Barriers to English housing energy efficiency: stakeholders' perspectives

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Abstract: Sustainable transformation to energy efficient housing remains very challenging. While implementing effective governance remains specific to local and global contexts, more encompassing interrelated essential conditions have emerged which serve as prerequisite to varying degrees in implementing strategies for energy efficient housing in Europe. Notably, the existing English housing system has incorporated these critical drivers to leverage effective governance for energy efficient housing environments. Whilst these are important, there is a paucity of work on the understanding of 'barriers' against the backdrop of these prerequisite essential conditions from the whole system-wide stakeholders' perspectives. The purpose of this paper is to address these issues and identify a list of correlated and commonly agreed barriers from the stakeholders' perspectives. From the initial set of 40 barriers, this research identifies ten, as prioritised by online survey respondents. The paper, therefore, directs future research to investigate strategies that can overcome these key barriers.

Keywords: systems-thinking; stakeholders' perspectives; principal component analysis; sustainable transformation; energy efficient housing; English housing system; EHS; correlated and commonly agreed barriers; online survey.

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1 Introduction

Implementing a number of policies for energy efficiency in existing housing has become a priority for most countries in Europe including the United Kingdom (UK) (for example, UNFCCC, 2012; EC, 2011; CCC, 2013). This is in unison with widely accepted fact that housing offers the opportunity of extensive reduction in carbon emissions (ECOFYS, 2005; Lechtenböhmer, 2005). This assumption underlies a large volume of existing housing stock in Europe. As a consequence, the existing housing stock remains a primary concern for European housing policies (Bell et al., 2014). This is equally important for the UK on the grounds that it will have 70%–80% of existing housing stock in use in 2050 (Palmer and Cooper, 2011, 2014; Boardman et al., 2007). In addition, it is widely acknowledged that the English housing system (EHS) promises delivery of 60% of carbon emissions reduction through extensive implementation of energy efficiency measures such as increased air tightness, insulation, double or triple glazed windows and highly efficient boilers or heating systems and low-carbon strategies (Preston et al., 2013; HM Government, 2011).

The strategic transformation embedding energy efficiency in housing sectors in general is therefore currently recognised as a very important element for improving energy security, energy supply and housing sustainability (Marchand et al., 2015; Holdren, 2008). The empirical evidence show that there are enough technological solutions for energy efficiency (DECC, 2013; Killip, 2013). Besides, instruments like building regulations play a significant role in increasing energy efficiency (Krause et al., 2013; Lowe, 2000; Hitchin, 2008; Hoogma et al., 2005; Lowe and Oreszczyn, 2008). Moreover, the EHS has now constituted a regulative mechanism. Therefore, the oldest and most inefficient housing stock are identified as a target for the national energy efficiency strategy (UK CCC, 2010; DECC, 2012a; DCLG, 2015). In anticipation of contributing towards international agreements and in order to turn the energy efficient EHS into a successful contributor to climate change mitigation (UNFCCC, 1998), the UK's Climate Change Act (2008) and the Energy Act (2011) and a raft of energy efficiency and sustainability (EE&S) initiatives have been introduced in the EHS.

The account of transformational processes of the EHS development agenda section though not fully investigated (discussed later); demonstrate influence of policy processes within the EHS development pathways. These transformational processes are affected by how system-agents frame their activities informed by different perspectives, world-views and experiences. Simultaneously, regulations have growing influences on the organisational behaviour at different organisational levels. The development in the regulations and the regulatory mechanisms, seen as governance arrangements, has increased complexities in housing provision. Therefore, in spite of advances in the organisational structures; issues pertaining to complexities, effectiveness, and governance are not attended (Moore, 1995; Benington and Moore, 2010). Alongside, the dynamic of organisational field is influenced by inter-agency and inter-organisational working pattern (Benington, 2001; Sullivan and Skelcher, 2002), which in turn impacts EHS organisational leadership, strategic management and organisational change (Ferlie et al., 2003).

The strict and incremental energy efficiency regulations have been the results of broad institutional negotiations between regulators, policy makers and industry pressure groups, without considering greater number of niche level experiment activities involving householders (Marchand et al., 2015; Scott et al., 2014; Haines and Mitchell, 2014). As a consequence, the strategic development of energy agenda has resulted into peripheral incremental and confined to energy savings rather than ensuing strategic transformation. The outcomes of existing energy efficiency policies in general have mainly contributed on developing energy efficient technologies and not encouraged diffusion of these technologies (Jaffe et al., 1999; Kok et al., 2011; Fleiter and Plötz, 2013). In other words, the current energy efficiency policies are ineffective in changing behaviour of system-agents and the associated framings. This signifies that the scientific experiments of associating technologies' applications and technical change to actions and decisions of individuals are carried out without recognising the social or institutional context including localised practical knowledge and experience (Rogers, 2003; Macey and Brown, 1990). In a nutshell, strict disciplinarity of different actors have hindered the diffusion of technological advances; and the EE&S agenda of the EHS during the past

20 years have not realised into decrease in energy consumption and change in behaviour and values for sustainable use of resources (Dowson et al., 2012; Mallaburn and Eyre, 2014; Rosenow, 2012; UK CCC, 2010; DECC, 2012b; OFGEM, 2013; Hamilton et al., 2014).

The greatest challenge for todays' EHS is to conceive and accomplish sustainability within housing development that may offer houses with integrated health, economic, social, environmental and institutional benefits (Hulchanski, 2002; Salama and Alshuwaikhat, 2006; Ko and Fenner, 2007; Cooper and Jones, 2008; Olsson et al., 2014; Jerneck et al., 2010; Walker et al., 2004). This suggests that the EHS needs to overcome a series of weaknesses, for example, inconsistent mechanisms of decision-making, incapability to govern, manage and engage strategically with problems of EE&S, non-conformities of regulatory compliance and inability to appreciate multi-dimensional perspectives (Marchand et al., 2015; Wilson et al., 2015; Hayles and Dean, 2015; Turcu, 2012; Boza-kiss et al., 2013; Pan and Garmston, 2012; Pettifor et al., 2015; Leßmann and Masson, 2015). These assumptions are identified to be capable of carrying out scientific inquiries for this research.

The aim of this paper is to understand, explain and interpret the latent reasons for not embracing broader conceptualisation of sustainable transformations considering multiple perspectives of the system-agents, respecting complexity and dynamic relationships in the EHS. The design for this research is an exploratory and interpretive. The knowledge for this research is developed through ambiguous mixed methods research (AMMR) (Holt and Goulding, 2014) evaluating participants' perspectives and determining latent reasons for not embracing broader conceptualisation of sustainable transformations. The paper concludes with suggestions for further research and investigations to contribute to the body of knowledge of local EHS stakeholders in dealing with the housing sustainable transformations.

2 Sustainable transformations

Having recognised the need for sustainable transformations, a number of studies have analysed these processes and provided several explanations: sustainable transformations require systemic change in fundamentals including values and beliefs, behaviour patterns, and governing practices (Clark, 2001; Raskin et al., 2002; Adger and Barnett, 2009; Solomon et al., 2009; Biesbroek et al., 2010; Leach et al., 2010; Ford and Berrang-Ford, 2011; Park et al., 2012; Haasnoot et al., 2013; Olsson et al., 2014; Eakin et al., 2014; Wise et al., 2014; Carter et al., 2015); sustainable transformations are recognised as being interlinked and multi-dimensional; sustainable transformations require both economies and societies to undergo transformations; sustainable transformations are processes that incorporate coevolution of demographic, technological, economic, social, cultural, institutional, informational and ideological developments; sustainable transformations are carried out in order to achieve greater (wider) sustainability and embark on sustainable development pathways (Walker et al., 2004; Gell-Mann, 2010; Olsson et al., 2014).

Of the many explanations given for sustainable transformations, this paper interprets sustainable transformation as 'long-term and restructuring processes – through intervention techniques – required to articulate multi-dimensional EE&S objectives– in order to effectively overcome development pathways challenges and direct alternative development pathways towards multi-dimensional sustainability (MDS) opportunities' (Rotmans et al., 2001; Rotmans and Loorbach, 2009; Frantzeskaki and De Haan, 2009; Meadowcroft, 2011; Grin et al., 2010; Frantzeskaki et al., 2012; Rauschmayer et al., 2015; McCormick et al., 2013). When calling for such a transformation, emphases are made on developing capabilities and decision-making strategies to leverage sustainable transformations using the complex adaptive perspective of dynamic societal systems (Avelino, 2011; Loorbach, 2010; Park et al., 2012; Poli, 2015; Mohrman and Shani, 2011; Holland, 2006; Axelrod and Cohen, 1997).

The contributions in the areas of sustainable transformations have increased understanding of these processes; however, the governance and the framing problems in delivering effective sustainable transformations have not yet been addressed (Mohrman and Shani, 2011; Holtz et al., in press; Voß et al., 2009). In response to this, a broader conceptualisation has been advocated to increase the effectiveness of sustainable transformations. Broader conceptualisation of sustainable transformations include a number of factors ranging from integration of multiple contexts through coordination between every processes to simultaneously overcoming barriers and delivering objectives interpreted from stakeholders' perspectives (Haasnoot et al., 2013; Wise et al., 2014; Leach et al., 2010; Pelling, 2011; Maru et al., 2014). Accordingly, the broader conceptualisation of sustainable transformations not only increases capacity for dealing with temporal transformations, it also allows to view implications of sustainable transformations, in order that entities (including societal systems, organisations and individuals) lacking in capacities for decision-making can be assisted through appropriate interventions and increase opportunities for sustainable transformations (Stafford Smith et al., 2011; Eriksen et al., 2011; Maru et al., 2014).

Given this, identifying and understanding complex processes of societal systems undergoing transformations are prerequisite. These include identifying theoretical underpinnings that contribute to the understanding of constructs of societal systems, different kinds of challenges and opportunities these systems hold, and different kind of attempts and resources go into the processes of sustainable transformations. Theories underpinning 'systems-thinking' are applied in order to understand the complexity and multi-perspective dynamics of the societal system undergoing transformation. The systems-thinking is a worldview which allows appreciation of holistic system having interconnections between component-elements, having properties such as drivers, outcomes and feedbacks and can be applied to problems of multiple disciplines (Forrester 1969; Voinov, 2008; Cerar, 2012). Hence, decision-making can be improved by considering characteristics of the system such as dynamism, network, adaptive capacities, and cross-level interconnections (Arnold and Wade, 2015; Plate and Monroe, 2014).

The sustainable transformations literature mainly contributes to two dimensions: scientific understanding of transformational processes of large-scale complex societal systems; and the effectiveness of sustainable transformations (including initiating and driving sustainable interventions and achieving sustainability outcomes) (Holtz et al., in press). However, these contributions have not been able to capture current realities and diversities of sustainability challenges and opportunities that may have an

impact on specific integrated contexts in which the transformational processes take place. The key challenge underpins interpreting theories for societies, economies, polities, organisations and individuals. The current theories are confined to limited contexts and underpin traditional practices or understandings that are based on unsustainable behaviour (UNEP, 2012; Juhola et al., 2011; Bassett and Fogelman, 2013; Meadowcroft, 2011). Therefore, theoretical transformations are required to capture current understanding – realities and dynamics of complex systems, including perspectives of system agents – to facilitate broader conceptualisation of sustainable transformations (Juhola et al., 2011; UNEP, 2012; Voß et al., 2007; Mohrman and Shani, 2011).

Examples of the contexts range from availability of natural resources through advances in information, communication and computational technology to global reach and integration between economic growth and exploitation of natural as well as human resources. Today, there are some new realities associated with development pathways. These realities include factors challenging sustainable development such as limited resources, a need to change economic growth patterns, reduce energy use and decrease carbon emissions. Therefore, it is expected that system-agents accept these new realities, diagnose their problem, assess and plan for adaptation to the new (emerging) contextual realities (Astley, 1985; Gorddard et al., 2012; Moser, 2010). The next section presents the account of transformational processes of the EHS to highlight the realities related to the EHS including different research methods, framing, policy-making processes, decision-making and energy efficiency.

3 The English housing system

Illustrating few examples of how the different EHS sector representations have generally impacted on the EHS development strategies and agenda, this section highlights strategic implications of these representations. The scope of analysis is aimed to the dynamics involved in the EE&S agenda in the existing stock of the EHS. Two reforms have taken central entry points in the EHS: the public service reforms and energy efficiency regulatory reforms. However, these do not exclude other reforms as central to the EHS policy arena in which the EHS system-agents engage. The empirical entry points and relationships between different representations are identified through literature review.

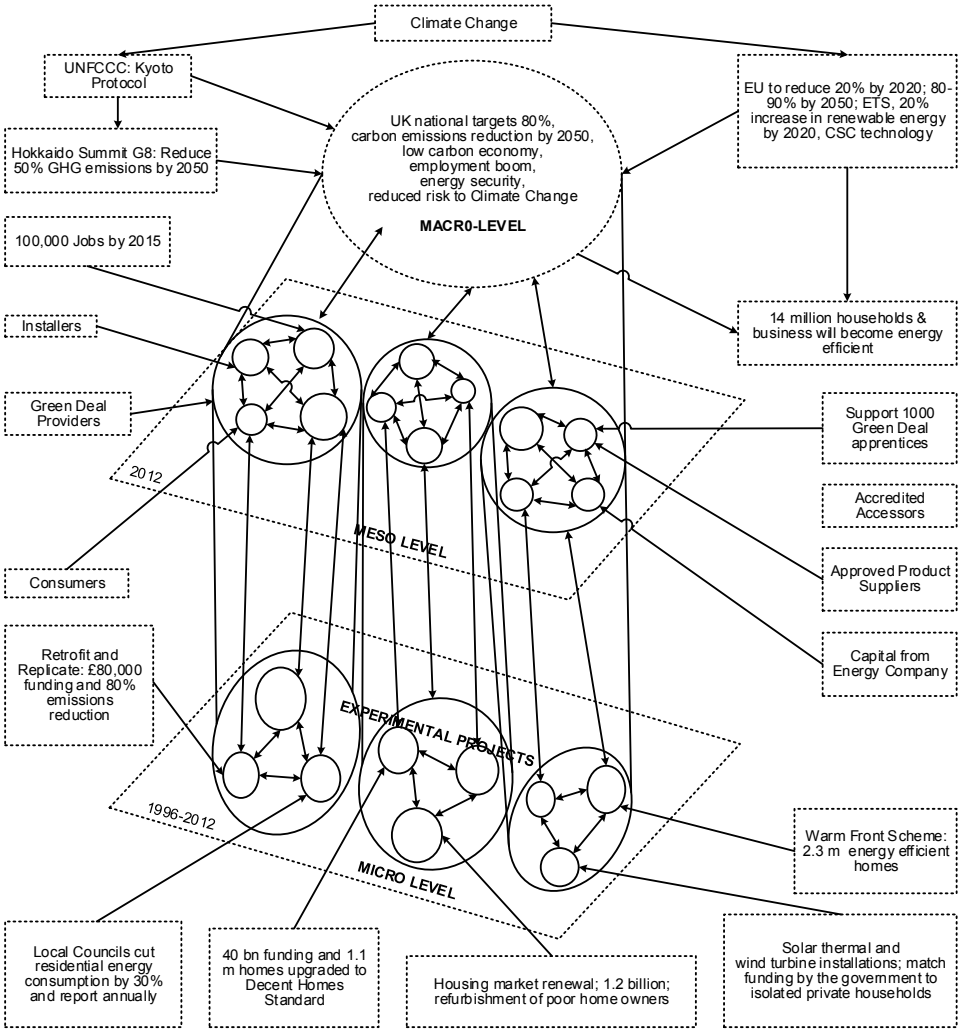
Traditionally, the EHS policies are built on positivist epistemological approach without having apparent theoretical explanation (Pinker, 1971; Kemeny, 1992; Clapham, 1997). Following this, the Fabian-inspired housing research has emerged applying rigorous methodology (see Jacobs and Manzi, 2000) and has influenced the development of housing social policies (Pinker, 1971; Power, 1999). Subsequently, a number of studies have applied 'constructivist' epistemologies giving alternative representations (Jacobs and Manzi, 2000; Kemeny, 2004). However, this approach does not fully appreciate complexity of the 'real world housing system' (Jacobs et al., 2004; King, 2009). This implies the EHS theories must focus on the relationship of trio: the housing system-agents, the housing system and the societal processes (King, 2009; Kemeny, 1992) integrating alternative approaches such as 'interpretivism' (Clapham, 2009).

The planned public service reforms applied through the idea of 'new public management (NPM)', 'managerialism' and 'modernisation' marked the long-term transformation of housing provision from 'public' to 'social' and contributed towards the governance, strategic management and institutional agenda. These reforms initiated several adaptations in the EHS. For example, increase in privatisation, provision of good quality and affordable housing, development of skilled workforce in housing (Malpass and Victory, 2010); the 'joined-up' organisational policies among the associated network to delivery services, association with service-users in order to achieve excellence in service provision, instigation of local accountability, societal learning and values in the organisational culture (Armstrong, 1999; Ferlie et al., 2003; Stewart and Ranson, 1988; Mullins and Murie, 2006, Taylor, 2008); remodelling of both top-down and bottom up approaches (Reid and Hickman, 2002; Mullins and Riseborough, 2000); and provision of 'customer-focused services' underpinning managerialism and shifting the control of services from professionals to managers (Mullins and Riseborough, 2000).

The governance theory, importantly, provides references to mechanisms of governing and networking of actors and organisations having stake in the governing process (Kooiman, 2003). The modernisation agenda have impacted the EHS governance arrangements at various levels and three different coordinations, namely, hierarchies, markets and networks are evident (Mullins et al., 2001; Stoker, 1999; Lowndes, 1999). A top-down approach governs the system with vertical communication and reporting procedure in hierarchies (Stoker and Young, 1993). Markets coordination mechanism induced privatisation in housing offering better housing products and services (Levacic, 1993; Williamson, 1985). The 'networks' provide goods or services that support the system (Alter and Hage, 1993; Thompson, 2004). Most importantly, these coordinations of governance occur simultaneously, either at one point of interaction or at a number of different points of interactions (Lowndes and Skelcher, 1998). Given this, a number of studies argue that different modes of governance are strategically used to structure coordinations internally within the organisation as well as externally in a multi-organisational system to manage their responsibilities and achieve concrete aims (Pollitt, 1990; Walker, 1998; Lowndes and Skelcher, 1998).

A broader energy agenda originally was introduced in the EHS in response to public health issues [The Building Regulations (Local Enactments) Order 1966, 1966]. The energy agenda was latter used to respond to the international oil crisis in early 1970s (Shove, 1998). Gradually, a series of regulative instruments such as reduced data standard assessment procedure (RdSAP) rating [RdSAP, 2009, Version 9.91; SAP, (2012), version 9.92] have been implemented to improve the energy performance of mass existing buildings. Following social, economic, health and psychological outcomes in addition to contributions to carbon emissions reduction from the initial energy efficiency programs such as warm front (DCLG, 2006a; DEFRA, 2004), several other EE&S initiatives have been introduced in the EHS. Namely, the energy company obligation (ECO), the Green Deal, the carbon emissions reduction target (CERT) and the community energy saving program (CESP) (Guertler, 2012; Mallaburn and Eyre, 2014; DECC, 2011).

Figure 1 Socio-technical representation of the Green Deal

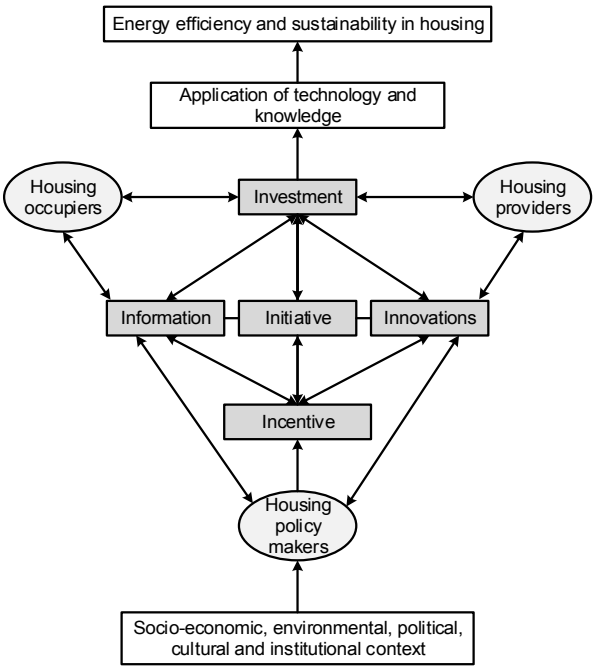


Source: Thakore et al. (2013)

According to several analysts, the Green Deal holds sufficient potential to encourage EE&S in the EHS (for example, Guertler, 2012; Dowson et al., 2012; Marchand et al., 2015). The qualitative analysis of the dynamics of the Green Deal initiative through the lens of ex-ante SNM tool signify that this initiative encourages development of policies, processes and actions in order to expedite EE&S in the EHS (see Figure 1) (further details referred to Thakore et al., 2013). The Green Deal is designed to decrease overall energy consumption, reduced energy bills for end-users and increased comfort (Guertler, 2012; DECC, 2011; Dowson et al., 2012; Thaler and Sunstein, 2008). However, the success of the uptake of the Green Deal depends to a large extent on the willingness of the EHS system-agents (as consumers) to engage with the Green Deal improvements (Gough, 2013).

The account of transformational processes of the EHS development agenda; though not fully investigated, presented in this section demonstrate that in spite of advances in the organisational structures; issues pertaining to complexities, effectiveness, and governance are not attended (Moore, 1995; Benington and Moore, 2010). Further, it highlights that the environmental framing and representations through various energy efficiency programs have constituted to energy savings, resource savings and well-being; however, it has been lower than anticipated because it has not necessarily engaged all relevant EHS householders including householders (Bell and Lowe, 2000; Marchand et al., 2015; Scott et al., 2014; Haines and Mitchell, 2014). Therefore, there are justifiable social, economic and environmental representations (for example, see Petrova et al., 2013; Liddell and Morris, 2010; Brown et al., 2014; Genovese et al., 2013; Gough, 2013) that needs to be embodied into the broader conceptualisation of sustainable transformations.

Figure 2 Five essential conditions approach for housing sector



Source: Adapted from UNECE (2009)

The above account of the EHS, therefore, identifies a need for dynamic and multi-layered governance structure that embodies multiple disciplines and multiple perspectives employed and accepted for framing processes (Mohrman and Shani, 2011; Holtz et al., in press; Voß et al., 2009). To this end, in 2009, the Committee for Housing and Land Management of the United Nations Economic Commission for Europe (UNECE[1]) has identified a coherent integrative framework encompassing five 'essential conditions', which serve as prerequisite to effectively leverage a more comprehensive strategy for governance of sustainable transformations in relation to energy efficient housing (see Figure 2). These are investment, information, innovation, incentive, and initiative,

conceptualised as 5-INs (hereafter mentioned as 5-Ins). However, establishment of these prerequisite conditions, according to UNECE (2009, 2011, 2014), is determined by decision-making of various system-agents having influence or being influenced by the process of sustainable transformations. While the establishment of these essential conditions depend on decision-making of the system-agents, these essential conditions depend on specific reality established by their social, technical, economic, political and institutional context as well as cultural and environmental inherited circumstances.

Theoretical underpinnings of 5-INs have practical implications. Investing in energy efficiency is widely acknowledged to be a cost effective measure for reduction of carbon emissions concluding in multiple benefits (Davenport et al., 2004; Rudge and Nicol, 2000, Boardman, 2010; Kuholski et al., 2010; Fuller et al., 2010). Also, it is important because large stocks of the EHS offer immense opportunity for installations of energy efficient measures. Information is generally considered an essential condition for increasing investment in energy efficiency measures (Fuller et al., 2010; Williams, 2010; Dietz, 2010). Innovations in technologies have been successful in promoting energy efficiency on the technical front (Herring and Roy, 2007). Thus, there is a need for innovations for diffusion of these energy efficient technologies.

Incentives within housing energy efficiency policies are required to include adequate financial incentives, strict enforcement of standards, and regulatory structure. This is in order to persuade all system-agents to take responsibility and invest in energy efficiency measures (Baek and Park, 2012; Williams, 2010; Painuly, 2001). Energy efficiency initiatives are required in order to turn expectations of system-agents to realistic objectives (Jacobsson and Johnson, 2000; Makovich, 2011; Wolsink, 2012). Moreover, establishing 5-INs is accepted to provide improved living conditions, affordable housing, savings in energy bills, savings in energy production, job creation, local, regional and national development, decreased inequality, increased integrity, increased resilience against Climate Change, improved landscape and improved environmental conditions (Rudge and Nicol, 2000; Boardman, 2010; Kuholski et al., 2010; Bell et al., 1996; World Bank, 2010).

Given these 5-INs are interrelated and complement each other, no one of 5-INs can be the reason for not embracing broader conceptualisation of sustainable transformations. However, a number of barriers exist to each of 5-INs and challenge their functionality in offering carefully designed governing pathways for housing (UNEP-SBCI, 2009; WBCSD, 2010). A number of evaluation studies which assessed ineffectiveness of EE&S policies within the institutional setting of housing system have identified several barriers, these are compiled under each category of 5-INs (see Annex 1). However, the EHS needs to be more productive and more innovative supported by inclusive and consensus-based processes that recognise worldviews and interests of all EHS system-agents to generate a whole sector representation. Above all, sustainable transformations requires considering implications between various agents (individuals and collectives, humans and non-humans, experts and non-experts, etc.) at multiple levels (Jensen, 2012; Gaziulusoy and Brezet, in press).

4 Methodology

Philosophically, this research is exploring a complex real-world problem. This r esearch's domain fundamentally belongs to the social sciences and draws on dynamic

decision-making in construction management. The research aim is 'to understand, explain and interpret the latent reasons for not embracing broader conceptualisation of sustainable transformations considering multiple perspectives of the system-agents, respecting complexity and dynamic relationships in the EHS'. The philosophical stance adopted in this research is constructivist/interpretivism (Fellows and Liu, 2013; Smirchich, 1983). This is to allow explore subjectivism and interpretation of understanding of the problem and potential solution from different viewpoints (Klein, 2004) within the context of this research (Boulding, 1956; Reeves and Hedberg, 2003). Given a high consideration to make social integration between multiple realities such as individual, organisation and national-global, and understand several perspectives, combine factual (science) and tacit (latent) knowledge developed through engagement with the EHS agents adoption of such philosophical stance directs this research to consider mixed methods for collecting and analysing research data (Chileshe and Dzisi, 2012; Hughes et al., 2012; Holt and Goulding, 2014).

This research requires developing whole systems knowledge (Hadorn et al., 2008; Hadorn et al., 2006; Rauschmayer et al., 2015). The barriers to 5-INs are abstract and they are interpreted differently by different people. Different dimensions are associated to these barriers and their conception by various EHS system-agents could be in a number of different ways. When a process involves consideration of unobservable concepts, evaluating these concepts is a difficult task. A survey questionnaire is a measuring instrument to evaluating unobservable concepts using variables associated with these concepts (Fowler, 2014; Thomas et al., 2011; Corbin and Strauss, 2015). Structured survey questionnaires and statistical analysis are used in AMMR research designs (Holt and Goulding, 2014). Respondent's subjective perceptions are captured through tools such as Likert scale and subjective analysis are used to generalise the respondent's views (Carifio and Perla, 2008; Norman, 2010; Jamieson, 2004; Merriam, 2015). A well designed survey questionnaire was developed and administered after a pilot study (Fink, 2009; Turner and Martin, 1985).

The purpose of the survey questionnaire was to identify correlated commonly agreed perspectives on very important barriers to 5-INs, respecting complexity and dynamic relationships in the EHS. The questionnaire opened with introduction followed by five sections associated with 5-INs (see Annex 2) (Dillman and Smyth, 2007). Each section had eight item-questions. These item-questions were operationalised using barriers identified in Annex 1. These questions were presented in a 'matrix' format and respondents were requested to consider only one answer from four options (Check and Schutt, 2011; Dillman, 2011). At the end of each section, an optional open-ended question was provided for participants to express their opinions on the barriers. The common errors such as errors of observation and errors of non-observation were minimised by clear, interesting and well organised survey questionnaire (Groves et al., 2013; Engel and Schutt, 2014; Couper et al., 2001).

In line with the philosophical conception of this research topic, matrix questions were formed using Likert-type response questions. A four-point Likert scale was used for measuring degree of importance of each item from the respondents' perspective (Likert, 1932; Mclver and Carmines, 1981; Alphen et al., 1994). Through the use of Likert scale, it was assumed that the Likert scale allows scientific survey and interpretation of the context specific research results (Göb et al., 2007). Further, response rate being an important factor in online surveys, about 11% lower than other modes of surveys,

(Manfreda et al., 2008); absolute response rate was considered (Denscombe, 2014). The response rate was increased by reaching the right participant and continuously emailing the targeted samples until saturation point was reached (Hewson, 2003; Kittleson, 1997). Ethical approval was obtained in accordance with the university code of conduct for research ethics and ethical issues such as confidentiality were addressed as well as anonymity of the participant was supported (Fowler, 2014; Check and Schutt, 2011; Mangione, 1995). A small-scale intensive pilot was carried out using 10 participants, representatives of the target population and the structure and format of the questionnaire was improved (Aldridge, 2001; Thomas et al., 2011). The empirical analysis of evidence collected through this methodology is discussed next.

5 Results

The data, however, was required to undergo analysis and identify principal components underlying the complex, multivariate and ambiguous perspectives (Cattell, 1988) represented through responses of the EHS multi-disciplinary system-agents. The number of responses (N = 108) was adequate for analysis (Costello and Osborne, 2005; Tabachnick and Fidell, 2013). In addition, Cronbach's alpha was .938 (see Table 1), which confirmed internal consistency of the data. The Kaiser-Meyer-Okin (Kaiser, 1960) was 0.807, which was considered acceptable (see Table 2) (Field, 2009). The Barrlett's test of sphericity (see Table 2) demonstrated correlation between responses and their suitability for analysis.

Table 1 Reliability statistics

Cronbach's alpha	*Cronbach's alpha based on standardised items*	*No. of items*
.938	.938	40

Table 2 Kaiser-Meyer-Olkin measure of sampling adequacy

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy		.807
Bartlett's test of sphericity	Approx. chi-square	2,608.851
	df	780
	Sig.	.000

Applying principal component analysis (PCA), ten factors were identified based on the value of eigenvalue = 1 (Kaiser, 1960). The scree plot (Cattell, 1966) showed two principal components. The first principal component with the eigenvalue = 12.174 accounted for total variance = 30.436%. The second principal component with the eigenvalue = 2.949 accounted for total variance = 7.372%. Thus the first two components accounted for 38.807%, which were significantly greater than remaining eight components. Finally, as these variables were assumed to be correlated, these variables were subjected to oblique rotation, direct oblimin (Jones and Johnston, 1999). The pattern matrix for direct oblimin reported factor loadings for each variable that were greater than 0.50, highlighting two components and gave the best possibility to interpret the hidden continuum (see Table 3) (Rietveld and Van Hout, 1993; Field, 2009; Rattray and Jones,

2007). The component 1 consisted of nine variables. These were lack of priority for energy efficiency, lack of leadership, lack of management, lack of innovation, lack of capacities, lack of accountability, lack of responsibilities to reduce environmental impacts and lack of culture to embrace innovation. The component 2 consisted of six variables. These included lack of subsidies systems/grants, lack of funds or high cost, lack of tax exemptions/reductions/credits on investment related to housing energy efficiency, lack of support from intermediary agencies, high upfront costs or lack of investment and use of exclusively 'high technology'.

In addition to above, a number of measures for reliability and validation were applied for empirical data collection (Campbell and Fiske, 1959; Eby et al., 2009). These included reliability test to identify internal consistency of online survey responses using Cronbach's alpha and sampling adequacy using Kaiser-Meyer-Olkin measure (Field, 2009). The validity of the responses was determined by face validity and criterion validity (Brewer and Hunter, 1989). Face validity was determined by eyeballing for missing values and entry errors, and identifying outliers and central tendency through descriptive analysis using SPSS (Boone and Boone, 2012). Criterion validity was determined by Kaiser's criterion (Kaiser, 1960, Ferguson and Cox, 1993) including scree plot (Cattell, 1966). Construction and interpretation of qualitative constructs identified by online survey analysis were validated by anonymous built and environment researchers (Campbell and Fiske, 1959; Eby et al., 2009). In this manner, combing qualitative and quantitative research methods (Moffatt et al., 2006) have offered opportunity to develop theory with balanced objectivity and subjectivity in addition to conducting an effective valid research (Denzin, 1978).

Table 3 Results of principal component analysis

Barriers		*Components*	
		Component 1	*Component 2*
1	Lack of priority for energy efficiency	0.86	
2	Lack of leadership	0.824	
3	Lack of management	0.754	
4	Lack of priority for energy efficiency	0.752	
5	Low priority given to energy issues or lack of innovation	0.669	
6	Lack of capacities	0.616	
7	Lack of accountability	0.593	
8	Lack of responsibilities to reduce environmental impacts	0.55	
9	Lack of culture to embrace innovation	0.504	
10	Lack of subsidies systems/grants		0.82
11	Lack of funds (public or provided on a competitive base) or high cost		0.712
12	Lack of tax exemptions/reductions/credits on investment related to housing energy efficiency		0.643
13	Lack of support from intermediary agencies		0.595
14	High upfront costs or lack of investment		0.581
15	Use of exclusively 'high technology'		0.579

6 Discussion

A coherent integrative framework encompassing 5-INs has been proposed to provide effective comprehensive governance strategy for sustainable transformations in housing system (UNECE, 2009, 2011, 2014). Accordingly, 5-INs are considered as prerequisite conditions for the EHS to process broader conceptualisation of sustainable transformations. However, a number of barriers exist to these 5-INs and challenge their functionality in offering carefully designed pathways for housing (UNEP-SBCI, 2009; WBCSD, 2010). A number of evaluation studies which assessed ineffectiveness of EE&S policies within the institutional setting of housing system have identified several barriers (see Annex 1). Further, the coherent integrative framework emphasises that these essential conditions depend on decision-making of the system-agents and on specific reality established by these system-agents' social, technical, economic, political and institutional contexts as well as cultural and environmental inherited circumstances (Golubchikov and Deda, 2012). Therefore, it was required to identify barriers to 5-INs that were common from multiple perspectives hold by relevant system-agents in the EHS (Schneider and Rist, 2014; Aeberhard and Rist, 2009).

In order to identify common valued perspectives, an online survey questionnaire was administered throughout the EHS demographics involving multiple housing developers, housing end-users and housing regulators or policy-makers. A logical, systematic and structured approach to the design and development of the survey questionnaire fetched appropriate results for descriptive analysis and factor analysis. The internal consistency was high which provided reliability and validity to the questionnaire. This provided confidence in the results. Results revealed some engrossing facts. It was interesting to note that many of the same barriers which were flagged up as important barriers in past years still existed in the EHS. Reflecting on the important barriers the descriptive analysis of the online survey highlighted that the EHS faced difficulties in establishing 5-INs. These barriers included variables such as arranging for upfront cost, funds and grants. Other important barriers include getting support and exemption on investment. Nevertheless, there existed a good level of knowledge and awareness of energy efficiency issues in the EHS.

Exploratory factor analysis (Corbin and Strauss, 2015; Thomas et al., 2011; Check and Schutt, 2011; Kim, 2008; Tabachnick and Fidell, 2013) was carried out to retain two components which had positive loadings. The items within these components were very important from a composite common correlated multi-perspective (Morrison and Shortt, 2008; Nardo et al., 2005; Rietveld and Van Hout, 1993; Kim, 2008; Tabachnick and Fidell, 2013; Gorsuch, 2003) of the EHS. The online survey results contributed towards research aim and development of systems knowledge (Hadorn et al., 2008; Hadorn et al., 2006; Rauschmayer et al., 2015). Collating an overall picture of these barriers to 5-INs experienced by the EHS, it was required to delve into details to identify how these barriers can be addressed. Based on literature review, the very important barriers were linked to strategic capabilities. It was posited that specific capabilities are needed to recognise and effectively intervene to overcome these barriers to 5-INs, which are assumed to delivery MDS (Schäpke and Rauschmayer, 2014; Leßmann and Rauschmayer, 2013; Shove et al., 2012; Sen, 2013) in the EHS. However, before operationalising these barriers for further investigation, the list of barriers identified through PCA were required to be complied. For example, the barriers that had more or less same meaning and appeared more than once were compiled into one barrier to reduce

anonymity. Each barrier was then associated to strategic capability criteria as shown in Table 4. These changes and operationalisation were reviewed and validated by two independent reviewers.

There is, therefore, a need to invest in strategic capabilities. Perhaps more importantly, it cannot be assumed that investing in strategic capabilities for EE&S will lead to MDS. Assumptions around the possible MDS impacts need to be empirically tested through evaluations which assess changes in strategic outcomes following strategic interventions developed through investing in strategic capabilities. At the same time, empirical evidences need to ensure strategic interventions are in relation to 5-INs allowing strategic governance of EE&S for sustainable transformations in the contexts of specific reality of the EHS. According to Engle (2011), when a number of strategic capabilities are needed to overcome critical barriers, perspective and pragmatic differences in decision-making and prioritisation of relevant interventions may occur. Also, these strategic capabilities are latent and rarely possessed uniformly by any given population (Engle, 2011).

Table 4 Strategic capabilities criteria

No.	*Very important barriers*	*Strategic capabilities*
1	Lack of priority for energy efficiency/lack of responsibilities to reduce environmental impacts	Strategic ownership (SO)
2	Lack of leadership	Strategic leadership (SL)
3	Lack of management/capacities	Strategic management (SM)
4	Lack of accountability	Strategic accountability (SA)
5	Lack of culture to embrace innovation	Strategic cultural awareness (SCA)
6	Lack of priority for energy efficiency	Intermediate energy policies (IEP)
7	High upfront costs or lack of subsidies systems/grants/funds	Targeted energy policies (TEP)
8	Lack of tax exemptions/reductions/credits on investment related to housing energy efficiency	Technology-specific policies (TSSP)
9	Lack of support from intermediary agencies	Building specific codes, standards, regulations (BSCSR)
10	Use of exclusively 'high technology'	Policies supporting supply chains in making technology easy to implement

Little is known about the interventions, challenges and impacts of strategic capabilities for housing EE&S programs which can lead sustainable transformations and contribute to the MDS objectives of the EHS (Jaffe et al., 2004, Howarth et al., 2000, Golove and Eto, 1996; Stern, 2011; Martinot and McDoom, 2000). Therefore, there is a need to explore further details of 10 strategic capabilities linked to very important barriers identified by the respondents of the online survey (see Table 4). Possibly, research methods such as the Delphi study can ensure wide participation of the organisational stakeholders across multiple levels and multiple disciplines. The views of these EHS expert system-agents are required to be collected for in-depth evaluation of strategic capabilities. Such evaluation requires capturing insights of a broad spectrum of strategic interventions, challenges and impacts implementation at any level for EE&S. In addition, the evaluation

requires capturing core values of the participants by evaluating the importance of aligning EE&S strategies with business strategies. Such data can provide a broad spectrum of knowledge and experience in terms of emerging properties of the EHS.

7 Conclusions

An important feature of transforming theoretical framing relates to accommodating inter-related multiple societal theories. The degree of contextual complexity in a societal system needs to be explicit of considering such framing of decision-making process in order to increase the effectiveness of the broader conceptualisation of sustainable transformations (Voß et al., 2007; Smith et al., 2011; Eriksen et al., 2011; van Vuuren et al., 2011; Wise et al., 2014). This research applied triangulation in the research process (Webb et al., 1966; Greene, 2008; Johnson et al., 2007) in order to increase the trustworthiness of the data and its inferences. Initially, a number of theories have been drawn from integration of concepts (Denzin, 1978) of sustainable transformation, theoretical underpinnings of systems-thinking and empirical systems knowledge of the EHS.

Further, constructivist/interpretivism philosophical stance (Fellows and Liu, 2013; Smirchich, 1983) adopted in this research for knowledge inquiry and development has attempted to consider multiple viewpoints, perspectives and disciplines offered acknowledgement of appreciative and inclusive local and broader contextual realities (Greene, 2008; Johnson et al., 2007). Furthermore, grounded theory was applied to identify theory implications based on synthesis or integration of multiple perspectives (Denzin, 1978; Jick, 1979). Such triangulation of multiple theories acknowledges the comprehensiveness of this research (Jick, 1979). In addition to these, between- or a cross-method triangulation has been applied using AMMR (Webb et al., 1966; Denzin, 1978; Holt and Goulding, 2014), namely, literature review, survey and statistical analysis. These research methods have been used in support or compliment to one another in order to establish methodological rigour (Denzin, 1978).

The broader conceptualisation of sustainable transformations requires identifying barriers to all parameters involved in driving EE&S (Amundsen et al., 2010; Burch, 2010). A comprehensive review of barriers to 5-INs illustrated that a single perspective or dimension was insufficient in representing them. Therefore, understanding these barriers is a multi-perspective or multi-dimensional issue. Latent composite constructs have ability to summarise such issues, thus easing the process of identifying areas that need to be targeted (Morrison and Shortt, 2008; Nardo et al., 2005; Rietveld and Van Hout, 1993; Kim, 2008; Tabachnick and Fidell, 2013; Gorsuch, 2003). Here, the composite common correlated multi-perspectives held by the respondents were represented by finding latent constructs that underpinned combinations of contextual and interrelated (composite) 'very important' agreed barriers (Max-Neef, 2005; Nicolescu, 1998, 2008).

In addition, this analysis described how complex (multi-perspective, multi-dimensional, multi-level) issues such as EE&S can be problematic in evaluation and offers an explanation by describing how respondent's subjective perceptions can be captured. The Likert-type item response format survey questionnaire was instrumental in capturing such perceptions as illustrated in this research. In addition, identification of latent constructs was enabled by the statistical PCA technique (Carifio and Perla, 2008; Norman, 2010; Holt and Goulding, 2014). For example, respondents were asked to

indicate their level of agreement by choosing one of four given number of ordered response categories ranging from 'unimportant' to 'very important'. This is an important contribution to the literature since issues of EE&S have ranged from being discounted to being explicitly focused but with slow success rate (Hamilton et al., 2014; Nalau et al., 2015; Gibbs and O'Neil, 2015).

Given the complexity of the research problem and need to interrelate the systems knowledge to the target knowledge to get a comprehensive understanding of the research problem, this simplistic rating scales used in the survey are not capable of providing rich and detailed data that would offer valuable insights in the complex processes involved in the real situations (Merriam, 2015). The further research design therefore needs to combine qualitative and quantitative methods to yield rich and detailed analysis and support the survey findings (Creswell, 2013).

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Notes

1 UNECE was set up in 1947 by ECOSOC. It is one of five regional commissions of the United Nations. UNECE's major aim is to promote pan-European economic integration. To do so, it brings together 56 countries located in the European Union, non-EU Western and Eastern Europe, South-East Europe and Commonwealth of Independent States (CIS) and North America (http://www.unece.org, 2015).

Appendix

Annex 1: barriers to five essential conditions

Essential condition	*Sr. no.*	*Barriers*	*Author/s*
Investment	1	High upfront costs or lack of investment	Fuller et al. (2009), Caird et al. (2008), Allen et al. (2008), Ravetz (2008) and Williams (2008)
	2	Lack of incentive	Taylor (1997, p.123), Boardman (1993) and Dowson et al. (2012)
	3	Low priority given to energy issues or lack of innovation	Osmani and O'Reilly (2009), Gann et al. (1998), Allen et al. (2008), Ravetz (2008) and Wolsink (2012)
	4	High energy prices	Banfi et al. (2008)
	5	Inability to visualise financial returns in any form of value gain	Bahaj and James (2006) and Power (2008)
	6	Lack of time or effort	Ravetz (2008)
	7	Lack of information and awareness	Allen et al. (2008)
	8	Lack of 'regulatory capacity' or explicit statutory duty	Allman et al. (2004)
Information	9	Information asymmetries/monopoly (one party knows better than others)	Golove and Eto (1996) and UKGBC (2008)
	10	Lack of information	Fuller et al. (2010), Allen et al. (2008), Fuller et al. (2009), Baek and Park (2012) and William (2010)
	11	Lack of awareness	Baek and Park (2012) and William (2010)
	12	Lack of knowledge	Dietz (2010) and UKGBC (2008)
	13	Lack of expertise	William (2010)
	14	Lack of effective communication	William (2010)
	15	Lack of time	Ravetz (2008)
	16	Lack of transparency (ability to win the trust of other stakholders)	William (2010)

Annex 1: barriers to five essential conditions (*continued*)

Essential condition	*Sr. no.*	*Barriers*	*Author/s*
Innovation	17	Lack of funds (public or provided on a competitive base) or high cost	Baek and Park (2012), Power (2008) and Williams (2010)
	18	Lack of support from intermediary agencies	Williams (2010)
	19	Use of exclusively 'high technology'	Wolsink (2012)
	20	Lack of skills	Dowson et al. (2012)
	21	Lack of availability in local proximity	Devine-Wright (2013)
	22	Lack of market for efficient technology	Williams (2008)
	23	Lack of culture to embrace innovation	Ravetz (2008) and Wolsink (2012)
	24	Lack of policy support	Williams (2010)
Incentive	25	Lack of subsidies systems/grants	Baek and Park (2012) and Williams (2008)
	26	Lack of tax exemptions/reduction/credits on investment related to housing energy efficiency	Baek and Park (2012), Clarke et al. (2008) and Power (2008)
	27	Lack of strict enforcement of standards; lack of regulatory capacity	Williams (2010)
	28	Lack of information on financial incentives	Baek and Park (2012) and Painuly (2001)
	29	Lack of higher energy prices	Druckman and Jackson (2008)
	30	Lack of responsibilities to reduce environmental impacts	DCLG (2006b) and UKGBC (2008)
	31	Lack of reward (token or real)	De Young (2000)
	32	Lack of priority for energy efficiency	Ravetz (2008), Osmani and O'Reilly (2009), Gann et al. (1998) and Allen et al. (2008)
Initiative	33	Lack of management	Williams (2010) and Wolsink (2012)
	34	Lack of leadership	Williams (2010)
	35	Fragmentation of the housing sector	Williams (2010)
	36	Lack of coordination (internal or external)	Bulkeley and Kern (2006) and Williams (2010)
	37	Lack of communication	UKGBC (2008)
	38	Lack of capacities	Williams (2010)
	39	Lack of accountability	Clarke et al. (2008) and Wolsink (2012)
	40	Lack of priority for energy efficiency	Osmani and O'Reilly (2009), Gann et al. (1998), Allen et al. (2008) and Ravetz (2008)

Annex 2: Online survey questionnaire

How important are these barriers for energy efficiency in housing?

Introduction

The houses in their use phase are very energy intensive. They are required to become energy efficient by implementing energy efficiency measures/installations/products. Examples of energy efficiency measures in housing include roof and loft insulation, wall insulation, floor insulation, draught-proofing, double glazed windows, energy performance certificates, etc. This survey is to identify important barriers to installing energy efficiency measures in housing.

Housing stakeholder

For simplicity, housing stakeholders are grouped into three major categories.

a Regulator: representing regulators and policy-makers.

b Provider: representing housing provider.

c Consumer: representing end-users: tenants or owner-occupier.

1	With reference to above, please choose the category that best suits you (or your organisation).

Investment

In order to achieve benefits from energy efficiency, *investment* is needed.

2	Please identify the main factors which prevent you (or your organisation) from *investing* in energy efficiency measures. 'Check one response on each row'.				
		Unimportant	*Moderately important*	*Important*	*Very important*
a	High upfront costs or lack of investment	☐	☐	☐	☐
b	Lack of incentive	☐	☐	☐	☐
c	Low priority given to energy issues or lack of innovation	☐	☐	☐	☐
d	High energy prices	☐	☐	☐	☐
e	Inability to visualise financial returns in any form of value gain	☐	☐	☐	☐
f	Lack of time or effort	☐	☐	☐	☐
g	Lack of information and awareness	☐	☐	☐	☐
h	Lack of 'regulatory capacity' or explicit statutory duty	☐	☐	☐	☐

3	Please mention any other factor which you (or your organisation) have identified as a barrier to investment in energy efficiency measures. (*Optional*)

Information

The implementation of energy efficiency measures is affected/hampered due to lack of *information*.

4 Please identify the main factors which prevent you (or your organisation) from gaining the *information* for energy efficiency measures?
'Check one response on each row'.

		Unimportant	*Moderately important*	*Important*	*Very important*
a	Information asymmetry/monopoly (one party knows better than others)	☐	☐	☐	☐
b	Lack of information	☐	☐	☐	☐
c	Lack of awareness	☐	☐	☐	☐
d	Lack of knowledge	☐	☐	☐	☐
e	Lack of expertise	☐	☐	☐	☐
f	Lack of effective communication	☐	☐	☐	☐
g	Lack of time	☐	☐	☐	☐
h	Lack of transparency (ability to win the trust of other stakeholders)	☐	☐	☐	☐

5	Please mention any other factor which you (or your organisation) have identified as a barrier to information for energy efficiency measures. (*Optional*)

Innovations

Innovations means stimulating best practices and new techniques that would contribute towards housing energy-efficiency.

6 Please identify the main factors which prevent you (or your organisation) from contributing towards innovation?
'Check one response on each row'.

		Unimportant	*Moderately important*	*Important*	*Very important*
a	Lack of funds (public or provided on a competitive base) or high cost	☐	☐	☐	☐
b	Lack of support from intermediary agencies	☐	☐	☐	☐
c	Use of exclusively 'high technology'	☐	☐	☐	☐
d	Lack of skills	☐	☐	☐	☐
e	Lack of availability in local proximity	☐	☐	☐	☐
f	Lack of market for efficient technology	☐	☐	☐	☐
g	Lack of culture to embrace innovation	☐	☐	☐	☐
h	Lack of policy support	☐	☐	☐	☐

7 Please mention any other factor which you (or your organisation) have identified as a barrier to innovations in energy efficiency measures. (*Optional*)

Incentives

Incentives can stimulate stakeholders to invest in energy efficiency measures.

8 Please identify the main factors which prevent you (or your organisation) from investing in energy efficiency measures?
'Check one response on each row'.

		Unimportant	*Moderately important*	*Important*	*Very important*
a	Lack of subsidies systems/grants	☐	☐	☐	☐
b	Lack of tax exemptions/reductions/ credits on investment related to housing energy efficiency	☐	☐	☐	☐
c	Lack of strict enforcement of standards	☐	☐	☐	☐
d	Lack of information on financial incentives	☐	☐	☐	☐
e	Lack of higher energy prices	☐	☐	☐	☐

f	Lack of responsibilities to reduce environmental impacts	☐	☐	☐	☐
g	Lack of reward (token or real)	☐	☐	☐	☐
h	Lack of priority for energy efficiency	☐	☐	☐	☐

9 Please mention any other factor which you (or your organisation) have identified as a barrier to incentives for energy efficiency measures. (*Optional*)

Initiatives

Initiatives need to be developed urgently to address the challenge of energy efficiency.

10 Please identify the main factors which prevent you (or your organisation) from promoting *initiatives* for energy efficiency
'Check one response on each row'.

		Unimportant	*Moderately important*	*Important*	*Very important*
a	Lack of management	☐	☐	☐	☐
b	Lack of leadership	☐	☐	☐	☐
c	Fragmentation of the housing sector	☐	☐	☐	☐
d	Lack of coordination (internal or external)	☐	☐	☐	☐
e	Lack of communication	☐	☐	☐	☐
f	Lack of capacities	☐	☐	☐	☐
g	Lack of accountability	☐	☐	☐	☐
h	Lack of priority for energy efficiency	☐	☐	☐	☐

11 Please mention any other factor which you (or your organisation) have identified as a barrier to initiatives for energy efficiency measures. (*Optional*)

Follow up

Invitation to participate in the follow up interview.

12	Are you able to participate in a follow-up questionnaire via the telephone (not more than 20 mins) or interested to receive results compiled as part of this survey? If so, please enter your interest and contact details in the box below. (*Optional*)

Thank you.

Thank you for taking part in the survey.