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Home for the Common Future (HCF): The use of home-meanings to promote domestic energy retrofit

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ABSTRACT

The promotion of energy retrofit to homeowners is an important policy strategy to reduce operational energy use in dwellings and mitigate climate change. Energy research and policy typically focus on the *cognitive* (logical) aspects to motivate retrofit decisions, such as savings on energy bills and health considerations. However, this focus appears to have neglected the *emotional* aspects of how homeowners themselves make sense of the potential benefits of low-carbon dwellings.

To encompass both the emotional and cognitive aspects of energy retrofit decisions, the authors developed a *home-meanings framework* around the concept of *perezhivanie* (emotional and cognitive experience). We backgrounded our theoretical construction by drawing upon current literature of home-meanings and empirical insights from: (i) eighteen case studies, in ten of which homeowners achieved significant carbon emission reductions through retrofit activities, while in eight they did not; (ii) a stakeholder workshop (n = 36), representing various actors interested to advance domestic energy retrofit activities in the UK, e.g. industry, government, academia, intermediaries.

We analysed the data to identify positive experiences associated with low-carbon dwellings. These experiences are organised in five themes: (i) control over one's environment; (ii) **H**ealth and well-being & **H**appiness in everyday life, (iii) **C**limate concerns & **C**aring identity, (iv) **F**inancial considerations & **F**uture-resilience; (v) a full integration between and individual and their environment. The authors developed a **H**ome for the **C**ommon **F**uture (**HCF**) heuristic, which captures three out of five identified themes (ii–iv). We suggest that the heuristic can be used for promoting the benefits of low-carbon dwellings.

1. Introduction

The promotion of energy retrofit in the owner-occupied sector is an important strategy to reduce operational energy use in dwellings, meet global targets for carbon emission reductions [1,2], and mitigate climate change [3]. Residential buildings account for 22 % of global energy use and 17 % of global CO_2 emissions [4], while the majority of global residential stock is owner-occupied [5,6]. The installation of energy-efficiency and renewable measures and technologies globally can contribute between 30 % and 70 % to the reduction of greenhouse gas emissions in the building sector [7]. Various policies have been implemented globally to encourage investment in domestic energy retrofit [8–10]. Despite this, the level of annual investment remains low [11], compared to 3.5 % GDP per annum deemed necessary to achieve desired reductions [12–14].

Research and policy on the built environment typically focus on the

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cognitive (logical) aspects of retrofit decisions such as health and well-being considerations [15,16], climate concerns [17,18], and financial considerations, i.e. returns on investment and savings on energy bills [19–22]. This focus neglects the *emotional* aspects of the sensemaking process [23,24], through which homeowners attach meaning to the potential benefits of low-carbon dwellings. However, emotional motivations can be more important predictors of technology adoption than cognitive ones (see debate on symbolic, environmental and instrumental motives [25,26]). Home is a place of a great significance and meaning for individuals, and previous research suggests that homeowner motivations to carry out energy retrofit should be understood through the meanings they attach to their homes [19,27]. As individuals pursue a broad set of goals and use both emotion- and cognition-based processes in their retrofit decisions, energy policies should use a broad range of behavioural tools that complement subsidies, taxes and regulations [7,28].

To broaden the current policy focus, the authors focus on emotional aspects of energy retrofit decisions and use the concept of *perezhivanie* (emotional and cognitive experience) to develop a framework to analyse meanings people attach to the low-carbon benefits of their homes. We draw on current literature of home-meanings, as well as empirical insights from: (i) ten cases where homeowners achieved significant carbon emission reductions through retrofit activities, and eight cases where they did not; (ii) a workshop with 36 participants, representing various actors interested to advance domestic energy retrofit activities in the UK, e.g. industry, government, academia, intermediaries. The analysis identifies five themes of positive emotional and cognitive experiences associated with low-carbon dwellings. We illustrate the analytical use of the home-meanings framework to build narratives for energy retrofit promotion, which resonate with homeowners emotional and cognitive reasoning.

The rest of the paper is structured as follows. Section 2 provides the underpinning for the chosen theoretical lens. Section 3 provides the methodology for empirical data collection and the framework for qualitative data analysis. Section 4 describes the study findings. Section 5 discusses the insights drawn from the findings in line with current literature and derives possible implications for policy. Section 6 concludes and provides suggestions for future research.

2. Theoretical conceptualisation

This section brings together the following conceptual elements to frame the analysis: (i) the concept of *home-meanings* necessary to understand homeowner energy retrofit intentions and subsequent decisions; (ii) the concept of *perezhivanie* (emotional and cognitive experience) to analyse home-meanings that underpin homeowner energy retrofit motivations; (iii) the concept of a *cognitive frame* to understand and shape the trajectory of one's energy retrofit motivations.

The conceptualisation for perezhivanie and cognitive frame draws upon the intellectual tradition of *cognitive developmental psychology* [29]. As this tradition is not well known in energy research, this section will first briefly describe it and make explicit links between the concepts used.

2.1. Perezhivanie and cognitive frame

Cognitive developmental psychology is a scientific study concerned with changes involved in human development from infancy to old age. Originally concerned with child development [29], the field has expanded to include the development through the entire human lifespan [30]. The field has recently expanded its focus to understand its role for sustainable development [31]. Most theorisation in cognitive developmental psychology can trace its routes to two influential psychologists of the last century — Jean Piaget (1896–1980) and Lev Vygotsky (1896–1934) [29]. In this paper, the authors draw upon two of their concepts — Vygotsky's 'perezhivanie' and Piaget's 'schema', with the latter forming the basis for the concept of a 'cognitive frame'.

Perezhivanie was introduced by Lev Vygotsky [32,33], and is best translated into English as 'emotional and cognitive experience' [34,35]. The concept emphasises that only those elements of the environment that are refracted through the emotional and cognitive experiences of the individual are of developmental significance, shaping the whole organisation of consciousness and, subsequently, one's identity [35]. The concept emphasises that cognition and emotion is something an individual enacts through one's dynamic living activities. It is not something that happens solely in one's head [35]. The combination of one's *environment* and living *activities* gives one a platform for *perezhivanie*.

Schema (plural schemata) as a concept was introduced by Jean Piaget [36], and can be described as a pattern of thought or behaviour, through which people organise information to make the interaction with the environment more efficient [37]. The concept is reminiscent of Vygotsky's understanding of perezhivanie as a *prism* that refracts environmental moments and determines the influence of these environmental moments on the course of individual development [34]. In this paper, we do not rely on the terminology of a schema or a prism, and use a concept of 'cognitive frame' instead, which is one of the most prominent concepts within the field of communication studies, and which most researchers use analogously to schema [38]. We assert that promoting retrofit decision-making is a communication phenomenon, and thus a concept of 'cognitive frame' could apply. Framing is used to describe how people communicate about reality by emphasising specific aspects of it. Framing can and is often used in journalism and political discourse, to influence recipients' cognitive frames [38].

The concept of a 'cognitive frame' can be applied in discourse on the promotion of domestic energy retrofit. It is hypothesised that the way that a homeowner makes sense of what a low-carbon dwelling[1] is and evaluates its benefits, shapes their eventual decision on whether to make a significant investment in energy retrofit or not. Other actors, i.e. building professionals, government and local authorities, can utilise cognitive framing to shape their message to homeowners about the benefits of low-carbon dwellings, and through that, motivate them to retrofit their homes.

2.2. Home-meanings framework

We built on previous research that suggests that homeowner energy retrofit motivations should be ultimately understood through the meanings people attach to their homes [19,27]. We carried out a critical literature review to identify various layers, facets and dimensions of 'home' as a construct. A *critical literature review* is a non-systematic type of review, aimed to synthesise extant literature on a broad topic with a conceptual model being a typical outcome [39,40]. An initial broad search only included the word 'home', which returned ~380,000 results on the *Web of Science* database. Identified sources were sorted by the number of citations, and the titles were searched to identify sources that conceptualise the meanings people attach to their homes. The relevant, most cited sources were identified, and their references and citations were traced to identify further literature. The emphasis of this critical literature review was on the conceptual contribution of each new source to the understanding the notion of home. The choice was eventually narrowed down to fourteen sources (Table 1), which provide a rich synthesis of the current literature. The authors made a judgement that a further detailed review of the literature would not have made a significant conceptual contribution to the understanding of the notion of home.

[1] For this paper, low-carbon dwelling technology is conceptualised at the level of a technological system, rather than a design option or a particular product [121]. For instance, it could focus on a Passivhaus dwelling as a system, rather than on external of external wall insulation as design options, or a choice of a particular product for the insulation material.

Table 1
Literature sources used in the critical literature review.

Sources	Disciplinary approaches	Source	Source type
Blunt, 2005 [41]	Geography	Progress in Human Geography	Editorial article
Blunt and Dowling, 2006 [42]	Geography	Routledge	Book
Blunt and Varley, 2004 [43]	Geography	Cultural Geographies	Editorial article
Coolen and Meesters, 2012 [44]	Ecological psychology	Journal of Housing and the Built Environment	Editorial article
Després, 1991 [45]	Psychology	Journal of Architectural and Planning Research	Critical review
Easthope, 2004 [46]	Geography	Housing, Theory & Society	Review
Fox, 2002 [47]	Law	Journal of Law and Society	Critical review
Heidegger, 1964 [48]	Phenomenology	Routledge	Book
Mallett, 2004 [49]	Multidisciplinary	The Sociological Review	Review
Manzo, 2003 [50]	Psychology	Journal of Environmental Psychology	Review
Molony, 2010 [51]	Nursing	Research in Gerontological Nursing	Qualitative metasynthesis
Moore, 2000 [52]	Environmental psychology	Journal of Environmental Psychology	Review
Saunders and Williams, 1988 [53]	Sociology	Housing Studies	Theoretical position
Somerville, 1997 [54]	Sociology	Journal of Architectural and Planning Research	Critical review

Table 2
Research-identified meanings of home.

Després, 1991 [45]	Somerville, 1992 [57]	Mallett, 2004 [49]
Relationships with family and friends	Shelter (materiality)	House, neighbourhood, town
Material structure	Adobe (place)	People's relationships, especially family
A place to own	Hearth (warmth)	Lived space of interactions between people, places and things
Physical security and control	Heart (love)	Home ownership
Reflection of one's ideas and values	Privacy (control)	Being-in-the-world (being at home)
Permanence and continuity	Roots (source of identity)	Experience of one's (possibly fluid) identity
Refuge from the outside world	Paradise (ideality, sense of spiritual security)	Haven, comfort, ease, intimacy, relaxation and security OR *oppression, tyranny and persecution*
Indicator of personal status		Belonging OR *marginalisation and estrangement*
Acting upon and modifying one's dwelling		Feelings, repository of memories
Centre of activities		Staying, leaving and journeying

Note: Text in *italics* signifies the original author's acknowledgement that home might not be recalled or experienced in a positive way.

The review highlighted that *home* is a complex, multi-layered, multi-faceted and multi-dimensional construct, with a long-standing theoretical and practical research tradition on the topic [41–56]. The complex nature of the construct of home makes its clear definition[2] a difficult task. Some authors even argue that a complete definition of home is not only difficult, but is also undesirable [46], as the notion of home is imbued with personal meanings and is likely to mean different things to different people at different times and in different contexts.

For the same reason, a comprehensive and exhaustive list of all possible meanings that people might attach to their homes, is futile, as such a list of meanings is inevitably just a snapshot, specific to particular people, time and context. However, such lists can provide a good sense of the diversity of possible home-meanings. Table 2 provides three exemplary lists based on the findings from three key articles, recognised as such in the field [42], which rely on studies in the western world, where people were asked what home means to them [45,49,57].

There are several disciplinary theoretical models that describe the forces that shape home-meanings (see Box 1 for an overview). Each of them has conceptual limitations, as each emphasises certain home-meanings and downplays or neglects others [54]. This is not surprising, as a given theoretical model would need to relate to a particular research questions and disciplinary tradition.

The authors build upon the rich literature on the topic of home to develop a conceptual *framework of home-meanings*, which can be used to understand meaningful dimensions of low-carbon dwellings and, subsequently, homeowner energy retrofit intentions. Five dimensions of home-meanings are identified: Vygotsky's concept of (i) *perezhivanie (emotional and cognitive experiences)* is used to capture the diversity of psychological and social values and attributes, such as comfort and security. The concept suggests that emotional and cognitive experiences associated with low-carbon dwellings should be understood through the unity of one's (ii) *environment* and (iii) *activities*. The framework also acknowledges the importance of (iv) *real and ideal realms* and (v) *time* in shaping home-meanings. These five dimensions of the home-meanings framework are described in more detail below:

(i) Perezhivanie (emotional and cognitive experience) is afforded via the unity of one's environment and activities. Commonly[3] identified positive emotional and cognitive experiences associated with one's home include a sense of happiness, joy, security, control, comfort, as well as self-expression and personal status. These experiences give meaning to a place [59], shape one's consciousness and give rise to multiple identities, such as the ones of gender, race, class and sexuality [35], and can potentially include one's environmental identity. The concept of perezhivanie also allows to capture the notion of home as a repository of memories [49].

(ii) The environment includes three elements, which are in the immediate proximity to the processes that shape emotional and cognitive experiences in one's home. First, *physical* and *spatial* elements, such as the type of structure of the dwelling, its size and aesthetic properties

[2] One of the most comprehensive definitions of home has been put forward by Benjamin [55]: "The home is that spatially localised, temporally defined, significant and autonomous physical frame and conceptual system for the ordering, transformation and interpretation of the physical and abstract aspects of domestic daily life at several simultaneous spatio-temporal scales, normally activated by the connection to a person or community such as a nuclear family. It is thus the autonomous interpretation of domestic life, and that which is interpreted." Benjamin acknowledges that his definition is not inclusive of all dimensions discussed in the literature on home-meanings. For instance, he points out that he chose to regard the home-as-state-of-mind as a metaphor, rather than a part of the definition.

[3] For the reasons mentioned earlier, this framework does not give a definitive list of possible emotional and cognitive experiences, but rather provides a concept of perezhivanie to think about the diversity of possible experiences.

Box 1
Theoretical models of home-meanings (based on [42,45,54,58]).

Territorial/ geographical. This approach gives priority to the spatial boundaries associated with home. It emphasises the existence of different physical scales of home boundaries, and the idea that home places are simultaneously shaped in real and imaginative worlds. The emphasis in this approach is on the social and psychological attributes that places offer to individuals, primarily feelings of security, control, identity and stimulation.
Psychological. This approach traces the meaning of home to deeply rooted psychological needs. For instance, home can be defined as a powerful extension of psyche and a symbol of oneself. Alternatively, home can be understood as the means to fulfil the hierarchy of human needs, such as a need for privacy, security and control.
Social-psychological. This approach focuses on explaining how home plays a role in shaping people's self-identity, as well as being an important symbol of individual social identity.
Phenomenological and developmental. These approaches focus on the temporal dimension of home. Home is understood through a continuous process of creation and recreation of its meaning in the context of everyday life. Being-at-home is associated with a sense of familiarity and routine, which contributes to the creation of the feeling of continuity that connects individual's past and future.
Sociological. This approach focuses on the interpretation of home-meanings using concepts of social relations, particular the ones of family. Other sociological categories such as class, gender and tenure are also used for interpretations.

[45]; as well as spatial elements, such as the house itself, neighbourhood, hometown, homeland or the whole world [42,49]. Second, *self* and *social* elements, which include one's own self as well as one's social relations, such as family, friends or even ethnic groups [42,44]. Third, *financial* and *legal* elements, which include the type of tenure and modes of land ownership. These elements are used to suggest that a house can be a financial asset [47].

(iii) The activities in one's home are grouped in two types. The first type captures *recurring* activities, such as everyday mundane activities, seasonal or cyclical events, e.g. holiday celebrations, and rituals. With time, such repeated activities, begin to 'bind' an individual, as places and things get symbolically meaningful by this process of timebinding [60]. The second type captures *temporary* activities, such as formative experiences or home renovation. For instance, modifying one's dwelling has been shown to be an important part of expressing one's identity and making a house a home [45].

(iv) A distinction between real and ideal realms of one's home highlights that the notion of home is constructed simultaneously in both realms as part of a single process [42,54]. Material and imaginative geographies of home are relational to each other, as the material form of home can be altered through retrofit and personalisation based on what home is imagined to be, while imaginaries of home are influenced by the physical forms of a dwelling [42,45].

(v) Time as a dimension of home-meanings highlights that the notion of home is ever-changing and is found in one's memories and nostalgia for the past, everyday life in the present, and future dreams and fears [41,42]. When talking about home, an individual might refer to the place where one was born and raised, or the place where one had happily lived, for instance, before a tragic event, or the place one desires to have one day [44]. The temporal dimension of home can also be seen through seasonal and cyclical events, such as holiday celebrations or times of the season, which contribute to the formation of what home means to a particular individual [45].

These five dimensions of home-meanings should be understood within a broader economic, political, social and cultural *context* for a more comprehensive picture. The described framework is visualised in Fig. 1.

3. Methodology

The authors draw upon current literature on home-meanings, case-studies of homeowner energy retrofit and an expert workshop with stakeholders among those interested to advance energy retrofit activity in the UK, in order to (Fig. 2): (1) choose a conceptual base for the home-meanings framework; (2) identify benefits of low-carbon dwellings through the meanings households articulate about their homes; (3) build narratives to promote energy retrofit that resonate with homeowners and account for their socio-cultural needs. The analysis features several iterations between the steps, and includes a combination of multiple-case studies and thematic analysis.

3.1. Data collection

Table 3 presents the three main types of empirical data used in the study, its sources and their use. The rest of the subsection describes them in more detail.

3.1.1. Case study profiles

The unit of analysis for the case studies is the household retrofit journey, and each one is considered a case [61]. The literature on multiple case-study research suggests 4–10 cases to generate enough complexity for theory development, while keeping the volume of the data manageable [62,63]. A *purposive* sampling strategy was used to select 10 *confirming* cases of successful domestic retrofit to low-carbon standards, and 8 *disconfirming* cases where retrofit activities did not result in low-carbon settings [63,64]. Another 8 case studies were used in the pilot to sharpen the research design prior to the main data collection. The main data collection was carried out from June 2018 to October 2019. All participants volunteered their participation, no incentives were provided.

Eight out of 10 confirming cases were selected from the SuperHomes network, a voluntary UK network of about 200 homeowners, who achieved at least 60 % carbon reductions[4] as a result of a retrofit activities [65,66]. The participants were approached through a SuperHomes representative. Another 2 confirming and 8 disconfirming cases were selected with a convenience sampling strategy among first author's personal and professional network. All the cases are listed in Table 4. The case identifiers for 10 confirming cases start with 'C', and for 8

[4] For these cases, the SuperHomes network used a Standard Assessment Procedure (SAP) to estimate both pre-retrofit and post-retrofit emissions with data collection at one point in time, post-retrofit [122]. The estimation procedure has changed since data collection for this paper. Since spring 2021 the network measures two variables: 'Energy and Emissions' and 'Health, Comfort and Wellbeing' on an absolute rather than a relative scale. The assessment takes place at two stages, Design and Evaluation. The former is based on the estimated performance, and the latter – on actual measured performance [123].

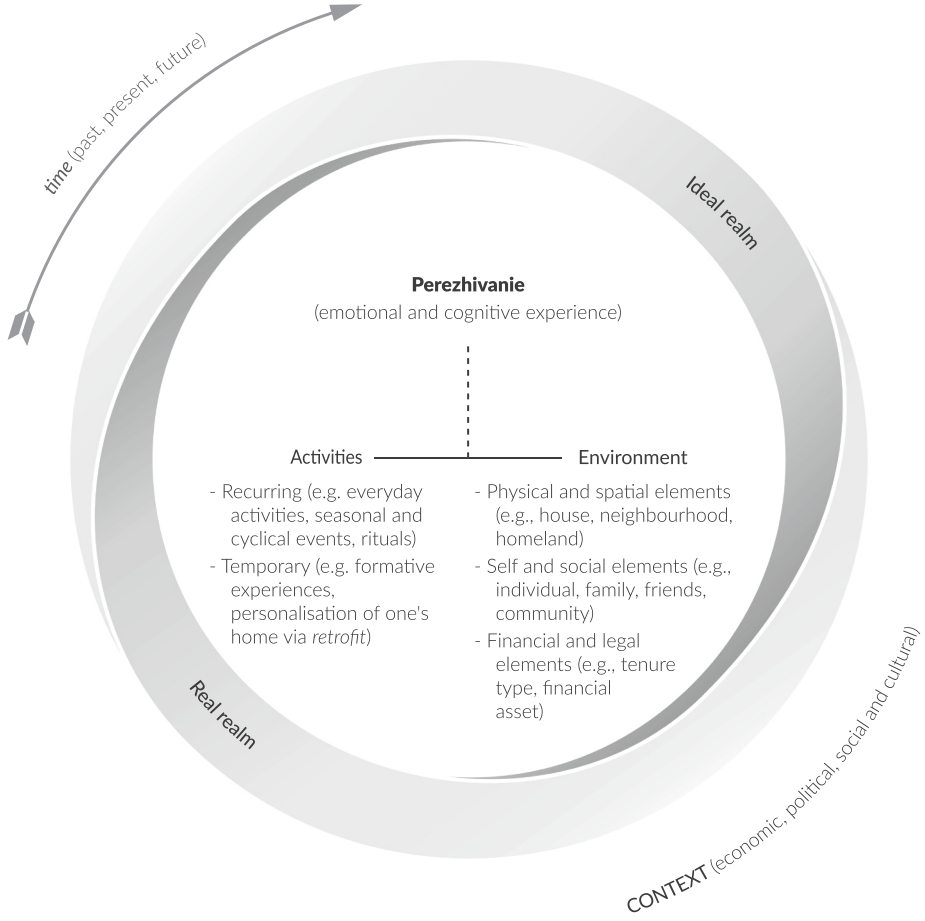

Fig. 1. Home-meanings framework.

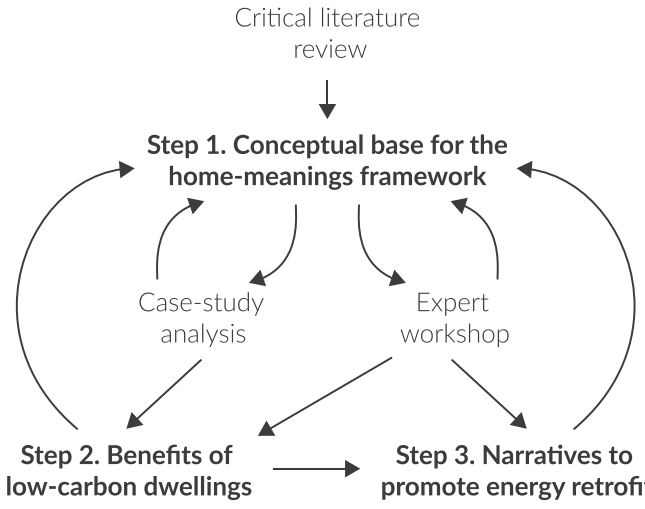

Fig. 2. Steps of the iterative research design.

disconfirming cases — with 'D'. The selected cases range from Victorian terraced houses, to detached houses and converted ground floor flats. The houses are located in England, mostly London. At the time of data collection, the households in the study ranged from a single occupier to a family of five. Two households had tenants. Most adult occupants in the sample were professionally active with more than half having sustainability- or construction-related background. All owners in the sample carried out some home improvement activities, including energy retrofit. A variety of fabric, ventilation, heating and energy generation measures were installed, a detailed description of which can be found in Appendix A.

3.1.2. *Post-retrofit interviews with homeowners*

Case-study data was primarily generated though *semi-structured interviews* with one of the owners, normally the one who was more involved in the retrofit project. In case C1, the owner rented out the property after the retrofit; so in this case, the interview included the owner-retrofitter and one of the tenants. In case C8, both owners participated in the interview. All interviewees received an information sheet and signed a consent form. The interviews lasted between 35 and 160 min and took place at interviewees' homes.

The interviewees were asked to draw their retrofit timelines as part of the interview. The condensed presentation of a retrofit journey on a single diagram allowed interviewees to instantly assess the completeness of the information provided [67]. Interviews also incorporated a walk-through procedure – a spatial-visual technique used to evoke interviewee's memories about the retrofit experience [68]. Photographs of different aspects of the retrofit were taken, to retain visual information for future analysis. Information was collected on general household characteristics, dwelling characteristics prior and post retrofit, the retrofit process itself, goals and motivations, pre- and post-retrofit living experience and practices affecting domestic resource use. See Appendix B for the summary of question topics. All interviews were digitally recorded and transcribed verbatim for analysis.

3.1.3. *Associative experiments*

Another part of case study data was generated through continuous associations. A *continuous association task* is a data collection method,

Table 3
Data, its sources and use.

Type of data	Sources	Use in the analysis
Interview transcripts	In-depth semi-structured interviews with homeowners-retrofitters: 10 cases of low-carbon retrofit (confirming) and 8 cases that did not result in low-carbon settings (disconfirming).	Multiple case-study analysis to identify benefits of low-carbon dwellings by recognising positive emotional and cognitive experiences (perezhivanie) associated with them.
Continuous associations	Associative experiments with homeowners-retrofitters *(see above)*.	*Same as above*
Workshop transcript	Participatory workshop with actors, interested to advance energy retrofit activity in the UK: (i) demand side actors (n = 2); (ii) supply-side/ industry actors (n = 10); (iii) governmental actors (n = 5); (iv) intermediary organisations that operate to advance change towards sustainability (n = 11); (v) academics that specialise in low-carbon home retrofit (n = 8).	Participatory creation of narratives to promote energy retrofit, using home-meanings framework and benefits of low-carbon dwellings, identified in the case-study analysis. These were then analysed thematically.

where the participants are asked to produce as many responses as possible in association with a specific word or phrase [69]. The method is used to reveal the associative structure of a single individual. Regularities identified in word association, such as order and meaning apparent in association responses, have been used to cast new light on the meanings of words [70], to identify responders' knowledge in a specific area of studies [71], to make generalised statements regarding collective semantic understanding of particular cultural phenomena [72] and others [69]. As part of the in-depth interviews, the homeowners were asked to say as many words as possible in an association with the words 'home' and 'low-carbon home'. Their responses indicate that they associate their homes with comfort, joy and overall positive experiences. Full responses to associative tasks can be found in Appendix C.

Table 4
Profile of sample households.

Case	House age/type	Location	Occupants	Owner-retrofitter professional background[1]	Carbon/energy rating[2]
Confirming cases: achieved significant carbon/ energy reductions as a result of retrofit activities					
C1	Victorian, former mews house, *split into a ground-floor office and a four-bed flat upstairs, with loft conversion*	London	Four adult tenants	Architect	*75 % carbon reductions; CHS 4*
C2	1920, three-bed, mid-terrace, *heated glass conservatory not separated from the house*	London	Family of four	Former professional builder	*67 % carbon reductions; annual energy generation and consumption are roughly the same*
C3	1930s, three-bed, semi-detached	Buckinghamshire	Young couple	Architectural technologist	*70 % carbon reductions*
C4	Edwardian, three-bed, mid-terrace	Buckinghamshire	One adult, one child	Project manager in the energy efficiency/ renewable energy sector	*78 % carbon reductions*
C5	Victorian, five-bed including loft conversion, mid-terrace	London	Family of four and an au pair	Former energy and sustainability consultant	*68 % carbon reductions*
C6	1967, *five-bed/ fourteen-room*, detached, *extended internal layout over 50 %*	Hertfordshire	Family of five	Technical	*92 % carbon reductions*
C7	1925, semi-detached, former three-bed house, *two-storey side extension and one-storey back extension, split in two flats: two- and three-bed*	London	Family of four	Technical	*80 % carbon reductions*
C8	1933, three-bed *with loft conversion*, semi-detached	London	Retired couple, one tenant	Non-technical	*90 % carbon reductions*
C9	2011, four-bed, detached	Bedfordshire	Two adults	Academic position in Low-Energy Buildings	EPC band B, *carbon neutral for one year*
C10	Victorian, *three-bed with loft conversion*, mid-terrace, *side return extension*	London	Family of four	Urban planner	n/a, *self-reported good levels of thermal comfort*
Disconfirming cases: did not achieve significant carbon/ energy reductions as a result of retrofit activities					
D11	1900s, five-bed, detached	Leicestershire	Family of three	Technical	EPC band F
D12	1927, two-bed, mid-terrace	London	Family of five	Non-technical	EPC band D
D13	Victorian, three-bed with a loft conversion, end-of-terrace, side return extension	London	Two adults and a teenager	Academic position in Environmental Design and Engineering	EPC band E
D14	1880, ground floor two-bed flat in a mid-terrace house, 2007 back extension	London	Two adults	One owner – academic position in Energy and Sciences; another owner – academic position in Energy in the Built Environment	n/a
D15	1990, ground floor two-bed flat in a semi-detached house	London	Two adults	Academic position in Machine Learning for Smart Building and Cities	EPC band D
D16	1991, three-bed, semi-detached	Kent	One adult	Building Performance Analyst	n/a
D17	1930s, three-bed/ ten-room, semi-detached	Hampshire	Family of four	One owner – academic position in Building Performance; another owner – academic position in Energy and Buildings	n/a
D18	1960s. ground floor two-bed flat in an apartment block	Surrey	Two adults	Technical	n/a

Text in italics indicate changes achieved as a result of retrofit activities of the owners in the sample.
Note.
[1] Sustainability- or construction-related background is stated in detail; 'technical' indicates non-sustainability- or construction-related technical background; 'non-technical' indicates non-sustainability- or construction-related non-technical background. Background of only one owner is given if most relevant.
[2] Percentage of carbon emission reductions are calculated by a representative of a SuperHome network post-retrofit, using Standard Assessment Procedure (cases C1–C8).

3.1.4. Workshop

A 1,5-h online *workshop* was carried out on 25th May 2021 with 36 participants via online Zoom platform in line with participatory action research tradition [73,74]. The participants were recruited among those interested to advance energy retrofit activity in the UK. Interest was self-assessed, no incentives were given to participate. Participants were identified through the first author's personal and professional network, via publicly available contact details and via snowballing technique. A maximum variation-purposive sampling strategy was used to ensure the diversity of actors [63].

Workshop participants represented the following actors (Table 5): (i) *demand-side* actors (n = 2), both participants from a housing association; (ii) *supply-side/ industry* actors (n = 10), e.g., an architectural studio, an energy provider; (iii) *governmental* actors (n = 5), e.g. a government department, a local authority; (iv) *intermediary* organisations [75] that operate to advance change towards sustainability (n = 11), e.g. a charity/social enterprise, a member organisation; (v) *academics* that specialise in low-carbon home retrofit (n = 8). These actors can potentially act purposefully to shape homeowner cognitive frames around the meaning of low-carbon dwellings, and through that influence their motivation for energy retrofit.

Workshop participants filled in a survey via Opinio online platform prior to the workshop. It was used to collect participant names and contacts, the names and profiles of the organisations they work for, their job title/ role within the organisation, participant consent, as well as participant perceptions of UK policy on domestic retrofit (drivers and barriers to success). During the workshop, the participants were introduced to the project in the plenary session. They were then split in groups of three and four with each group overseen by a facilitator, with group sizing consistent with suggestions in the literature on participatory workshops [76]. Each group had representatives from different actors (e.g. governmental, intermediary, academic) to facilitate thinking outside of the comfort zone. The groups were asked to build emotionally and cognitively compelling motivational narratives to encourage domestic energy retrofit among homeowners using the project insights. The workshop was digitally recorded and transcribed verbatim for further analysis.

3.2. Data analysis

The data analysis was iterative, a simplified representation of which can be described in three steps.

Step 1: Home-meanings framework. The critical literature review identified five dimensions of home (see Section 2.2). However, they lacked a conceptual binding (initially, the dimension of perezhivanie was captured by the idea of psychological and social attributes associated with one's home, such as the feelings of security or belonging). During the first iteration of the analysis, we followed an example by Coolen and Meesters [44] to use the concept of 'affordance' [77,78] to conceptualise what the environment of one's home can offer to the individuals. We later introduced the concept of 'practice' [79–83] to talk about recurring, mundane activities at one's home. Finally, the fourth author, ST, suggested the concept of 'perezhivanie'. The version of the framework, featuring all three concepts (perezhivanie, practice and affordance) was used during the project workshop, during which it became clear that the concepts are not self-exclusive as they often refer to the same dimensions of home. This resulted in confusion and loss of clarity among the workshop participants on how the framework can be used. The participants found the concept of perezhivanie especially helpful to aid their thinking. Therefore, the home-meanings framework was once again re-iterated to organise the dimensions of home around one concept only — that of perezhivanie.

Table 5
Profile of workshop participants.

Participant identifier	Actor category	Actor subcategory
WP01-int	Intermediary	Network of low-carbon dwellings (the participant is currently retired)
WP02_aca	Academia	Sustainable Design
WP03_gov	Government	Government department
WP04_int	Intermediary	National charity with the focus on improving the use of energy in buildings
WP05_aca	Academia	Energy and Buildings
WP06_int	Intermediary	Non-profit company with the focus on delivering energy locally
WP07_gov	Government	Regional governance body
WP08_ind	Industry	Professional services firm, including engineering, architecture, design, planning, project management and consulting
WP09_aca	Academia	Building Engineering Physics
WP10_int	Intermediary	National charity with the focus on sustainable energy
WP11_ind	Industry	Infrastructure consulting firm
WP12_int	Intermediary	Charity and social enterprise with the focus on sustainable ways of living
WP13_int	Intermediary	Non-profit organisation with the focus on ultra-low energy buildings
WP14_aca	Academia	Energy and Climate Change
WP15_int	Intermediary	Membership organisation with the focus on the built environment
WP16_dem	Demand	Housing association
WP17_ind	Industry	National energy provider
WP18_aca	Academia	Energy and Sustainable Development
WP19_int	Intermediary	Council owned local energy company
WP20_aca	Academia	Engineering and Architectural Design
WP21_dem	Demand	Housing association
WP22_ind	Industry	Sustainability engineering company
WP23_int	Intermediary	Community group with the focus on creating climate friendly and sustainable town
WP24_aca	Academia	Sustainable Urban Environments
WP25_ind	Industry	Architectural studio
WP26_gov	Government	Local authority
WP27_aca	Academia	Architecture and Civil Engineering (Building Technology)
WP28_int	Intermediary	Not-for-profit social enterprise with the focus on trusted tradesmen in the domestic sector
WP29_ind	Industry	Software development company
WP30_int	Intermediary	Not-for-profit centre with the focus on energy sector
WP31_gov	Government	Local authority
WP32_ind	Industry	Sustainability engineering company
WP33_gov	Government	Non-departmental public body
WP34_ind	Industry	Retrofit assessor
WP35_int	Intermediary	Council owned local energy company
WP36_ind	Industry	Building and energy consultancy

Step 2: Benefits of low-carbon dwellings. Case studies were analysed to identify benefits of low-carbon dwellings. Interview transcripts, the corresponding photographs and retrofit timelines were sorted into cases and reports were written for each case. Notes and memos taken during the interviews, and those arising from the interview reports were kept for further analysis. The interviews were coded by the first author, the analysis and results were continuously reviewed by the first two authors to further raise the confidence in data interpretation. The home-meanings framework (Fig. 1) was used *deductively* to sort data into five dimensions of the notion of home. The data was then analysed *inductively* to identify emotional and cognitive experiences associated specifically with low-carbon dwellings. This was achieved by juxtaposing emotional and cognitive experiences associated with one's home in general with the experiences associated with living in a low-carbon home in particular. The former was identified based on: (i) exciting literature on home-meanings (Table 1); and (ii) interviews and associative experiments from the case studies. The latter was identified solely based on the case studies.

Step 3: Narratives to promote low-carbon retrofit. The home-meanings framework together with the preliminary results on the benefits of low-carbon dwellings were presented at the project workshop. Workshop participants were asked to critically reflect on the framework and use it to create narratives to promote energy retrofit among homeowners. Participants were not corrected on their interpretations of the introduced framework. The home-meanings framework was re-iterated based on the feedback from the workshop (see step 1). The final version of the framework was used to reanalyse case study data and analyse workshop transcripts and answers to the pre-workshop survey. After the final iteration, five themes of emotional and cognitive experiences were identified, capturing the benefits of low-carbon dwellings.

ATLAS.ti 8 and 9 CAQDAS software was used throughout to assist data analysis. The full coding scheme can be found in Appendix D. Cross-tabulation was used to support constant systematic comparison [63], an illustrative example of which can be found in Appendix E. A range of credibility strategies for qualitative research was followed [61,64,84], a full description of which can be found in Appendix F.

4. Results

4.1. Five themes of the benefits of low-carbon dwellings

The analysis focused on homeowner retrofit motivations[5] and identified five core themes of positive[6] perezhivanie (emotional and cognitive experiences) associated with low-carbon[7] dwellings: (i) control over one's environment; (ii) health and well-being & happiness in everyday life, (iii) climate concerns & caring identity, (iv) financial considerations & future-resilience; (v) a full integration between and individual and their environment (Fig. 3).

The theme *control over one's environment* highlights one's desire to live one's own life rather than a life chosen by someone else. Thus, it relates to personal autonomy. Control is required to achieve positive emotional and cognitive experiences in any of the others four identified themes. Homeowners in the case studies described how their low-carbon dwellings give them more control to achieve desired indoor environment. For instance, the owner in case C7 mentioned that "it's never cold, it's not warm, you can control".

The owners in both confirming and disconfirming cases were aware of the positive effect of low-carbon dwellings on one's *health and well-being*, especially in relation to improved thermal comfort and indoor air quality. The analysis highlighted that these well-known desired rational outcomes can be supplemented to encompass a broader idea of home as a platform for *happiness in one's everyday life*. A well-designed and constructed low-carbon dwelling has better controls, thermal comfort, indoor air quality, moisture regulation, acoustic properties, lighting conditions, and is free of mould, draught and dust. As such, a low-carbon dwelling provides a better platform to be happy in one's home. The owner in case C7 explained: "When it comes to energy efficiency, which, actually, I don't think many people understand that is also a part of feeling cosy. That you have good air in the morning, you don't have draughts, you have a constant 20-22°C… it is quiet… I think it's a part of feeling cosy, for me at least". All owners in the confirming cases highlighted improved thermal comfort and its importance to feel comfortable in one's home. The owners in case C8 explain:

> Interviewer: Could you tell me how the retrofit changed your living experience? How does it feel to live in such a house?
> C8-homeowner1: It's so relaxing. We don't have to wear so many clothes. … before, everything had to be done in the one room. And we couldn't spread out. So, everyone's trying to crowd into the same space, because the other spaces were not liveable.
> C8-homeowner2: Because of the nature of the work I do [guitar teacher], I'd had problems… Because I don't do very well with cold. And if I have to practice new material, it got so cold… And I just… I couldn't get my mind into what's I was doing.
> C8-homeowner1: Cold is a brain-numbing experience.
> C8-homeowner2: It is, actually, it makes you kind of shut down. But since you'd have that done, well, that's gone.
> C8-homeowner1: In this less arguing, like: "shut the door, or you are the one that left it open." Or, you know, all of that sort of thing, which comes from being uncomfortable, physically uncomfortable.
> C8-homeowner2: So, yeah, I think, just more relaxed state of mind. Because it is warmer. It is that simple.

Energy retrofit can help minimise operational energy use and carbon emissions. Thus, it helps address individual *climate concerns* and desire to do one's part to save the planet. The broader emotional aspects are captured in the fusion of one's *caring identity* and the identity of a place called home. The analysis revealed that the idea of 'low-carbon home' is linked to an identity of a broader social responsibility, as compared to the idea of 'home', which is typically linked to oneself and one's family. This was most visible in homeowner associations. Associations with the word home 'home' were 'me'(C7), 'children'(C7, C8, C10, D12), 'family'(C3, C6, C7, C9, C10, D17), 'parents'(C10). Associations with the words 'low-carbon home' were 'citizenship'(C8), 'concerned'(C1), 'conscious'(C1), 'considerate'(C3), 'helping something bigger'(C10), 'responsibility'(C8, D16). One of the owners in the case C8 gave the following associations with the words 'low-carbon home': "Responsibility, citizenship… You know, low-carbon home sounds to me like… The whole world is safe, protected. it's much more national and global and then just us." Associations of the owner in case C9 were: "Future, secure. It's all about the future, that's how we see it. We don't do this for us, we are not doing this for ourselves to be honest. Because in my lifetime, what I am doing now, has no impact on my lifetime. It's all about the future." This social aspect of one's caring identity manifested in homeowners joining the SuperHomes network "as a means to share my knowledge and experience" (C3), "to promote that it could be done

[5] Many factors beyond motivation affect retrofit decisions. As the focus of the paper is on motivation, they are not analysed here. A summary of such non-motivational factors mentioned during case-study interviews and the project workshop are summarised in Appendix G.

[6] The results section of this paper focuses solely on the *benefits* of low-carbon dwellings. However, the analysis featured comparing and contrasting confirming and disconfirming cases to capture both positive and negative emotional and cognitive experiences associated with such dwellings, in order to capture the full emotional response. See Appendix H for further detail on reported negative experiences. See Appendix I for further insights on the similarities and differences of the confirming and disconfirming cases.

[7] This results section of this paper focuses solely on the positive emotional and cognitive experiences associated with *low-carbon* aspects of the dwellings in the case studies. See Appendix J for further description of positive emotional and cognitive experiences, reported by the interviewees, which were not related to the low-carbon nature of their dwellings.

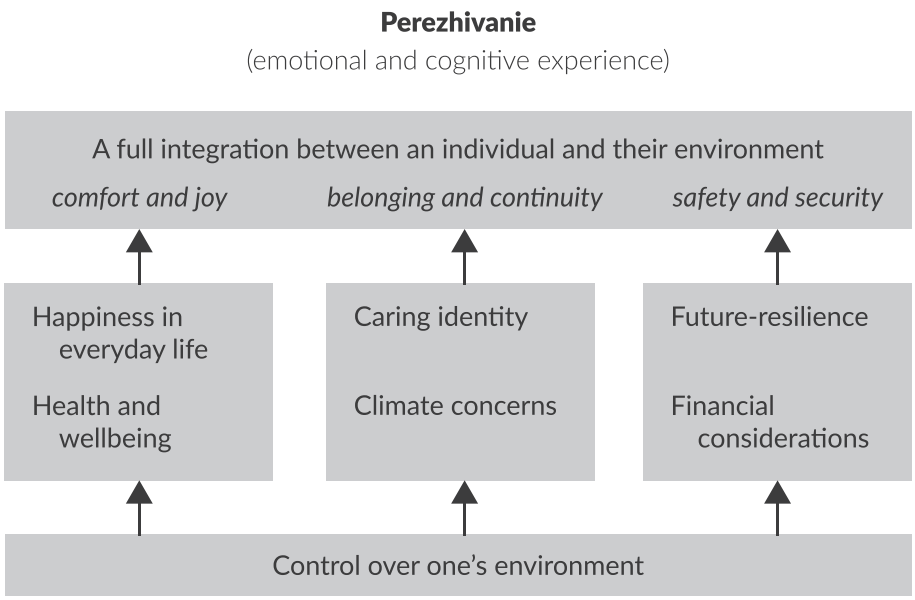

Fig. 3. Five themes of positive emotional and cognitive experiences (perezhivanie) associated with low-carbon dwellings.

in any kind of home" (C2), and to "inspire" (C4).

Energy retrofit is widely understood as able to address some of the homeowner *financial considerations*, and thus build a sense of *future-resilience*. In case C4, the owner explained: "I like the idea of being self-sufficient. The fact that I got a solar panel, helps me to feel that." In case C6, the configuration of the on-site heating technologies meant that "even on the coldest winter day, we know we can heat the house with the power cut for three days in snow". As governments around the world commit to a long-term net-zero target, there is a growing understanding that energy retrofit can futureproof one's property investment, so "you have security that your house won't be obsolete if and when you have to sell it" (WP21_dem). As this future unfolds, more and more properties will be retrofitted to low-carbon standards. Therefore, if households "don't retrofit their properties against others that have been upgraded, their property value [will be] going down" (WP29_ind). Energy retrofit can build resilience against that potential future loss in the property value. In case C8, the owners spoke about financial resilience in their old age:

> C8-homeowner1: We think prices are going to rise, and our income isn't. So, we are worried about being sustainable in our old age.
> C8-homeowner2: Yeah, I mean certain things are guaranteed that you are going to have to pay for. No matter where you are in life. From council tax to energy bills and to utilities. And as you do get to fixed incomes, you get older, it'd be nice to mitigate some of those costs.

A full integration between an individual and their environment describes a situation when one's home becomes one's primary anchor in space and time. This is achieved through the diversity of relations the home setting offers to an individual across different physical and temporal dimensions. The following emotional responses characterise the unifying outcome of the last three themes described above: (i) feelings of *joy, happiness and comfort* in a cosy, warm place with a healthy indoor environment, e.g. described as "better, nicer environment to live in" in case C3; (ii) feelings of *belonging and continuity*, as the identity of one's home becomes interlinked with the identities of its inhabitants with time, e.g. the owner in case C4 explained: "I've put my stamp on it. I have certainly not built it, but I have, to a certain extent, created it"; (iii) feelings of *safety and security* in a place that one thinks is future-resilient, e.g. the owners case C8 spoke of "economic security in the future" due to significantly reduced energy use and associated energy bills.

For the analytical purposes of the paper, we distilled the aspects of home-meanings that particularly resonate with the benefits of low-carbon dwellings. However, the owners themselves made no such distinction. For them, it was their homes, they thought of them in a holistic manner with both low-carbon-related and non-low-carbon-related aspects forming a part of a single whole. The owner in case C7 used the following statement to highlight this holistic nature: "We have tried to make it so it's just like a normal home, it is not an eco-facility, if that makes sense."

4.2. Home for the Common Future (HCF) as a cognitive frame

The authors have constructed a Home for the Common Future (HCF) heuristic to help stakeholders to promote the benefits of low-carbon dwelling to homeowners by building compelling narratives. The heuristic captures only three out of five themes of emotional and cognitive experiences described in Section 4.1., as the themes of 'control over one's environment' and the 'a full integration of an individual and their environment' are implicit in achieving positive experiences associated with low-carbon dwellings. The simplification also helps to crystallise the core argument and aid communication of the idea. To convey the

Fig. 4. Home for the Common Future (HCF) heuristic to promote low-carbon dwellings.

underlying rationale, emotional and cognitive reasoning are separated out. Emotional experiences include: (i) **H**appiness in everyday life, (ii) **C**aring identity, (iii) **F**uture-resilience. Cognitive experiences include: (i) **H**ealth and well-being, (ii) **C**limate concerns, (iii) **F**inancial considerations. The three themes are synthesised into a single heuristic – **H**ome for the **C**ommon **F**uture (HCF). The acronym HCF can simultaneously be used to refer to the heuristic itself, or to separately describe motivations involving emotional and cognitive reasoning (Fig. 4). The inspiration for the heuristic title was taken from the project workshop, where one of the participants suggested "Home of the Future" as a heuristic to talk about low-carbon dwellings, as a "next model up" from non-low-carbon dwellings (WP13_int).

To build emotionally and cognitively compelling narratives to encourage domestic energy retrofit, we suggest showing how one of the three positive *emotional and cognitive experiences* in HCF emerges in the interaction between one's *environment* and *activities*, and results in a *full integration with it*, given *control over one's environment*. Ideally, all five dimensions of the home-meanings framework (Fig. 1) should be considered when building a narrative. Project workshop participants used the earlier version of the home-meanings framework, which featured concepts of perezhivanie, affordance and practice, to create a variety of narratives. See Box 2 for an example of such a narrative.

5. Discussion

The authors make a number of contributions in this paper. We introduce the method of associative experiments to energy research (see Section 3.1.3. Associative experiments), which is a methodological contribution. We contribute to widen the theoretical choice in energy research by introducing the concept of perezhivanie and applying it to formulate a conceptual framework of home-meanings. We contribute to the literature arguing that a successful promotion of domestic energy retrofit should look beyond techno-economic influences and consider socio-cultural ones [20,22,85–87]. In particular, we contribute to the growing debate on the importance of understanding the multidimensional meanings of home to fully grasp the diversity of such socio-cultural influences on domestic energy retrofit decisions [19,27].

The choice of perezhivanie as an integrative concept to understand home-meanings and retrofit decisions finds support in the literature, which recognises that retrofit decisions entail high emotional and cognitive involvement [88]. This conceptual choice also resonates with innovation and technology literature that highlights the importance of both emotion and cognition in evaluating and choosing various technologies, including energy-related ones [7,89]. The range of positive emotional and cognitive experiences associated with low-carbon dwellings identified in this paper corresponds with the insights from the literature on energy retrofit motivations, which are historically framed as drivers and barriers to retrofit [86,90–93], but have recently embraced a more holistic approach [19,20,85,87,94–100].

The use of cognitive framing to understand and shape the trajectory of homeowner domestic energy retrofit motivations finds support in the literatures of innovation and technology, discourse and social marketing. *Innovation and technology* literature uses the concept of 'technological frame' to explain its role on the way actors make sense of a technology and evaluate its usefulness, before taking an action to adopt the technology [101]. Technological frames influence how various technologies get imbued with specific meanings (e.g. comfort, identity or status), and subsequently, influence the willingness of individuals to use existing technologies or shift to new ones [7,102,103]. Energy research and climate change literature acknowledge the importance of *discourse* for explaining the current carbon lock-in and facilitating change [104]. Novel narratives are seen as a key enabler to break away from the established values, norms and status quo, and encourage societal transformation [105–108]. For instance, discourses that portray plant-based diets as healthy help to increase the share of such diets in the population [7]. Finally, *social marketing* approaches have gained prominence among governmental actors seeking to engage the public on climate change [109]. They predominantly focused on shaping the

Box 2
'Retiree pension pot lump sum' narrative, created during one of the breakout sessions of the project workshop by WP21_dem, WP19_int, WP22_ind and WP20_aca.

WP22_ind: I like the retiree, retiree pension pot lump sum, worried about getting colder in their own home. I'm going to get weaker and more sedentary, so, I am planning for the future.
WP21_dem: And they don't want lots of hassle. You know, their home is probably fairly settled as to how they want it. So, if you are coming in and promising something very disruptive, you may not have a high tolerance of that in that age group. So, you are looking at promises over the nature of the activity being suitable and fitting within your lifestyle in terms of the actual physical retrofit.
WP20_aca: So low disruption… is there a way to have new practices with the non-gas future?
WP22_ind: We could say that the heating system would retain radiators because it's familiar, and they use what's familiar. But we might change the heat source, which they probably wouldn't need to know or worry about. If we move to the point of retirement, maybe there is a point of change there, which is quite useful. Even if you are at the same house, actually…
WP20_aca: So, maybe also staying longer indoors, so you want an environment that allows constant temperatures.
WP21_dem: Yes, and that sort of connects to… You're changing your identity, going from a "worker" to a "retiree". And, so, capturing the ideas and changes that experience will bring to you and what positive things you'll get as a result of that change. That seems like a useful thing. I've had experience of retrofit clients in the past, who've been exactly that category — bought a place to retire. So, they wanted to make it comfortable for their retirement and they didn't want to pay energy bills. So, we kind of did everything around that.
WP20_aca: Yes, I think, having lower running costs is a value for them. They are probably scared of having a lower budget…
WP22_ind: Yes, it's that pot of money, as we said. You've got this pot, you don't know how long you're going to live, so you have to "eek it out" as much as possible…
WP20_aca: Sounds good, so you have control of your future…
WP22_ind: So, the familiar controls, this sort of practice. Rather this sort of familiarity with your environment
WP20_aca: Yeah, so you're not making it more complicated, you're… you feel greener, you feel more related to the future, because you have something that is not going to be obsolete, but you don't have difficult new practices to learn.
WP7_supply: And we're not required to put in that extra effort just to be greener…
WP20_aca: And as you're going to be more comfortable, you can probably have more activities at home, you feel more inclined to have more people around, because it's not a cold and damp place.

context within which decisions are made, i.e., 'nudging' individuals [110]. It has been argued that this is not enough, that we cannot simply 'nudge' our way to sustainability [111], and that 'deep framing' approaches are required [109].

The authors argue for a more holistic approach to promoting domestic energy retrofit, which draws attention to individuals' emotions, such as the feelings of comfort, joy, happiness, belonging, continuity, control, safety and security. The idea itself is not new. Especially occupant health and comfort has long been recognised as a strong benefit of low-carbon dwellings and a powerful reason to carry energy retrofit (e.g. [112]). The contribution of the paper to policy lies in bringing together the diversity of possible benefits associated with low-carbon dwellings into a single framework (Fig. 3), grounded in a broader literature of meanings of home, and the development of a heuristic that can be used by different actors to create motivation narratives (Fig. 4). Currently, stakeholders relevant to the success of the widescale energy retrofit programmes often have different and sometimes conflicting understandings on how the homeowners themselves perceive the benefits of low-carbon dwellings. For instance, it has been consistently reported that building practitioners can assume a very narrow set of homeowner motivational priorities, primarily focused on energy bill reduction [113]. Given that the return on investment for many measures is long-term and uncertain, the practitioners can choose to pro-actively protect their customers, and not suggest or even discourage them from energy retrofit, arguing that it is not cost-effective [114–116]. For such practitioners, the suggested frameworks will provide a powerful aid to broaden their understanding. Undoubtedly, there are many practitioners who understand the emotional benefits of low-carbon dwellings and use them to encourage energy retrofit (e.g. [117,118]). For such actors, the suggested frameworks can serve as a common point of reference. Indeed, if the frameworks get accepted as a common point of reference and become widely used, they have a potential to usher a paradigm shift, accelerate the rate of domestic energy retrofit, minimise operational energy use and associated carbon emissions, and mitigate global environmental change.

6. Conclusions

The authors developed a framework of home-meanings (Fig. 1) around the concept of perezhivanie (emotional and cognitive experience) to capture various dimensions of the notion of one's home. It was used to identify five themes of positive emotional and cognitive experiences associated with low-carbon dwellings (Fig. 3). The home-meanings framework together with the identified five themes can be used conceptually to direct further research on motivating domestic energy retrofit. The auhtors also illustrates the use of the framework to create narratives for energy retrofit promotion, which resonate with homeowner cognitive and emotional reasoning. Three out of five identified themes of positive emotional and cognitive experiences associated with low-carbon dwellings are combined into a single heuristic that is aimed to shape homeowner cognitive frames — **H**ome for the **C**ommon **F**uture (HCF) (Fig. 4). The acronym can simultaneously be used to describe motivations involving *emotional* reasoning – **H**appiness in everyday life, **C**aring identity, **F**uture-resilience, as well as *cognitive* reasoning – **H**ealth and well-being, **C**limate concerns and **F**inancial considerations. To build compelling narratives, it is suggested to show how *control over one's environment* can afford the experiences in the HCF framework, and how such experiences lead to *a full integration between an individual and their environment*. All these experiences should be shown to arise from one's *environment* and *activities*.

Several possibilities for future research exist. First, the diversity of possible communication strategies for a successful implementation of the HCF framework could be explored. For instance, visuals can be used alongside text for greater success in motivating positive cognitive frames, as images require less cognitive effort than text and can generate a stronger emotional appeal [119], and text and visuals function best in combination [120]. Appendix K provide examples of the illustrative images for some of the narratives generated during the project workshop. Second, the empirical data for this research is UK-based, while the literature on home-meanings utilised in the paper draws heavily on the insights from the white male population of the Western world. Future research can explore the meanings of home and low-carbon home among a more diverse set of groups and contexts. The thoroughly detailed methodological steps documented in this paper will aid researchers in this pursuit. Third, future research can look at tenure types other than homeowners and take a market segmentation approach to make meaningful narrative specific to different population categories. Finally, future research can investigate the formation of negative experiences associated with low-carbon dwellings and outline strategies to avoid them.

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CRediT authorship contribution statement

Yekatherina Bobrova: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. **George Papachristos:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. **Lai Fong Chiu:** Conceptualization, Supervision, Writing – review & editing. **Svetlana Tikhomirova:** Conceptualization, Methodology. **Thomas M. Coon:** Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data

Data from the project workshop is available at https://doi.org/10.5255/UKDA-SN-855219

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Appendices A-K. Supplementary data:

Supplementary data (Appendices A-K) to this article can be found online at https://doi.org/10.1016/j.erss.2023.103358.

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APPENDIX A

Table A.1 summarises the variety of fabric, ventilation, heating and energy generation measures installed by the homeowners in the study sample.

Table A.1. Summary of dwelling characteristics

Case	Walls	Roof	Floor	Windows	Air-tightness[1]	Heating and cooling	Ventilation and moisture control	Lighting and appliances	Energy generation	Non-energy-related renovation/ retrofit[2]
Confirming cases: achieved significant carbon/ energy reductions as a result of retrofit activities										
C1	Solid brick walls, *breathable IWI on the ground floor, non-breathable IWI upstairs*	*Converted warm loft*	Suspended timber floor, *insulated*	*DG, TG*	*Low leakage, airtightness test carried out*	*Condensing boiler with CH in the flat, no heating downstairs*	*MVHR, 25mm cavity between IWI and the wall upstairs*	*Low energy lighting; at least A+ appliances*	*STE*	*Structural and utility, amenity, aesthetics and lifestyle*
C2	*IWI*	Cold loft, *habitable*	Suspended timber floor, *insulated*	*DG argon-filled with shutters*	*Intermediate leakage, draft through chimneys*	*Heating: electric UFH, zone control in each room; cooling: AC with ATA heat pump*	*Natural*	*LED, at least A+ appliances; voltage optimizer*	*PV, battery tank*	*Structural and utility, amenity, aesthetics and lifestyle*
C3	Solid brick walls*, front – IWI, back – EWI; PWI*	Cold loft, *insulation*	Uninsulated solid concrete kitchen floor, *insulated* suspended timber floor elsewhere	*DG*	*2 $m^3/(m^2 \cdot h)$ @50 Pa*	*Condensing boiler with CH, wood-burning stove*	*PVHR, trickle vents, damp proof course, insulation with vapour control layer*	*CFL/ LED, A+ rated appliances*	None	*Structural and utility, amenity, aesthetics and lifestyle*

Table A.1. Summary of dwelling characteristics

Case	Walls	Roof	Floor	Windows	Air-tightness[1]	Heating and cooling	Ventilation and moisture control	Lighting and appliances	Energy generation	Non-energy-related renovation/ retrofit[2]
C4	Solid brick walls, *IWI*, uninsulated extension	Cold loft, *insulation*	Original house – *insulated* suspended timber floor, extension – uninsulated solid floor	SG, DG, *secondary glazing*	*Intermediate leakage*	*Heating: Condensing boiler with CH, learning thermostat, multi-fuel stove; cooling – a fan*	Natural, *reported some localised condensation and draughts*	*CFL/ LED, at least A rated appliances*	*PV, STE*	*Structural and utility, amenity, aesthetics and lifestyle*
C5	Solid brick walls, *original house – IWI, extension – EWI*	*New roof, warm loft*	Suspended timber floor, *insulated*	*Replaced and restored DG, secondary glazing*	*Intermediate leakage, draught proofing, balloons in the chimney*	*Condensing boiler with CH*	Natural	*Energy efficient lighting and appliances*	*PV, STE*	*Structural and utility, amenity, aesthetics and lifestyle*
C6	Cavity brick walls, *CWI*	*New roof, cold loft with insulation*	Solid floor, *insulated*	*DG argon filled*	*Low leakage*	*Wood pellet boiler, wood burning stove, water UFH; eight heating zones on the ground floor, no heating on the first floor*	*MVHR (heating switched off)*	*CFL/ LED, A rated appliances*	*PV, STE*	*Structural and utility, amenity, aesthetics and lifestyle*
C7	Solid brick walls, *EWI*	*New roof, insulated*	Suspended timber floor, *insulated*	*Passivhaus certified*	*Passivhaus certified*	*Condensing boiler with CH*	*MVHR*	*LED, at least A+ rated appliances*	*PV, STE*	*Structural and utility, amenity, aesthetics and lifestyle*
C8	Solid brick walls, *EWI*	*Warm loft*	Suspended timber floor, *insulated*	*DG, TG*	*High leakage, still have draughts*	*Condensing boiler, wood burning stove, water UFH with thermostats in every room*	Natural, *reported draughts*	n/a	*PV*	*Structural and utility, amenity, aesthetics and lifestyle*

Table A.1. Summary of dwelling characteristics

Case	Walls	Roof	Floor	Windows	Air-tightness[1]	Heating and cooling	Ventilation and moisture control	Lighting and appliances	Energy generation	Non-energy-related renovation/ retrofit[2]
C9[3]	Brick blocks cavity walls with partial film insulation*; bay window CWI*	Cold loft, *insulated*	Solid concrete ground bearing floor, insulated	*DG with low-e coating*	*2 $m^3/(m^2 \cdot h)$ @50 Pa*	Gas condensing boiler *with eight-zone wireless controller*	Natural, *sealed extract fan ducts in the bathroom*	*CFL/ LED, at least A++ rated appliances, wireless metering system*	STE, *PV*	*Amenity, aesthetics and lifestyle*
C10	Solid brick walls, *EWI, AWI*	*New roof, warm loft*	Suspended timber floor, *insulated*	*DG, including DG for roof windows*	*Intermediate, leakage, sealed the floorboards with silicon*	*Heating: gas condensing boiler with remote controller; cooling: fans in kids' rooms*	Natural, *re-introduced air bricks*	*LEDs, at least A+ rated appliances, tumble drier*	None	*Structural and utility, amenity, aesthetics and lifestyle*
Disconfirming cases: did not achieve significant carbon/ energy reductions as a result of retrofit activities										
D11	Solid brick walls, uninsulated	Cold loft, minimal insulation	Suspended timber floor, *covered with laminate with thermal underlayer*	SG, DG	High leakage	*System condensing boiler*	Natural, *reported localised draught and mould*	*LED, at least A+ rated appliances*	None	*Aesthetics and lifestyle*
D12	Solid brick walls, uninsulated	Cold loft, minimal insulation	Suspended timber floor, uninsulated	DG	High leakage	Combo condensing boiler	Natural	Halogen, *phased out with LED*	None	*Structural and utility, aesthetics and lifestyle*

Table A.1. Summary of dwelling characteristics

Case	Walls	Roof	Floor	Windows	Air-tightness[1]	Heating and cooling	Ventilation and moisture control	Lighting and appliances	Energy generation	Non-energy-related renovation/ retrofit[2]
D13	Main house – solid brick walls, uninsulated; Side return extension – minimal insulation	Main house – warm loft; extension – *new roof, insulated*	Main house – suspended timber floor, uninsulated; extension – solid floor, uninsulated	Main house – DG, *some replaced with low-e coating DG, blackout blinds*; extension – *TG highlights*	High leakage	*Condensing boiler, learning thermostat with remote control*	Natural, *electric heater in the corner of the master bedroom wardrobe to prevent condensation*	Halogen, *phased out with LED; appliances phased out with top A-rated ones at the end of their life*	None, *switched to renewable energy provider*	*Structural and utility, aesthetics and lifestyle*
D14	Solid brick walls, *foil behind wall panelling in one of the bedrooms*	Main house – n/a (ground floor flat); extension – some insulation	Main house – suspended timber floor, uninsulated; extension – solid concrete floor – uninsulated	SG, *two windows replaced with DG*	High leakage	*Condensing gas boiler, radiators with thermostatic valves, remote heating control, one portable electric heater*	Natural, *dehumidifier, reported draught and mould*	Halogen, CFL, LED		*Structural and utility, aesthetics and lifestyle*
D15	Solid brick walls, uninsulated	n/a (ground floor flat)	Suspended timber floor, uninsulated	DG	High leakage	Condensing gas boiler	Natural, trickle vents, *reported localised mould*	Halogen, *LED*	None	*Aesthetics and lifestyle*
D16	Thermocrete cavity wall with an outside brick leaf	Cold roof, insulated	Concrete floating floor	DG	Intermediate leakage	Electric storage heaters, *one portable electric heater*	Natural, *reported localised condensation and mould*	CFL, LED	None	*Amenity, aesthetics and lifestyle*
D17	Brick cavity walls, uninsulated	Cold loft, *insulated*	Suspended timber floor, uninsulated	DG	High leakage	*Combi condensing gas boiler with remote control*	Natural, *use of conservatory for drying clothes, reported mould*	*Halogen, SFL*	None	*Aesthetics and lifestyle*

Table A.1. Summary of dwelling characteristics

Case	Walls	Roof	Floor	Windows	Air-tightness[1]	Heating and cooling	Ventilation and moisture control	Lighting and appliances	Energy generation	Non-energy-related renovation/ retrofit[2]
D18	Solid brick walls, uninsulated	n/a (ground floor flat)	Not known	*DG*	High leakage	*Condensing boiler, electric heater in the bathroom, one portable electric heater*	Natural, *air cabinet, trickle vents, dehumidifier, reported condensation from the outside wall*	Tungsten, halogen	None	*Structural and utility, aesthetics and lifestyle*

Note: Walls: **AWI** = acoustic wall insulation; **CWI** = cavity wall insulation; **EWI** = external wall insulation; **IWI** = internal wall insulation; **PWI** = perimeter wall insulation.
Windows: **DG** = Double glazed windows; **SG** = single glazed windows; **TG** = triple glazed windows.
Heating/ cooling/ ventilation: **AC** = air conditioner; **ATA** = air to air (heat pump); **CH** = central heating; **MVHR** = mechanical ventilation heat recovery; **PVHR** = passive (stack) ventilation heat recovery; **UFH** = underfloor heating.
Lighting: **CFL** = compact fluorescent lamp; **LED** = light-emitting diode.
Appliances: **A-rated appliances** – refers to an energy consumption labelling scheme, which rates energy efficiency in terms of a set of classes from A+++ to G, with A+++ being the most energy efficient.
Energy generation: **PV** = photovoltaics; **STE** = solar thermal energy.
Carbon/ energy rating: **CHS4** = code of sustainable homes level 4, which is a former environmental assessment method for rating the performance of dwellings in the UK. Level 4 indicates that a dwelling achieved 44% better energy standard than required by the UK Building Regulations: Approved Document L (2006) – 'Conservation of Fuel and Power.' **EPC** = The Standard Assessment Procedure (SAP) represents the government's official method of rating the energy efficiency of the houses, which has been used since 2003. The rating is using a non-linear scale from A to G with higher rates indicating lower annual energy costs and, thus, better energy efficiency.

Text in italics indicate changes achieved as a result of retrofit activities of the owners in the sample.

[1] A visual assessment of the airtightness of the properties was done by the first author to distinguish between low, intermediate and high leakage.

[2] The following categories of non-energy-related retrofit are distinguished (Bobrova et al., 2022): (i) structural and utility works, e.g., a replacement of a worn-out roof in case C5; (ii) amenity retrofit, e.g., a complete reconfiguration of the internal space in case C6 and the extension of the property by over 50%; (iii) aesthetics and lifestyle retrofit, e.g., a use of reused, restored and reclaimed wood for floorboards in case C10.

[3] In case C9, the owner chased the house builder and original installers and forced them to fix poor construction, including filling in the cavity in the bay window wall and eliminating thermal bridge there; doubling the loft insulation to meet regulatory requirements; replacing some of the scratched double-

glazed windows and doors; putting extra seals for windows for them to close properly; introducing zone heating to meet regulatory requirements; sealing ducts from the bathroom vents and repainting the ceiling as the moisture from the unsealed ducts accumulated and created a wet patch; sealing the sewer drain under the floor; refitting and sealing the shower. The owner himself sealed some of the leaks identified through thermal images.

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APPENDIX B

Table B.1 summarises question topics for semi-structured interviews with homeowners.

Table B.1. Question topics for semi-structured interviews with homeowners

Topic	Sub-topic	Purpose of the topic
General household information	▪ Contact information ▪ Household characteristics	▪ Depict household characteristics in the period of retrofit activities ▪ Establish preferred contact method
Retrofit process. Narrative	▪ Dwelling characteristics before and after the retrofit ▪ Timing of the retrofit journey	▪ Get information on house configuration, structure type, internal and external conditions prior and post retrofit ▪ Get a chronological order of the retrofit process
Retrofit process. timeline	▪ A graphical timeline of the retrofit journey	▪ A prompt for the participants to recall more memories regarding the retrofit as they see a condensed presentation of a retrofit journey on a single graph
Retrofit goals and motivations	▪ Rationale for each installed measure ▪ Possible influences on decision process for each measure ▪ Emotional relations between the participants and their dwellings (What do you like about your home? What are you proud of? What does your ideal home look like?) ▪ Pre- and post-retrofit living experience	▪ Use different questions to gather information on homeowner retrofit intentions, the meanings of home/ low-carbon home and energy retrofit ▪ Use different questions to gather information on lived-in experiences associated with low-carbon dwelling
Associative experiments	Continuous associations for words: ▪ Home ▪ Low-carbon home	▪ Gather information on similarities and difference between the notions of ‘home’ and ‘low-carbon home’ for the participants
Practices affecting domestic energy use	Gather information on different routines to achieve comfort, the associated use of resources, the role of structure, technology and behaviour to minimise associated energy use: ▪ Heating/ cooling ▪ Ventilation and moisture control ▪ Lighting ▪ Electricity use by appliances ▪ Water use	▪ Gather information on household energy-related behaviour ▪ Get an impression of the household commitment to minimise resource and energy use ▪ Gather information on the household understanding on the potential role of structure, technology and behaviour to minimise resources and energy use
Walk-through	▪ Retrofit-related stories ▪ Emotional relations between the participants and their dwellings (What do you like about your home? What are you proud of?)	▪ A prompt for the participants to recall more memories regarding the retrofit as they see the measures ▪ Gather further information on what home means for the participants

APPENDIX C

Table C.1 illustrates homeowners' responses to associative tasks.

Table C.1. Results of the associative tasks

Case	Home	Low-carbon home
Confirming cases: achieved significant carbon/ energy reductions as a result of retrofit activities		
C1	Calm, inspiring, comfortable, open, practical, easy to maintain, coherent	Careful, engaged, understanding, concerned, open-minded, forward-looking, conscious, environment-conscious, long-term
C2	Comfort, peace, calm, retreat, energy, beauty, love, care, oasis, paradise, garden of Eden	The same, I would say, paradise
C3	Cosy, community, roots, family, comfortable, warm, homely, rest, sleep, food, shelter	Comfortable, low cost to run, healthy, warm, quiet, peaceful, considerate, sustainable
C4	Safe, comfortable, peace, somewhere to be peaceful, relaxation, identity, cosy, calm	Inexpensive to run, quite modern, minimalistic, Passivhaus, a bit sterile, Grand Design, modern architecture, not cosy, airtight with mechanical ventilation
C5	Comfortable, pleasant, functional, cosy, space, work, chores, personality, reflecting my personality	Efficient, low energy consumption, comfortable, It's where the money is put where it doesn't get seen. So, people can't notice the difference. But it's put where it should be. Sustainable, resilient
C6	Family, comfort, a place to relax	n/a[1]
C7	Where your family is; high standard from an environment point of view and cosiness; high standard of design. A space where me, us and our children just feel comfortable in. Like I sit down, and it just ok, it just feels good. Fun and joy, peaceful, warm, cosy, comfortable, healthy, family and friends, kitchen, cooking	Comfort, health, sustainable, I'm proud to have one, very comfortable and good air quality. It's never cold, it's not warm, you can control.
C8	1: Family, warm, dry, safe, comfort, responsibility, DIY. 2: A room of my own, warm, celebration, safe, food, fun, kind of a workshop, children, friends, Christmas, pension, something about old age, continuity.	1: Sensible, being efficient. There is no reason not to be efficient. Efficiency. 2: Responsibility, citizenship. The whole world is safe, protected. It's much more national and global and then just us. Neighbourly.
C9	Comfort, secure, family	Future secure. We don't do this for us, we are not doing this for ourselves to be honest. Because what I am doing now has no impact in my lifetime. It's all about the future.
C10	Family, warmth, glowing warmth, I think of my parents and our house where I grew up, but I also think of just family being the main thing, so my children, my husband, somewhere safe, community and security, and a place to be yourself and relax and unwind, somewhere you can just recharge from the craziness of London especially comparing home in London vs home in other places.	Exciting or desirable, but I also think difficult to achieve in London. So expensive to achieve that or to get that. But if you have that [low-carbon home], you could feel good about that and it's an asset over time that you are helping something bigger, but it's also good for you.

Table C.1. Results of the associative tasks

Case	Home	Low-carbon home
Disconfirming cases: did not achieve significant carbon/ energy reductions as a result of retrofit activities		
D11	Comfort, warm, safe, mine	Exactly the same [as home] … I would add – proud
D12	Warmth, feeling warmth, a place where you can relax you can forget about your work, it is about having fun with the children and doing fun things ... maybe cooking and those are all with the children. Some of all these are with the children, making chocolate, all those or whatever. It's about clean, it's about having nice time with your friends, people you like, but I would say in one sentence that it is something to dissociate from your work life.	Where you don't have to spend a fortune when you pay energy bills. It doesn't feel as cold during the winter or as hot during the summer, so you feel comfortable throughout the year, no matter what the weather conditions are. It is where you have used sensibly, when you make a change, materials that are organic or sustainable materials. It is here you don't keep doing a lot of changes either because the more changes you do, the more energy you spend... it's finding that right balance.
D13	Safe, secure, warm, quiet, comfortable	More comfortable, cheaper, super comfortable, super low cost
D14	People, comfort, cosiness, and restfulness, and peace, quiet and organised, clean and sense of history and loving and beautiful, stimulating, restful, and haven… garden. Garden is everything associated with beauty and peacefulness and stimulating and also energising.	Quite negative thoughts: small windows, lack of beauty, of all of the quirkiness ironed out of a house. Aspects that I love about the idea of low carbon homes: could be lovely, warm and cosy, it can be free of draft, therefore free of dust as well. But can be devoid of personality, devoid of beauty.
D15	Relaxation, comfort, warm, spiritual	Environmentally friendly, technical
D16	Security, peace, quiet, safety, belonging, storage, community, roots, expense, obligations	Environmentalism, sustainability, high performance, low cost, responsibility, investment, cost, management, maintenance, value, green wash, bling, unmanageability, definition
D17	House building, some sense of permanence, family, ownership, comfort, where you came from	Energy efficient, well insulated, air tight, renewable generation, good controls, good boiler, well designed, new buildings, very often not very well delivered, lots of problems, lots of problematic issues, sometimes may be restricted in design so not very interesting, just quite contained, boxy, good glazing
D18	Comfort, relaxation and happiness	Environmentally friendly, energy efficient

Note: [1] For the confirming cases, the interviewees were carried out in two rounds. The owner in case C6 was not available for the second round of interviews. Thus, only answers given during the first round of interviews were incorporated in the analysis for this case.

APPENDIX D

Table D.1 illustrates a coding scheme.

Table D.1. Coding scheme

Themes and subthemes	Description	Reference
Elements of the environment		
Physical and spatial elements	One's home can be embodied in different *physical* structures such as a house, yurt, truck, caravan, tent. Physical elements commonly include the type of structure of the dwelling, its size, spatial organisation, aesthetical characteristics, neighbourhood characteristics and the facilities available such as gardens and parks.	(Després, 1991)
	Various *spatial* dimensions are covered by the spatial elements, such as a house itself, neighbourhood, hometown, homeland, nation or the whole world.	(Blunt and Dowling, 2006; Mallett, 2004)
Self and social elements	Various characteristics associated with home can be constructed at a scale of one's body and *self*. Phenomenological research describes the ideas of home as a state of being-in-the-world, being one's self.	(Blunt and Dowling, 2006; Mallett, 2004)
	Home is a societal entity and a platform for *social* relations, most commonly associated with one's family. Other social groups can be associated with one's home, such as friends or ethnic groups.	(Blunt and Dowling, 2006; Coolen and Meesters, 2012; Saunders and Williams, 1988)
Financial and legal elements	Financial and legal elements of the environment are used in the framework to describe the occupant's type of tenure, such as owner-occupancy or tenancy; modes of land ownership, such as private ownership or lease; and to suggest that a house can be a financial asset.	(Fox, 2002)
Activities		
Recurring	Home as a setting is associated with the recurring character of everyday activities and mundane aspects of everyday life, such as eating and cooking. Repeated activities, including mundane, seasonal and cyclical ones, tend to be performed in a fixed way, which means they begin to 'bind' you. Places and things get symbolically meaningful by this process of time binding.	(Manzo, 2003; Merloo, 1966, as cited in Westman, 1995)
Temporary	Formative experiences can shape one's associations with home, such as learning to be independent or living through a stressful period. Home retrofit is an important temporary experience, as place becomes meaningful through the process of acting upon and modifying one's dwelling.	(Després, 1991; Proshansky et al., 1979 as referenced in Sixsmith Sixsmith, 1986)
Perezhivanie (emotional and cognitive experience)		
Health and wellbeing & Happiness in everyday life	Low-carbon dwellings are good for ones' health and wellbeing, primarily as a result of improved thermal comfort and indoor air quality. However, the spectrum of reasoning should be broader. As a result of a better control over the indoor environment in a low-carbon dwelling, it is easier to achieve desired thermal comfort, indoor air quality, and often – acoustic and lighting settings. As such, a low-carbon	The theme is derived inductively from the data

Table D.1. Coding scheme

Themes and subthemes	Description	Reference
	dwelling provides a better platform to achieve what one is striving for in one's home – happiness. What happiness manifest in, depends on individual, e.g. reading a book on your own or spending time with family and friends. A low-carbon dwelling provides a better platform to reach this goal.	
	Literature support:	
	Cognitive reasoning: health and wellbeing. Low-carbon dwellings are associated with multiple benefits to human health and wellbeing.	(Shrubsole et al., 2014)
	Emotional reasoning: happiness in everyday life. Emotional aspects for this theme are captured in the feelings of happiness, joy and comfort. See 'a full integration between an individual and their environment' code for further details.	
Climate concerns & Caring identity	Energy retrofit can help minimise operational energy use and mitigate climate change. Thus, it aids an individual desire to do one's part to save the planet. Such reasoning goes beyond cognitive aspects and includes emotional aspects of one's *caring identity*. Such identity manifests in one's ability to live with and towards others, to recognise and express concerns for other people, future generations and the world of nature. One can express such identity through personalisation, modification (energy retrofit) and operation of one's house. A person can then take pride for doing the right thing, especially if it is recognised and felt normatively important.	The theme is derived inductively from the data
	Literature support:	
	Cognitive reasoning: climate concerns. Energy retrofit can help minimise operational energy use and mitigate climate change.	(Creutzig et al., 2022)
	Emotional reasoning: caring identity. Home is a place, where identities its inhabitants are important. Home could be a symbol of self-expression, an active statement of how one would want to be seen by others on one hand, and a symbol of social status of its inhabitants on the other hand. One's identity can be expressed via personalisation of one's place, e.g. through retrofit.	(Després, 1991; Molony, 2010; Porteous, 1976; Somerville, 1997)
	Emotional aspects for this theme are captured in the feelings of belonging and continuity. See 'a full integration between an individual and their environment' code for further details.	
Financial considerations & Future-resilience	Energy retrofit can help reduce energy bills. Emotional aspects associated with energy bill reductions include the feeling of future-resilience against volatility of energy prices and a decrease of income at the old age. Energy retrofit can promote not only the feelings of financial resilience, but also those of climate resilience (a house is future-proof against the changing climate); policy resilience (a house is future-proof against future policy changes, such as the UK 2030 ban of gas boilers); and material resilience (a well-built sustainable dwelling will last longer).	The theme is derived inductively from the data

Table D.1. Coding scheme

Themes and subthemes	Description	Reference
	Literature support: *Cognitive reasoning: financial considerations*. Energy retrofit can reduce energy bills and increase property value.	(Creutzig et al., 2022)
	Emotional reasoning: future-resilience. Emotional aspects for this theme are captured in the feelings of safety and security. See 'a full integration between an individual and their environment' code for further details.	
Control	To be at home in a place, the feeling of control is of a paramount importance. Control is necessary to achieve all three themes of the Home for the Common Future framework: (i) one needs to be in control of one's environment to be able to adjust it and be *happy* and *healthy*; (ii) an ability to have control over modifying one's environment is an important element of expressing one's *identity*, including caring one; (iii) a sense of control over the situation leads to a feeling of *future-resilience*, including financial resilience.	The theme is derived inductively from the data
	Literature support: Home is a sole area of control for an individual.	(Després, 1991)
A full integration between an individual and their environment	A full integration between an individual and their environment describes a situation when one's home becomes one's primary anchor in space and time, through which one is centred. This is achieved through the diversity of relations the home setting offers to an individual across different physical and temporal dimensions. The diversity is captured by the three themes of the Home for the Common Future framework: (i) one feels a sense of *comfort, joy and happiness* in a cosy place with a healthy indoor environment; (ii) individual and place identity of one's home are closely interlinked, most notably visible in the feelings of *belonging and continuity*; (iii) future-resilience of one's environment contributes to the feelings of *safety and security*.	The theme is derived inductively from the data
	Literature support: *A full integration between an individual and their environment*. The diversity of relations the home setting offers to an individual across different physical and temporal dimensions makes home one's primary anchor in space and time, though which individuals are centred. Home is a symbolic hearth, a place of origin and return, a place from which one ventures into the world, and to which one generally wants to return.	(Blunt and Dowling, 2006; Coolen and Meesters, 2012; Després, 1991; Mallett, 2004; Porteous, 1976)
	Happiness in everyday life (comfort and joy). The experience of happy events and general feelings of happiness are an integral part of home. Home is a place of comfort, a place of privacy, a place where one could withdraw to and regenerate, a place where one can relax and be oneself, a place of refuge, a haven, a place of peace.	(Giddens, 1986; Heidegger, 1964; Mallett, 2004; Molony, 2010; Saunders and Williams, 1988; Sixsmith, 1986)

Table D.1. Coding scheme

Themes and subthemes	Description	Reference
	Caring identity (continuity and belonging). Identity of a place called home and the identities of its inhabitants become closely interlinked with time. As home becomes a familiar environment, it provides a sense of continuity, permanence and belonging, somewhere to have roots.	(Després, 1991; Smaldone et al., 2005)
	Future-resilience (safety and security). Home provides shelter for its inhabitants, a setting where one feels safe and secure. The common expression 'my house is my castle' reflects the importance of home to establish the feelings of security and resilience.	(Blunt and Dowling, 2006; Bohn, 1888; Saunders and Williams, 1988; Somerville, 1997)

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APPENDIX E

Table E.1 provides an illustrative extract for the cross-tabulation employed in the analysis. The extract shows meanings of home, identified in the literature as well as in home-owner associations for the dimensions of environment, activities and perezhivanie. All five themes of perezhivanie are captured: (i) control over one's environment; (ii) health and wellbeing & happiness in everyday life; (iii) climate concerns & caring identity; (iv) financial considerations & future resilience; (v) a full integration between an individual and their environment.

Table E.1. Meanings of 'home' and 'low-carbon home' in the literature and in the homeowner associations grouped around the concepts of environment, activities and 5 themes of perezhivanie.

Source[1]	**Home**	**Low-carbon home**
	Elements of the environment	
Literature	Lived space of interactions between people, places and things Physical and spatial: Adobe (place); aesthetic properties; body; dwelling size; homeland; hometown; household; material/ physical structure of the house; neighbourhood; shelter (materiality); type of structure of the dwelling; world Self and social: own self; (relationships with) family and friends Financial and legal: a place to own; type of tenure, e.g. home ownership	n/a
Homeowner associations	Physical and spatial: a room of my own; concrete floors; food; combined living/ kitchen/ dining areas; garden (south-facing); guest bedroom; kitchen; mix materials; open plan/ space; playroom for the children; PV; solar thermal panels; space (more space, but not too big with shared space); renewable energy technologies; study area; timber frame construction Self and social: friends; love; me; (my) child(ren); (my) family; (my) husband; (my) parents Financial and legal: co-housing	* *Many implicit in the theme 'Health and wellbeing & Happiness in everyday life'* Physical and spatial: Airtight; renewable generation *Negative: small windows*

Table E.1. Meanings of 'home' and 'low-carbon home' in the literature and in the homeowner associations grouped around the concepts of environment, activities and 5 themes of perezhivanie.

Source[1]	Home	Low-carbon home
	Activities	
Literature	Acting upon and modifying one's dwelling; centre of activities; cooking; day-to-day life; eating; everyday/ mundane/ ordinary/ recurring activities; formative experiences, e.g. living through a stressful period; individual and social activities; practices; (taken-for-granted) routines; seasonal and cyclical events, e.g. holiday celebrations; sleeping; staying, leaving and journeying	n/a
Homeowner associations	Celebration; chores; Christmas; cooking; DIY; having fun/ nice time/ doing fun things (with children, with your friends, people you like); house building; sleep; recharge; rest; unwind; work	Maintenance
	Perezhivanie: Control over one's environment	
Literature	Control (actual and perceived)	n/a
Homeowner associations	* *Implicit in the theme 'Health and well-being & Happiness in everyday life'*	It's never cold, it's not warm — you can control. *Negative (no control): difficult to achieve; lots of problems/ problematic issues; not very well delivered; technical; unmanageability.*
	Perezhivanie: Health and wellbeing & Happiness in everyday life	
Literature	* *Implicit in themes 'control over one's environment' and 'a full integration between an individual and their environment'*	n/a
Homeowner associations	Air quality (good); clean; daylight (lot of); dry; easy to maintain; functional; healthy; organised; practical; smell (good, e.g. of wood); quiet; views (good); workshop (kind of)	Air quality (good); controls (good); free of draught and therefore free of dust; glazing (good); good for you; health(y); heating (good, e.g. good boiler); organic or sustainable materials; performance (high); not as cold during the winter or as hot during the summer; well designed; well insulated

Table E.1. Meanings of 'home' and 'low-carbon home' in the literature and in the homeowner associations grouped around the concepts of environment, activities and 5 themes of perezhivanie.

Source[1]	Home	Low-carbon home
	Perezhivanie: Climate concerns & Caring identity	
Literature	Identity: experience of one's (possibly fluid) identity; indicator of personal and social status; reflection of one's ideas and values; symbol of self-expression	n/a
Homeowner associations	Identity: beauty(-iful); community; continuity; high standard of design; house where I grew up; identity; inspiring; mine; (reflecting one's) personality; not plain; old age; roots; sense of history; stimulating; roots; where you come from Caring aspects of one's identity: care; high standard from an environment point of view; obligations; responsibility	Identity: definition; desirable; neighbourly; new building(s); proud to have one *Negative (personal and place identity mismatch): devoid of/ lack of beauty (all of the quirkiness ironed out of a house); devoid of personality; Grand Design; minimalistic; modern architecture; Passivhaus; restricted in design (not very interesting, quite contained, boxy)* Caring aspects of one's identity: balance (don't keep doing a lot of change); careful; citizenship; concerned; conscious; considerate; energy efficient; engaged; environment-conscious; environmentally friendly/ environmentalism; forward-looking; helping something bigger; open-minded; responsibility; sensible; sustainability; understanding It's where the money is put where it doesn't get seen. So, people can't notice the difference. But it's put where it should be. We don't do this for us, we are not doing this for ourselves to be honest. Because what I am doing now has no impact in my lifetime. It's all about the future. It's much more national and global and then just us. *Negative (misuse of the caring identity): bling; green wash*
	Perezhivanie: Financial considerations & Future-resilience	
Literature	* *Implicit in themes 'control over one's environment' and 'a full integration between an individual and their environment', especially in the feelings of safety and security*	n/a
Homeowner associations	Expense; pension	Asset over time; efficient; energy bills/ costs (cheaper/ low/ super low); energy efficient; long-term; inexpensive/ low cost to run; investment; low energy consumption; sustainable; resilient; value *Negative: expensive to achieve*

Table E.1. Meanings of 'home' and 'low-carbon home' in the literature and in the homeowner associations grouped around the concepts of environment, activities and 5 themes of perezhivanie.

Source[1]	Home	Low-carbon home
	Perezhivanie: A full integration between an individual and their environment	
Literature	A place to be oneself; a place to withdraw and regenerate; being-in-the-world (being at home); belonging; comfort; continuity; ease; empowering; freedom; haven; hearth (warmth); heart (love); independence; intimacy; paradise (ideality, sense of spiritual security); peace; permanence; primary anchor in space and time; privacy; refuge from the outside world; relaxation; roots (source of identity); safe; shelter; security (ontological and physical) *Negative (no integration): alienation; estrangement; marginalisation; oppression; persecution; tyranny*	
Homeowner associations	A place to be yourself; belonging; coherent; comfort(able); cosy(-iness); energising; fun; garden of Eden; happiness; haven; homely; joy; loving; peace(ful); energy; oasis; paradise; peace(fulness); pleasant; relaxation/ a place to relax/ a place to forget about your work; restful(ness); retreat; safe(ty); secure(-ity); shelter; spiritual; (glowing) warm(th). A space where me, us and our children just feel comfortable in. Like I sit down, and it just ok, it just feels good.	(More/ super/ very) comfort(able); cosy; exciting; garden of Eden; lovely; peace; energy; oasis; paradise; peaceful; retreat; quiet; (very) comfort(able); warm. The whole world is safe, protected. *Negative (no integration): a bit sterile; not cosy (e.g. airtight with mechanical ventilation)*

Note: Meanings are listed in an alphabetical order.

We chose not to duplicate the list of meanings, where they fit in more than one theme. The possibility of a duplication was acknowledged with notes, starting "*implicit in (the) theme(s)…"

[1] The following literature sources were analysed: (Benjamin, 1995; Blunt, 2005; Blunt and Dowling, 2006; Blunt and Varley, 2004; Coolen and Meesters, 2012; Després, 1991; Easthope, 2004; Fox, 2002; Heidegger, 1964; Mallett, 2004; Manzo, 2003; Molony, 2010; Moore, 2000; Saunders and Williams, 1988; Sixsmith, 1986; Somerville, 1997).

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APPENDIX F

Table F.1 illustrates to credibility strategies employed in this paper.

Table F.1. Credibility strategies

Definitions	Strategies employed in the paper	Reference
Credibility of procedures —	evaluates how informed, transparent and accountable are methodological strategies and techniques used in the research	(Daly, 2007)
Validity — evaluates how well the conclusions are grounded in the data.	Data collection: ▪ Non-leading interview questions ▪ Researcher displays neutral attitude to the phenomenon Data analysis: ▪ The use of data to support statements ▪ A provision of a full account of data collection and analysis strategies ▪ The use of visual display tools to provide clarity (tables and graphs) ▪ A thick description of the phenomenon	(Daly, 2007) (Geertz, 1973)
Construct validity — evaluates whether a measure of a concept really reflects the concept it intends to be measuring	▪ Pattern-matching within and across cases ▪ Iterative tabulation of evidence for each construct	(Yin, 2018)
Reliability — evaluates the level of confidence in data interpretation	▪ The use of a case study protocol ▪ A development of a case study database ▪ The maintenance of the chain of evidence ▪ Several questions are asked regarding the same phenomenon	(Yin, 2018)
Credibility of outcomes —	looks into quality and trustworthiness of the research results. Credibility of the results are not deterministic from the credibility of procedures, as it is accepted that the results cannot be absolutely proved.	(Daly, 2007)
Deepening the credibility of the outcomes. Absolute truth and, thus, credibility of the outcomes cannot be established, but can only be deepened	*Triangulation* — a process of using multiple standpoints to understand the phenomenon under investigation ▪ *Data triangulation,* as data is collected from different sources: interviews, associative experiments, participatory workshop ▪ *Method triangulation*, as two methods: case study analysis and thematic analysis of the workshop, are used to bring insights into the phenomenon of interest	(Creswell, 1998; Daly, 2007)
External validity — evaluates to which extend the research findings can be generalised	▪ Multiple-case study design with confirming and disconfirming cases ▪ Positioning the research findings in the extant literature ▪ The use of constructs well-established in the literature (perezhivanie)	(Daly, 2007; Eisenhardt, 1989; Yin, 2018)

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APPENDIX G

Table G.1 summarises non-motivational factors affecting energy retrofit decisions, which were mentioned in case-study interviews and the project workshop. COM-B model is used to group such influences (Michie et al., 2014). COM-B stands for Capability Opportunity Motivation — Behaviour. The central tenet of the model is that for any *behaviour* to occur: (i) there must be the '*capability*' to do it; (ii) there must be the '*opportunity*' for the behaviour to occur in terms of a conducive physical and social environment; (iii) there must be sufficient strong '*motivation*'. Various influences representing capability and opportunity are presented in Table G.1 in an alphabetical order.

Table G.1. Non-motivational factors affecting energy retrofit decisions, mentioned in case-study interviews and the project workshop

COM-B model component	Factors from the project empirical data
Capability	The person or people concerned must have the physical strength, knowledge, skills, stamina etc. to perform the behaviour.
Physical capability — physical skill, strength or stamina	▪ Physical skill and strength, in case of DIY retrofit
Psychological capability — knowledge or psychological skills, strength or stamina to engage in the necessary mental processes	▪ Knowledge of: – Physical configuration of the house, e.g. what is it built of, what are the structural problems, etc. – Non-energy retrofit: which structural and utility works need to be carried out and how to do so. – The diversity of pathways to achieve low-carbon living within one's dwelling, e.g. reliance on structure and technology to afford low operational energy use with minimum behavioural involvement (Passivhaus) OR reliance on significant behavioural adjustments to achieve low-carbon footprint. – What needs to be done and in which order to achieve desired technological system of a low-carbon dwelling without undesired consequences. – Basics of building physics, as well as an understanding of how various measures/ technologies work, what are possible undesired consequences and how to avoid them, how such technologies fit within the house as a system, how to operate such technologies. An ability to understand how well measure/ technology performs, and whether it works at all. – Embodied carbon of the products. – Information sources – whom to get good information from. – Building professional suitable to carry out the job. – Policies/ grants/ incentives and schemes, available for domestic energy retrofit. – Direction of the national energy policy, e.g. phasing out gas in the UK by 2035 and the implications for dwellings that are heated by gas. ▪ Management skills, as homeowners are almost always involved in management of the retrofit project to a certain degree. ▪ Mental strength and stamina, e.g. carry out a big project, go through disruption.

Table G.1. Non-motivational factors affecting energy retrofit decisions, mentioned in case-study interviews and the project workshop

COM-B model component	Factors from the project empirical data
Opportunity	There must be the 'opportunity' for the behaviour to occur in terms of a conducive physical and social environment: e.g. it must be physically accessible, affordable, socially acceptable and there must be sufficient time.
Physical opportunity — opportunity afforded by the environment involving time, resources, locations, cues, physical 'affordance'	▪ Affordability, including costs of non-renewable fuel, capital costs of energy-related measures and technologies, costs of work, operational costs. ▪ Legal configuration of the dwelling – Ownership vs rented property – Conservation area restrictions ▪ Timing – Availability of time to commit to the project, e.g. finding information, managing the project. – Household lifecycle stages, e.g. young household (1–2) members, household with young children, empty-nester/ pre-retirement, retired household. – Structural works that have to be carried out anyways, due to the deterioration of dwelling's structure or breakdown of building services. – Retrofit at the point of sale to increase property value. ▪ Physical configuration of the dwelling, e.g. age and type of the structure of the house; dwelling type (a flat or a house); the state of repair, including structural problems of the building; maintenance requirements of building components; space availability for energy-related technology. ▪ Supply chain – Market maturity, e.g. technology quality and availability. – Sustainable construction industry maturity, e.g. building professionals skills and expertise, quality of work.
Social opportunity — opportunity afforded by interpersonal influences, social cues and cultural norms that influence the way that we think about things, e.g. the words and concepts that make up our language	▪ Alignment of goals and values, as different actor goals and motivations often oppose energy reduction intentions – Competing goals and interests of a household, e.g. an unwillingness to disrupt aesthetically valued structure; or unwillingness to carry out major works in a property one is not planning to stay in for long. – Competing interests of various actors, e.g. building professionals and trades people tend to steer to the technologies they are familiar with (gas boilers instead of heat pumps); or competing interests between tenants and landlords. ▪ Disruption: physical and social opportunity to minimise it, e.g. living elsewhere during retrofit; opportunity to take time to do things (no strict deadlines); help from family, friends and colleagues with various responsibilities. ▪ Norms, e.g. societal acceptance of wasteful behaviour, or social acceptance of a particular technology. ▪ Policy – Building regulations and minimum efficiency standards – Planning policy, including planning permission – Policy mix conducive to energy retrofit initiatives, including alignment of energy-related and non-energy related policies, or lack of enforcement in energy retrofit-related policy – Policy stability and continuation of policies – Strong local authorities and local policies, as policies need to be built bottom up to hit the ground, e.g. bottom-up policies to support local construction industry – Strong top-down policies targeting supply chain. ▪ Trust – Trust in the safety of the participants involved, including household members, and supply side actors, such as consultants.

Table G.1. Non-motivational factors affecting energy retrofit decisions, mentioned in case-study interviews and the project workshop

COM-B model component	Factors from the project empirical data
	– Trust in the outcomes at the point of sale – trust that a dwelling, measure or technology are of the quality they were claimed to be and will perform in the claimed way. – Trust in the information provided and sources of information. – Construction industry, e.g. trust that the works will be carried out to the best quality. – Trust between homeowners and the building team to experiment with new solutions. – Trust in the supply chain for maintenance and resource (e.g. renewable fuel such as wood pellets) continuous availability.

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APPENDIX H

In this paper, the authors are concerned with a formation of positive experiences associated with low-carbon dwellings. Note however, that having positive emotional and cognitive experiences associated with one home is not a given. One might have positive (e.g. belonging and intimacy), or negative (e.g. fear, violence and alienation) experiences associated with home, or even a combination of the two (Coolen and Meesters, 2012). Thus, negative experiences associated with low-carbon dwelling are possible, and indeed were evident in the data.

The authors suggest that a low-carbon dwelling can provide better control over one's indoor environment. However, this is not a given. Low-carbon and smart home technology is increasing in complexity, which might feel like a loss of *control*, e.g. the owner in case C4 complained about the newly installed learning thermostat: "Sometimes, I feel like: 'Oh, it's coming on, I don't want it to come on!' So, I feel, a little bit, like it is in control rather than me."

A few interviewees mentioned negative associations with the aesthetics of low-carbon dwellings, i.e. the *identity* of such places. Such negative perceptions were visible in associations such as 'devoid of beauty and personality'(D14), 'all of the quirkiness ironed out of a house'(D14), 'not very interesting, quite contained, boxy'(D17). When talking about energy retrofit, the owner in case D14 argued that it should be possible to "achieve low-carbon living in a range of ways that does not involve butchering beautiful buildings."

At the same time, the owners noted that a low-carbon dwelling is not something one can readily see, as most measures are invisible post-retrofit. In this sense, the identity of low-carbon dwellings tends to be invisible. The owner in case C3 described his home as "not the most exciting of [SuperHomes] houses … not a huge amount to see, really", while the builders in case C4 told the owner: "You are putting all your money in the walls, in the insulation, in things that people can's see".

The owners in the case studies used several ways to make more visible the identity of their homes as low-carbon dwellings. Some owners from the SuperHome network explicitly noted that joining the network was a way to make their efforts visible, to get "a mark of approval" (C4) or a "badge of honour" (C3). In cases C7 and C9 the owners have extensive monitoring equipment, which makes energy use more visible. Energy generation technologies were found to make energy not only visible but also enjoyable. The owner in case C4 described: "I am a bit obsessed with that [solar PV], because I look at it every day and see what my solar panels have generated".

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APPENDIX I

The differences between emotional and cognitive experiences of confirming and disconfirming cases were a matter of scale rather than their intrinsic nature. For instance, the owners in both confirming and disconfirming cases mentioned their environmental concerns, underpinned by their personal attitudes, and in some cases – by their professional image. Both sets of cases reported some lifestyle changes beyond retrofit activities, underpinned by those concerns. However, in the disconfirming cases these changes were likely to be on smaller scale compared to the confirming ones, e.g. switching off lights or putting a jumper on when cold in case D16, as compared to a substantially orchestrated everyday life to minimise household's carbon footprint in case C9, which includes an elaborate monitoring of energy and water use and a continuous adjustment of associated domestic practices based on received feedback. Table I.1 summarises different combinations of technological improvements and behavioural adaptations to minimise operational energy use and alter other lifestyle choices, mentioned in the case studies. Material changes of the dwellings and technologies are summarised in Table A.1.

Table I.1. Environmental considerations: domestic energy-related aspects and other sustainability aspects

Case	Domestic energy-related[1] aspects	Other sustainability aspects
Confirming cases: achieved significant carbon/ energy reductions as a result of retrofit activities		
C1	Professional identity; no behavioural changes, they prefer to rely on structure and technology to deliver low-energy use	None. The owner relies solely on the physical structure and technology to deliver low-energy use, jokingly referring to this attitude as being a "champagne socialist".
C2	Professional identity; carbon neutral living (annual electricity consumption equals annual on-site renewable energy generation); low temperature settings (bedrooms, washing machine)	Car sharing; short showers
C3	Professional identity; naturally frugal	Growing their own vegetables
C4	Professional identity; heating water tank solely with solar panels during summer times; putting a jumper on when cold; switching lights off; do not leave things on standby	Water collection for the garden
C5	The heating is not switched on until late into the heating season; closing blinds and curtains to keep the house cold on a sunny day; switching lights off; using appliances during the day to maximise the use of solar PVs	Organic food; good quality things that last longer; less flights; water collection for the garden
C6	Choice not to install and use a tumble dryer	Minimise use of non-renewable resources, i.e. design environmentally friendly house to save not only energy, but also other natural resources, such as water.

Table I.1. Environmental considerations: domestic energy-related aspects and other sustainability aspects

Case	Domestic energy-related[1] aspects	Other sustainability aspects
C7	Zero behavioural adaptation to minimise energy use is required, as it is delivered by the structure and technology	Other aspects to minimise household carbon footprint (buying groceries locally and buying less things altogether); using as little chemicals as possible for cleaning
C8	Switching lights off	Growing their own vegetables; water collection for the garden
C9	Professional identity; choice not to install and use tumble dryer (labelled an "evil machine" during the interview); only heat the rooms in use; switching lights off; everything is switched off by isolation switch when leaving (so no standby use); the heating is not switched on until late into the heating season; closing blinds and curtains to keep the house cold on a sunny day. Water system (gas boiler and solar thermal): Changing the timing for when the hot water would come on to minimise the amount of time that the water would come from the gas boiler. Took about a year to find the perfect settings. Carbon intensity of energy consumption: Solar PV has a monitoring system that measures export and import and can tell which one is happening at any point of time. The owner uses it to minimise the use of the grid/ maximise the use of energy from the solar PV by coordinating domestic practices, e.g. switching washing machine on when it is sunny. The owner does the calculations monthly and makes sure to use the DEFRA carbon factors for gas and electric that are relevant for that year.	Not flying (took one flight in the last 14 years); shopping locally; vegetarian meals; short showers; taking a bath only when heated by solar panels; not flushing the toilet in the master bedroom every time
C10	Professional identity; smart thermostat; putting a jumper when cold; low heating settings	Draught resistant plants (less water required for gardening); appliances/ fixtures with low water use; short showers; reusing bath water
Disconfirming cases: did not achieve significant carbon/ energy reductions as a result of retrofit activities		
D11	Professional identity; choice not to install and use a tumble dryer; low temperatures settings (bedrooms); putting a jumper on when cold; switching off lights	Water collection for the garden; appliances/ fixtures with low water use
D12	Professional identity	Short showers
D13	Professional identity; switched to renewable energy provider; wearing enough clothes	Reusing water for cleaning
D14	Professional identity; wearing enough clothes; switching heating off when not required; witching lights off	Water collection for the garden; not taking deep bath
D15	Shutting windows and doors in winter; switching lights off	Got rid of the garden pond
D16	Closing off rooms that are not used; putting a jumper on when cold; switching lights off	Water collection for the garden and to wash the car
D17	Professional identity; using blankets in winter; remote heating controller; choice not to using a tumble dryer	n/a

Table I.1. Environmental considerations: domestic energy-related aspects and other sustainability aspects

Case	Domestic energy-related[1] aspects	Other sustainability aspects
D18	Professional identity; putting a jumper on when cold	Recycling; green choices; cautious about water use

Note: The table reflects environmental concerns mentioned by the interviewees. It is possible that more concerns are present but were not mentioned. Still, the table provides a good overview of what was on the forefront of the interviewees' minds.

[1] Material changes of the dwellings and technologies are summarised in Table A.1.

APPENDIX J

The authors identified positive emotional and cognitive experiences associated with low-carbon dwellings (see section 4.1.), by grouping all kinds of positive home-meanings into five themes that resonate with low-carbon dwellings. However, the original meanings are generic, and thus, it is possible to achieve positive emotional and cognitive experiences, described by the themes, in both low-carbon and non-low carbon dwellings. This appendix illustrates some of the positive emotional and cognitive experiences, reported by the interviewees, which are not related to the low-carbon nature of their dwellings. These are organised by the identified five themes.

Control over one's environment. An important aspect of control is manifest in one's ability to modify the property through retrofit and the choice of meaningful possessions, to fit one's needs. The owners in cases C10 and D18 stressed out that being homeowners meant that they can now decorate the properties as they see fit. This is in comparison with previously rented accommodations, where they were not allowed to do so. The homeowner in case D18 explained: "…the importance of the decorations, whether it is a painting, or putting pictures, or whatever, or plants… It is to feel… to live in a place, where you belong, basically. So, the decorations help to improve the climate of the house. …You're seeing things which you like. For example, you've put that painting, you have some paintings, or some pictures, or some plants. It makes you feel nice…because you're in an environment, where you like the things you have, rather than them being imposed on you. If the property is not yours, a lot of the things are imposed, rather than being what you feel at ease with".

Health and wellbeing & happiness in everyday life. The homeowners mentioned several ways to modify their homes to accommodate their everyday life, which are not related to low-carbon settings, e.g. the good use of space post retrofit (C2, C6); the fit of the new layout to their lifestyles (C8), especially when describing open plan kitchen/ living room arrangements (C4, C10, D11). Several homeowners mentioned a variety of clever solutions that made their everyday life easier, e.g. in case C1, the kitchen was put on the top floor, which meant that cooking smells do not end in the living space, as they naturally drift up not down. These meanings are further reflected in associations such as 'functional'(C5), 'organised'(D14) and 'practical'(C1).

Climate concerns & caring identity. Decoration and the choice of meaningful objects was mentioned in all cases as a non-energy-related way to express homeowner identity. The owner in case D18 explained that "the decorations help improve the climate of the house… when you decorate the house with the images and colours that you like, you feel at ease [with the

environment].” The owner in case C7 mentioned that they “feel more homish, when we have our painting on the walls.”

Financial considerations & future resilience. An owner in case C1 carried out a full scale deep retrofit, which strengthen material resilience of the property, as after such intensive work, “you don’t need to do anything new with it for another generation” (C1). Several households (e.g. C1, C6, C7, C10) made significant alterations to the layout of their properties, which they knew would increase the property value, thus strengthening the financial resilience of the households. For instance, the owners in case C7 had a two-storey side extension and one-storey back extension to their three-bed semi-detached house. They split the altered property into two flats: a three-bedroom one on the ground floor, where they live, and a two-bedroom one on the first floor, which they rent out.

A full integration between an individual and their environment. The homeowners in the confirming cases made significant alterations to their dwellings, tailoring them to their needs. The resulting well-integrated environment was described as “well-tailored to us” (C8); “set up precisely for the two of us” (C9); “fit for the family, for their purpose” (WP04_int). The associated feelings were described as: “the best house I’ve ever lived in” (tenant in case C1); “it is very nice, lovely” (C4). A successful integration between the identities of the homeowners and the place identities of their homes was described as: “it’s very much the expression of my taste” in case C1; “It reflects our thinking, the way we like to live” in case C8. This integration is further reflected in associations such as ‘reflecting my personality’(C5) and ‘identity’(C4).

APPENDIX K

Figures K.1–K.4 provide examples of the illustrative images for some of the narratives generated during the project workshop.

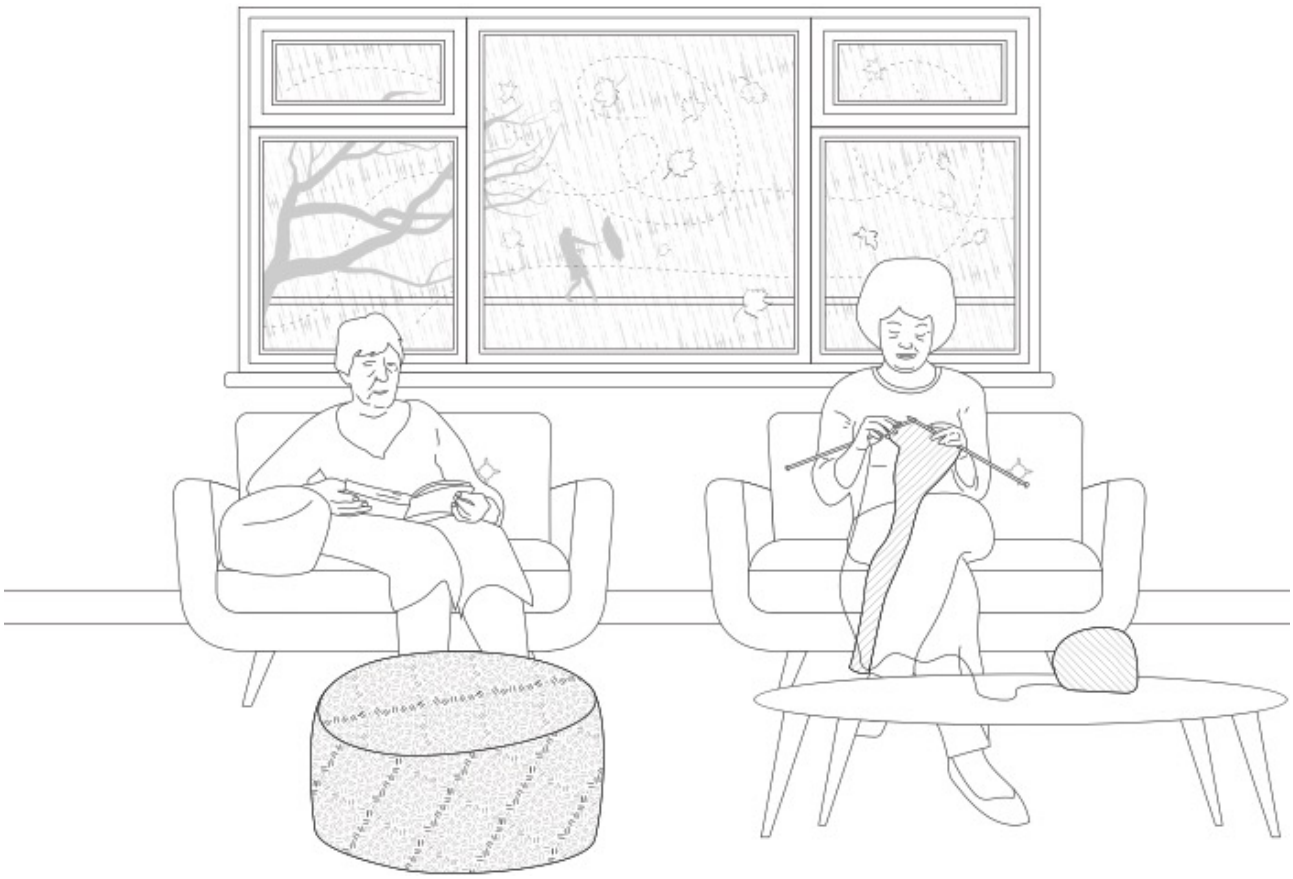

Figure K.1. A visual image to convey a message that a well-insulated and air-tight house with no draughts is a better platform to enjoy one's everyday life. The picture shows elderly ladies reading and knitting in front of a big double-glazed window, while there is heavy rain and wind outside. Yet, the weather does not distract the ladies from their activities, as there is no sense of cold air flow in the proximity of the window. The use of visuals in this example correspond to a similar use of images in conveying the Danish concept of *hygge*, which describes a mood of cosiness and feelings of wellness and contentment.

Figure K.2. The picture shows a lady doing yoga at her home. She is happy, relaxed and is not bothered by the sounds of the busy city outside, as her low-carbon home offers good acoustic insulation.

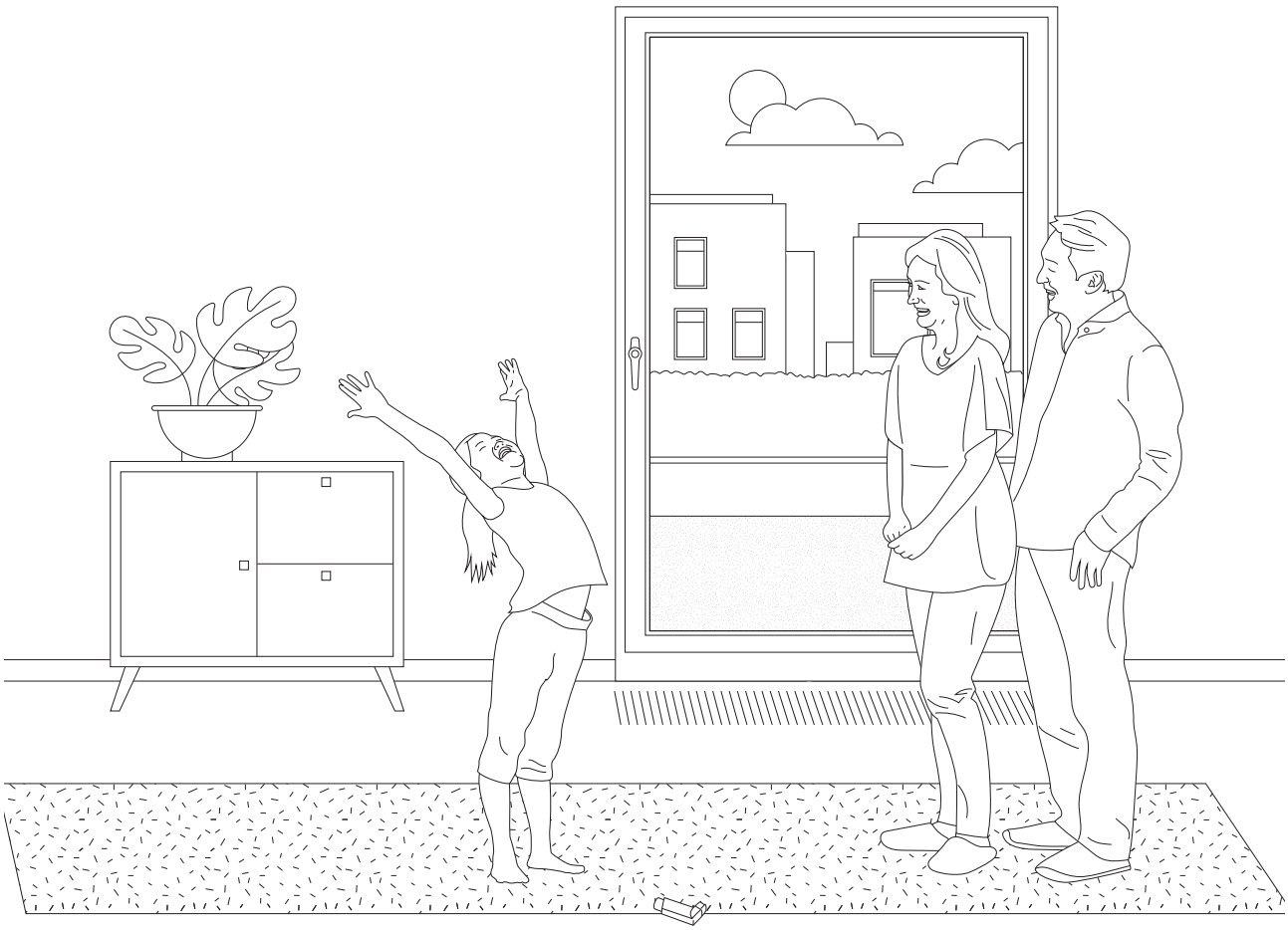

Figure K.3. The picture shows a family with a young child. The child just came home and threw her asthma inhaler on the floor. She likes the quality of the air afforded to her by mechanical ventilation. Parents are laughing looking at her antics.

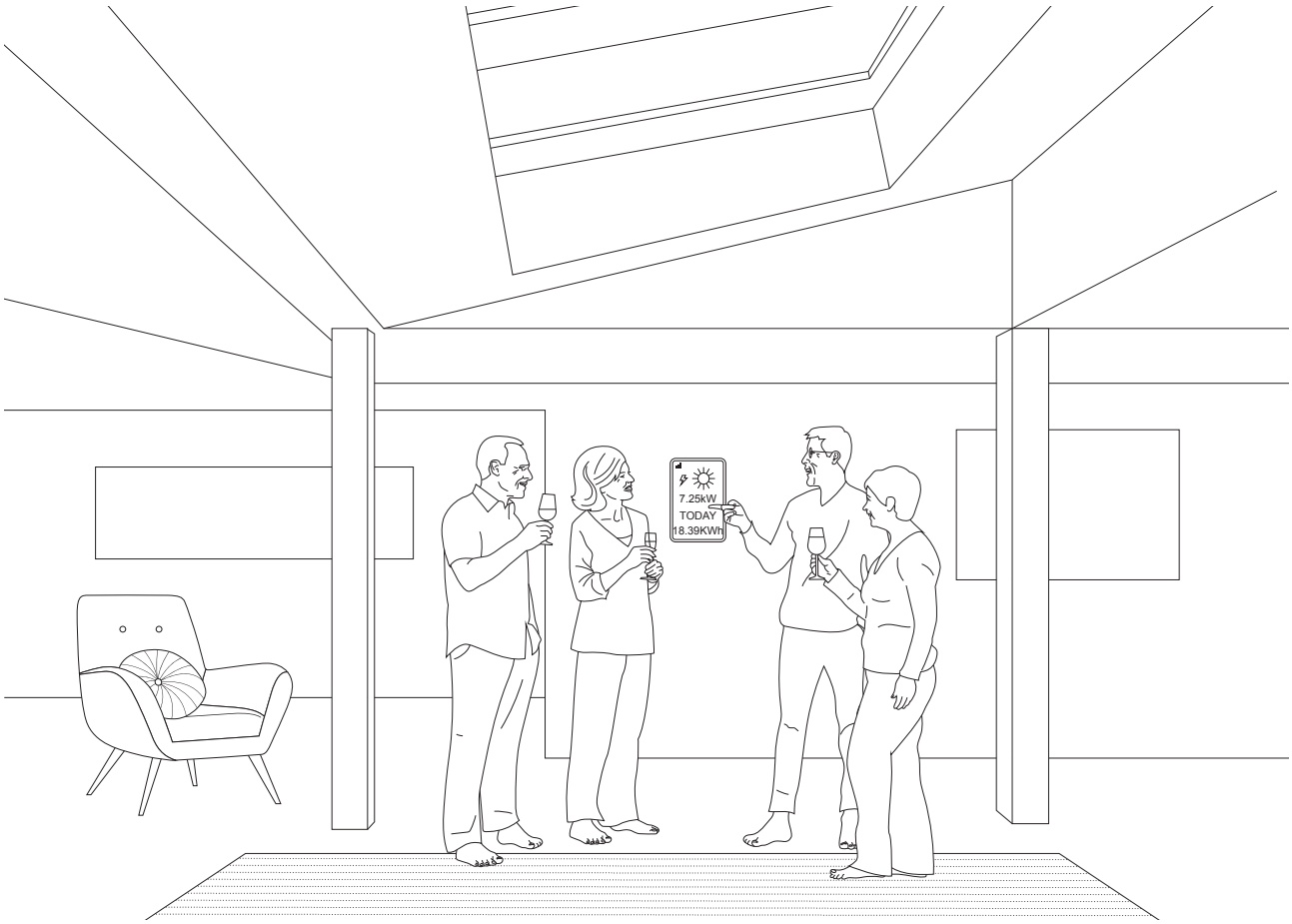

Figure K.4. The picture shows one couple having another couple over for drinks at their home. The house is a Passivhaus (see the depth of the roof insulation) and provides uniform and comfortable temperatures. All four people are barefoot, as the floor is nice and warm. They are gathered around a photovoltaic monitor and the owners explain their experience with the PV to the guests.