimate influences (originating or explaining emergence of decision process–e.g., *why renovate?*)
Attributes of efficiency renovations	Financing options	Energy savings	Experience of previously installed measures
Personal influences	Energy saving motivations	Awareness of energy/environment issues	Stage of life course
Contextual influences	Emergency repair	Age of property	Physicality of ageing
Differentiated households	Risk-aversion of financial decision maker	Competing opinions on preferred renovations	Roles and relationships within household dynamics
Amenity home improvements	Financing package	Contractor skill set and industry relationships	Conditions of domestic life creating tensions
Renovating and everyday domestic life	Renovation industry marketing and advertising	Habits and routines	Objects and skills used in DIY activities
Homes as emotional and social places	Aesthetics of renovation measures	Environmental and comfort objectives	Meanings of home

the absence of any policy [116]. "*A tremendous potential*" for energy savings in owner-occupied housing still remains (p. 406, [34]).

Decision influences identified by applied behavioural research provide the levers that energy efficiency policy seeks to push and pull. The understanding shared by policymakers and practitioners of how energy efficiency can and should be improved is deeply institutionalised, and continually reproduces similar portfolios of policies. One result is that "*residential energy efficiency policy discourse and supporting analysis must be conducted in a highly coded vocabulary . . . applied to energy consumers*" (p. 146, [16]). The decision influences summarised in Table 1 are all part of this vocabulary.

The limited effectiveness of energy efficiency policies can be explained in part by the methodological, conceptual and empirical limitations of supporting analysis. In particular, applied behavioural research on energy efficiency focuses on the proximate influences on renovation intentions, but largely fails to engage with the ultimate influences on renovation decisions which are situated in everyday domestic life.

As Gram-Hanssen [117] argues, what homeowners need is "*practical advice about retrofit options that relates to everyday life*" (p. 395). Judson and Maller [81] similarly conclude that "*policies to reduce the environmental impact of housing should be reframed around and positioned to address the mundane practices of everyday life*" (p. 501). But just how these arguments inform policy strategies is "*more difficult*", and requires an examination of people's life circumstances and sources of constraint and influence on energy consumption (Table 2 in [15]).

A situated approach to renovation decision making addresses this challenge by distinguishing ultimate influences, manifest in certain conditions of domestic life, from proximate influences on decision intentions once formed. Proximate influences still provide policy with potential levers to reinforce personal and contextual influences on decisions [34], and to lower the financial, information, and decision-making barriers to renovating [4].

But the ultimate influences on renovation decisions open up opportunities for creative policy approaches aimed at homeowners not considering energy efficient renovations, as well as those who already have renovation intentions. This can be illustrated by way of three recommendations for policymakers, renovation contractors, and researchers.

First, policy could support the 'bundling' of efficiency measures into other types of home renovation rather than try and stimulate efficiency-only renovations in a narrow market segment of committed efficiency renovators. This recognises that renovations are predominantly about adapting and improving the amenity features of a home [81,113].

Second, contractors could build and manage personal, trusted relationships over often lengthy time periods to support homeowners through periodic, successive, or ongoing renovations. Energy efficient renovations are rarely one-off [87], but the renovation industry still manages customer relationships on the basis of one-off sales and installations. Persistence and consistency are valuable, both by contractors towards homeowners, and by policymakers towards contractors [62].

Third, researchers could identify specific conditions of domestic life associated with renovation activity, both DIY as well as contractor-led. Examples of such conditions include competing commitments over the use of space at home, problems with the physicality of domestic life, or issues with how homes reflect or express identity. If these or other conditions are observable by proxy, they could be used to evaluate homeowners' renovation propensities, identify market segments of potential renovators, and develop analytical models that include ultimate influences on renovation decisions.

6. Conclusions

The widespread diffusion of energy efficiency measures through the existing housing stock is an important public policy objective. A wealth of policies, regulations, incentives, and other interventions have been introduced to stimulate and support this diffusion over the past four decades [118,78]. Yet despite all these inducements, instructions, prompts and prods, homeowners remain stubbornly resistant to improving their homes' energy efficiency by making structural changes to their heating systems, walls, windows, doors, lofts and basements.

The aim of this paper was to show how the body of research on which energy efficiency policies are based can be situated within a broader conceptualisation of renovating and domestic life. This strengthens understanding of the ultimate reasons why homeowners decide to renovate energy efficiently.

Applied behavioural research into energy efficient renovations understands renovation decisions in terms of drivers and barriers. A range of personal and contextual variables explain why homeowners may be motivated to renovate and why these motivations may be thwarted. Each explanatory variable presents a lever or opportunity for policy to exert influence.

Although applied behavioural research on energy efficiency speaks directly to policy concerns, it also has limitations. Methodological limitations include a reliance on stated preference data drawn from potentially biased samples and a strongly financial framing of renovation decisions. These limitations can be

addressed through research designs that include control groups of non-renovators, that sample renovators at different stages of the renovation decision process, and that use open-ended methods to inform a less constrictive scope of closed-ended questions for studies with larger sample sizes.

Conceptual and empirical limitations of applied behavioural research on energy efficiency are all associated with an overly narrow problem definition or scope of enquiry. Energy efficient renovations are implicitly conceptualised as a distinctive type of physical change made to houses as the outcome of a decision by a unitary household decision maker. This conceptualisation is challenged by sociological research into everyday life at home. From this perspective, energy efficient renovations are not inherently distinctive nor unique, and should not be partitioned off from other types of home improvement, large or small, with which households are continually engaging as part of the restlessness and motion of domestic life. Nor should the physical structure of houses be shorn away from the strongly social, symbolic and emotional connections of homes, as ultimately it is these homes that are being changed.

Situating energy efficient renovations within a broader understanding of why homeowners decide to renovate their homes means moving beyond immediate and proximate influences to the deeper, ultimate influences that explain the emergence of renovation decisions. Distinguishing these levels of causation allows for both applied behavioural research on energy efficiency and sociological research on domestic life to be drawn on by policymakers and practitioners concerned with energy efficient renovations.

Acknowledgements

Chris Foulds, Tom Hargreaves, Dana Abi Ghanem, and three anonymous reviewers all provided helpful comments on earlier drafts of this manuscript. This work was funded by the UK Energy Research Centre (UKERC) through Grant NE/J006017/1. Full details of the project are available at www.tyndall.ac.uk/renovation-decisions.

References

[1] Lucon O, Ürge-Vorsatz D, Ahmed AZ, Akbari H, Bertoldi P, Cabeza LF, et al. Buildings. Working Group III contribution to the IPCC 5th assessment report, climate change 2014: mitigation of climate change. Cambridge, UK/New York, NY, USA: Cambridge University Press; 2014 [Chapter 9].
[2] Dixon T, Eames M. Scaling up: the challenges of urban retrofit. Build Res Inf 2013;41(5):499–503.
[3] Eurostat. Distribution of population by tenure status; 2012 [accessed 19.11.14].
[4] Ürge-Vorsatz D, Eyre N, Graham P, Harvey D, Hertwich E, Jiang Y, et al. Energy end-use: buildings. Global energy assessment. Cambridge, UK: Cambridge University Press; 2012.
[5] Dowson M, Poole A, Harrison D, Susman G. Domestic UK retrofit challenge: barriers, incentives and current performance leading into the Green Deal. Energy Policy 2012;50:294–305.
[6] Grubb M. Tried and tested: four decades of energy efficiency policy. In: Grubb M, Hourcade J-C, Neuhoff K, editors. Planetary economics: energy, climate change and the three domains of sustainable development. London, UK: Earthscan; 2014.
[7] Dixon RK, McGowan E, Onysko G, Scheer RM. US energy conservation and efficiency policies: challenges and opportunities. Energy Policy 2010;38(11):6398–408.
[8] Hoicka CE, Parker P, Andrey J. Residential energy efficiency retrofits: how program design affects participation and outcomes. Energy Policy 2014;65:594–607.
[9] Zhou N, Levine MD, Price L. Overview of current energy-efficiency policies in China. Energy Policy 2010;38(11):6439–52.
[10] IEA. Promoting energy efficiency investments: case studies in the residential sector. Paris, France: International Energy Agency; 2008.
[11] IEA. Energy efficiency market report: market trends & medium-term prospects. Paris, France: International Energy Agency; 2013.
[12] Jaccard M, Dennis M. Estimating home energy decision parameters for a hybrid energy-economy policy model. Environ Model Assess 2006;11(2):91–100.
[13] Whitmarsh L, Upham P, Poortinga W, McLachlan C, Darnton A, Devine-Wright P, et al. Public attitudes, understanding, and engagement in relation to low-carbon energy: a selective review of academic and non-academic literatures. London, UK: Research Councils UK (RCUK); 2011.
[14] GfK. Survey of potential consumer demand for the Green Deal. London, UK: GfK NOP; 2011.
[15] Moezzi M, Janda KB. From "if only" to "social potential" in schemes to reduce building energy use. Energy Res Soc Sci 2014;1:30–40.
[16] Lutzenhiser L. Through the energy efficiency looking glass. Energy Res Soc Sci 2014;1:141–51.
[17] Maller CJ, Horne RE. Living lightly: how does climate change feature in residential home improvements and what are the implications for policy? Urban Policy Res 2011;29(1):59–72.
[18] Shove E. Gaps, barriers and conceptual chasms: theories of technology transfer and energy in buildings. Energy Policy 1998;26(15):1105–12.
[19] Guy S, Shove E. The sociology of energy, buildings and the environment: constructing knowledge, designing practice. Oxford, UK: Psychology Press; 2000.
[20] Strengers Y, Nicholls L, Maller C. Curious energy consumers: humans and nonhumans in assemblages of household practice. J Consum Cult 2015, http://dx.doi.org/10.1177/1469540514536194 [prepublished May 26].
[21] Stern PC. Individual and household interactions with energy systems: toward integrated understanding. Energy Res Soc Sci 2014;1:41–8.
[22] Wallenborn G, Wilhite H. Rethinking embodied knowledge and household consumption. Energy Res Soc Sci 2014;1:56–64.
[23] Royston S. Dragon-breath and snow-melt: know-how, experience and heat flows in the home. Energy Res Soc Sci 2014;2:148–58.
[24] EST. At home with energy: a selection of insights into domestic energy use across the UK. London, UK: Energy Saving Trust; 2010.
[25] EST. Trigger points: a convenient truth – promoting energy efficiency in the home. London, UK: Energy Saving Trust; 2010.
[26] Jakob M. Marginal costs and co-benefits of energy efficiency investments: the case of the Swiss residential sector. Energy Policy 2006;34:172–87.
[27] DEFRA. Attitudes & behaviours towards the environment. London, UK: Department for Environment, Food and Rural Affairs; 2009.
[28] Skelton B, Fernandez D, Fitzgibbons A. Energy saving trust green finance uptake. Final debrief. London, UK: Quadrangle & Energy Savings Trust (EST); 2009.
[29] Jaffe AB, Stavins RN. The energy efficiency gap: what does it mean? Energy Policy 1994;22(10):804–10.
[30] Levine M, Ürge-Vorsatz D., Blok K., Geng L., Harvey D., Lang S., et al. In: Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA, editors. Residential and commercial buildings. Climate change 2007: Mitigation. Contribution of Working Group III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge, UK/New York, USA: Cambridge University Press; 2007.
[31] Cabinet_Office. Behaviour change and energy use. London, UK: Cabinet Office: Behavioural Insights Team; 2011.
[32] COI. Insight and strategy for motivating take-up of home insulation measures. Final report. London, UK: Central Office of Information (COI) and Department for Environment, Food, and Rural Affairs (DEFRA); 2010.
[33] Sanstad AH, Howarth RB. Consumer rationality and energy efficiency. ACEEE Summer Study on Energy Efficiency. Asilomar, CA: The American Council for an Energy-Efficient Economy (ACEEE); 1994.
[34] Weiss J, Dunkelberg E, Vogelpohl T. Improving policy instruments to better tap into homeowner refurbishment potential: lessons learned from a case study in Germany. Energy Policy 2012;44:406–15.
[35] Phillips Y. Landlords versus tenants: information asymmetry and mismatched preferences for home energy efficiency. Energy Policy 2012;45:112–21.
[36] Roy R, Caird S, Potter S. In: Murphy J, editor. People centred eco-design: consumer adoption of low and zero carbon products and systems. Governing technology for sustainability. London, UK: Earthscan; 2007. p. 41–62.
[37] Emmert S, van de Lindt M, Luiten H. BarEnergy. Barriers to change in energy behaviour among end consumers and households. Integration of three empirical studies. Delft, The Netherlands: The Netherlands Organisation for Applied Scientific Research (TNO); 2010.
[38] Bell CJ, Nadel S, Hayes S. On-bill financing for energy efficiency improvements: a review of current program challenges, opportunities, and best practices. Washington, DC: American Council for an Energy Efficient Economy (ACEEE); 2011.
[39] Oxera. Policies for energy efficiency in the UK Household Sector. Oxford, UK: Oxera Consulting Ltd; 2006.
[40] Scarpa R, Willis K. Willingness-to-pay for renewable energy: primary and discretionary choice of British households' for micro-generation technologies. Energy Econ 2010;32(1):129–36.
[41] Element_Energy. Green deal household model assumptions. Cambridge, UK: Element Energy; 2011.
[42] Banfi S, Farsi M, Filippini M, Jakob M. Willingness to pay for energy-saving measures in residential buildings. Energy Econ 2008;30(2):503–16.
[43] Achtnicht M. Do environmental benefits matter? Evidence from a choice experiment among house owners in Germany. Ecol Econ 2011;70(11):2191–200.

[44] Rouvinen S, Matero J. Stated preferences of Finnish private homeowners for residential heating systems: a discrete choice experiment. Biomass Bioenergy 2013;57:22–32.
[45] Kwak S-Y, Yoo S-H, Kwak S-J. Valuing energy-saving measures in residential buildings: a choice experiment study. Energy Policy 2010;38(1):673–7.
[46] Wilson C, Crane L, Chryssochoidis G. Why do people decide to renovate their homes to improve energy efficiency? Norwich, UK: Tyndall Centre for Climate Change Research; 2014.
[47] Michelsen CC, Madlener R. Motivational factors influencing the homeowners' decisions between residential heating systems: an empirical analysis for Germany. Energy Policy 2013;57:221–33.
[48] Rogers EM. Diffusion of innovations. New York: Free Press; 2003.
[49] Poortinga W, Steg L, Vlek C, Wiersma G. Household preferences for energy-saving measures: a conjoint analysis. J Econ Psychol 2003;24:49–64.
[50] Jakob M. The drivers of and barriers to energy efficiency in renovation decisions of single-family home-owners. Zurich, Switzerland: Centre for Energy Policy & Economics (CEPE); 2007.
[51] Grosche P, Vance C. Willingness to pay for energy conservation and free-ridership on subsidization: evidence from Germany. Energy J 2009;30(2):135–53.
[52] Michelsen CC, Madlener R. Homeowners' preferences for adopting innovative residential heating systems: a discrete choice analysis for Germany. Energy Econ 2012;34(5):1271–83.
[53] Stern PC. Towards a coherent theory of environmentally significant behavior. J Soc Issues 2000;56(3):523–30.
[54] Nair G, Gustavsson L, Mahapatra K. Factors influencing energy efficiency investments in existing Swedish residential buildings. Energy Policy 2010;38(6):2956–63.
[55] Southwell BG, Murphy J. Weatherization behavior and social context: the influences of factual knowledge and social interaction. Energy Res Soc Sci 2014;2:59–65.
[56] McMichael M, Shipworth D. The value of social networks in the diffusion of energy-efficiency innovations in UK households. Energy Policy 2013;53:159–68.
[57] DECC. Consumer needs and wants for the Green Deal: researching the consumer response to the Green Deal proposition amongst homeowners and small businesses. London, UK: Department of Energy and Climate Change (DECC); 2011.
[58] DECC. Understanding potential consumer response to the Green Deal. London, UK: Department of Energy and Climate Change (DECC); 2011.
[59] Coulter R, van Ham M, Feijten P. A longitudinal analysis of moving desires, expectations and actual moving behaviour. Environ Plan A 2011;43:2742–60.
[60] DECC. The Green Deal: a way for owners and tenants to pay for home improvements. London, UK: Department of Energy and Climate Change (DECC); 2013.
[61] Rosenow J, Galvin R. Evaluating the evaluations: evidence from energy efficiency programmes in Germany and the UK. Energy Build 2013;62:450–8.
[62] Fuller MC, Kunkel C, Zimring M, Hoffman I, Soroye KL, Goldman C. Driving demand for home energy improvements. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL); 2010.
[63] Christensen TH, Gram-Hanssen K, de Best-Waldhober M, Adjei A. Energy retrofits of Danish homes: is the energy performance certificate useful? Build Res Inf 2014;42(4):489–500.
[64] Murphy L. The influence of energy audits on the energy efficiency investments of private owner-occupied households in the Netherlands. Energy Policy 2014;65:398–407.
[65] AECOM. Energy demand research project: final analysis. St Albans, UK: AECOM Ltd; 2011.
[66] Ayres I, Raseman S, Shih A. Evidence from two large field experiments that peer comparison feedback can reduce residential energy usage. Cambridge, MA: National Bureau of Economic Research (NBER); 2009.
[67] Vine E. An international survey of the Energy Service Company (ESCO) industry. Energy Policy 2005;I33(5):691–704.
[68] Gupta R, Barnfield L, Hipwood T. Impacts of community-led energy retrofitting of owner-occupied dwellings. Build Res Inf 2014;42(4):446–61.
[69] Guy S. Designing urban knowledge: competing perspectives on energy and buildings. Environ Plan C 2006;24(5):645–59.
[70] Shove E. Beyond the ABC: climate change policy and theories of social change. Environ Plan A 2010;42(6):1273–85.
[71] Lutzenhiser L. Social and behavioral aspects of energy use. Annu Rev Energy Environ 1993;18:247–89.
[72] Lutzenhiser L, Shove E. Contracting knowledge: the organizational limits to interdisciplinary energy efficiency research and development in the US and the UK. Energy Policy 1999;27(4):217–27.
[73] Røpke I. Theories of practice – new inspiration for ecological economic studies on consumption. Ecol Econ 2009;68(10):2490–7.
[74] Shove E. Comfort, cleanliness, and convenience: the social organisation of normality. Oxford, UK: Berg; 2003.
[75] Walker G. The dynamics of energy demand: change, rhythm and synchronicity. Energy Res Soc Sci 2014;1:49–55.
[76] Gram-Hanssen K. Understanding change and continuity in residential energy consumption. J Consum Cult 2011;11(1):61–78.
[77] Shove E, Pantzar M. Consumers, producers and practices: understanding the invention and reinvention of Nordic walking. J Consum Cult 2005;5(1):43–64.
[78] Karvonen A. Towards systemic domestic retrofit: a social practices approach. Build Res Inf 2013;41(5):563–74.
[79] Bartiaux F, Gram-Hanssen K, Fonseca P, Ozoliņa L, Christensen TH. A practice-theory approach of homeowners' energy retrofits in four European areas. Build Res Inf 2014;42(4).
[80] Vlasova L, Gram-Hanssen K. Incorporating inhabitants' everyday practices into domestic retrofits. Build Res Inf 2014;42(4):512–24.
[81] Judson EP, Maller C. Housing renovations and energy efficiency: insights from homeowners' practices. Build Res Inf 2014;42(4):501–11.
[82] Novikova A, Vieider F, Neuhoff K, Amecke H. Drivers of thermal retrofit decisions: a survey of german single- and two-family houses. Berlin, Germany: Climate Policy Initiative (CPI); 2011.
[83] Wilson C, Dowlatabadi H. Aligning consumer decisions and sustainabilty objectives: energy efficiency in the residential retrofit market. In: McNall SG, Hershauer JC, Basile G, editors. The business of sustainability: trends, policies, practices and stories of success, vol. 2. New York: Praeger Press; 2011. p. 221–40.
[84] Christie H, Smith S, Munro M. The emotional economy of housing. Environ Plan A 2008;40:2296–312.
[85] McCormack DP, Schwanen T. The space–times of decision making. Environ Plan A 2011;43:2801–18.
[86] Wilson C, Chryssochoidis G, Pettifor H. Understanding homeowners' renovation decisions: findings of the VERD project. London, UK: UK Energy Research Centre (UKERC); 2013.
[87] Fawcett T. Exploring the time dimension of low carbon retrofit: owner-occupied housing. Build Res Inf 2014;42(4):477–88.
[88] Tweed C. Socio-technical issues in dwelling retrofit. Build Res Inf 2013;41(5):551–62.
[89] Haidt J. The emotional dog and its rational tail: a social intuitionist approach to moral judgment. Psychol Rev 2001;108(4):814–34.
[90] Huber A, Mayer I, Beillan V, Goater A, Trotignon R, Battaglini E. Refurbishing residential buildings: a socio-economic analysis of retrofitting projects in five European countries. Brussels, Belgium: European Federation of Agencies and Regions for Energy and Environment (FEDARENE); 2011.
[91] Bioregional. Helping to inform the Green Deal: green shoots from Pay As You Save. Wallington, Surrey, Bioregional, with B&Q and the London Borough of Sutton; 2011.
[92] Reid L, Sutton P, Hunter C. Theorizing the meso level: the household as a crucible of pro-environmental behaviour. Prog Hum Geogr 2010;34(3):309–27.
[93] Buzar S, Ogden P, Hall R. Households matter: the quiet demography of urban transformation. Prog Hum Geogr 2005;29:413–36.
[94] van Diepen AML. In: Noorman K, Uiterkamp T, editors. Developments in household composition in Europe. Green households? Domestic consumers, environment, and sustainability. London, UK: Earthscan; 1998. p. 82–100.
[95] ONS. Appendix A: Definitions and terms. General lifestyle survey 2011. London, UK: Office of National Statistics (ONS); 2011.
[96] Casimir GJ, Tobi H. Defining and using the concept of household: a systematic review. Int J Consum Stud 2011;35:498–506.
[97] Haines V, Mitchell V. A persona-based approach to domestic energy retrofit. Build Res Inf 2014;42(4):462–76.
[98] Wilhite H. Why energy needs anthropology. Anthropol Today 2005;21(3):1–2.
[99] Oates CJ, McDonald S. Recycling and the domestic division of labour: is green pink or blue? Sociology 2006;40(3):417–33.
[100] JCHS. The remodeling market in transition. Cambridge, MA: Joint Centre for Housing Studies (JCHS), Harvard University; 2009.
[101] Lutzenhiser L. Marketing household energy conservation: the message and the reality. In: Dietz T, Stern PC, editors. New tools for environmental protection: education, information, and voluntary measures. Washington, DC: National Academy Press; 2002. p. 49–65.
[102] Hand M, Shove E. Orchestrating concepts: kitchen dynamics and regime change in good housekeeping and ideal home, 1922–2002. Home Cult 2004;1(3):235–56.
[103] Hand M, Shove E, Southerton D. Home extensions in the United Kingdom: space, time, and practice. Environ Plan D: Soc Space 2007;25(4):668–81.
[104] Southerton D. Consuming kitchens: taste, context and identity formation. J Consum Cult 2001;1(2):179–203.
[105] Watson M, Shove E. Product, competence, project and practice: DIY and the dynamics of craft consumption. J Consum Cult 2008;8(1):69–89.
[106] Shove E, Watson M, Hand M, Ingram J. The design of everyday life. Oxford: Berg; 2007.
[107] Blunt A, Dowling R. Home: a response and future directions. Soc Cult Geogr 2008;9(5):569–72.
[108] Baillie L, Benyon D. Place and technology in the home. Comput Support Coop Work 2008;17:227–56.
[109] Aune M. Energy comes home. Energy Policy 2007;35(11):5457–65.
[110] Martens L, Warde A. Power and resistance around the dinner table. In: Hearn J, Roseneil S, editors. Consuming cultures: power and resistance. Basingstoke, UK: Palgrave Macmillan; 1999.
[111] Gillingham K, Palmer K. Bridging the energy efficiency gap: policy insights from economic theory and empirical evidence. Rev Environ Econ Policy 2014;8(1):18–38.

[112] Borgeson M, Zimring M, Goldman C. The limits of financing for energy efficiency. ACEEE Summer Study on energy efficiency in buildings. Asilomar, CA: American Council for an Energy Efficient Economy (ACEEE); 2012.
[113] Pettifor H, Wilson C, Chryssochoidis G. The appeal of the Green Deal: empirical evidence for the influence of energy efficiency policy on renovating homeowners. Energy Policy 2015;79:161–76.
[114] DECC. Domestic green deal and energy company obligation in Great Britain: statistical release 20 November 2014. London, UK: Department of Energy and Climate Change (DECC); 2014.
[115] Ingle A, Moezzi M, Lutzenhiser L, Diamond R. Better home energy audit modelling: incorporating inhabitant behaviours. Build Res Inf 2014;42(4):409–21.
[116] Stieß I, Dunkelberg E. Objectives, barriers and occasions for energy efficient refurbishment by private homeowners. J Clean Prod 2013;48:250–9.
[117] Gram-Hanssen K. Retrofitting owner-occupied housing: remember the people. Build Res Inf 2014;42(4):393–7.
[118] Gillingham K, Newell R, Palmer K. Energy efficiency policies: a retrospective examination. Annu Rev Environ Resour 2006;31:161–92.
[119] DEFRA/Brook_Lyndhurst. Public understanding of sustainable energy consumption in the home. London, UK: Department for Environment, Food and Rural Affairs; 2007.
[120] Gardner GT, Stern PC. The short list: the most effective actions US households can take to curb climate change. Environment 2008;50(5):12–24.
[121] Braun FG. Determinants of households' space heating type: a discrete choice analysis for German households. Energy Policy 2010;38(10):5493–503.
[122] Dietz T, Gardner GT, Gilligan J, Stern PC, Vandenbergh MP. Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. Proc Natl Acad Sci 2009;106(44):18452–6.
[123] Mayr E. Cause and effect in biology. Science 1961;134:1501–6.
[124] Kruger DJ. Evolution and altruism: combining psychological mediators with naturally selected tendencies. Evol Hum Behav 2003;24:118–25.
[125] de Waal FBM. Putting the altruism back into altruism: the evolution of empathy. Annu Rev Psychol 2008;59(1):279–300.
[126] Agnew CR, Thompson VD, Gaines SO. Incorporating proximal and distal influences on prejudice: testing a general model across outgroups. Pers Soc Psychol Bull 2000;26(4):403–18.
[127] Blakely TA, Woodward AJ. Ecological effects in multi-level studies. J Epidemiol Community Health 2000;54(5):367–74.
[128] Lee BA, Tyler KA, Wright JD. The new homelessness revisited. Annu Rev Sociol 2010;36(1):501–21.