DELIVERING ZERO CARBON HOMES IN THE UK

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In the UK and internationally, a plethora of voluntary and mandatory energy efficiency standards for new buildings exist, with the common aim of mitigating the impact of new buildings on climate change. However, the take-up of voluntary schemes has been limited and, as a result, many governments have seen the need to introduce mandatory schemes through legislation; from 2016 all new build homes in England and Wales will be required to achieve zero carbon in regulated energy consumption. The international context of voluntary and mandatory building energy efficiency standards is examined through a review of the literature. The review is expanded by a series of semi-structured interviews with construction professionals involved in the delivery of low and zero carbon homes in the UK. In order to establish why zero carbon homes are not being developed, themes of drivers and barriers and challenges in relation to the delivery of zero carbon homes are explored. The drivers which emerged are categorised into four groups: legislative; economic; social responsibility and individual; and the barriers and challenges into a further four groups: skills and knowledge; legislative and governmental; economic and industry. Skills shortages and knowledge gaps for all involved in the delivery of zero carbon homes were seen as the primary barriers and a gap in the literature also exists in this area. Gaining a greater understanding of the skills and knowledge required for the delivery of zero carbon homes is therefore confirmed as the focus for further research.

Keywords: housing, skills and knowledge, sustainability, zero carbon.

INTRODUCTION

Approximately 29% of all carbon dioxide (CO2) emissions in the UK are directly from the domestic sector; the largest proportion of this (83%) is produced by space heating and domestic hot water (DECC 2011). Through the Climate Change Act (HM Government 2008), the UK Government has committed to a legally binding target of reducing CO2 emissions by 80% of the 1990 level by 2050. Working towards these targeted reductions, there will be a requirement for all new homes to be 'zero carbon' from 2016 (CLG 2007). New build housing has the potential to be a leader in both energy efficiency measures and meeting the CO2 emission reduction target. A broad range of voluntary and mandatory standards, regulations and rating tools for new build homes around the world currently exist, some with a focus on energy efficiency, some with a broader 'sustainable' agenda (CLG 2008). These standards provide a historic background to and current international context for the forthcoming zero carbon

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homes standards in the UK and therefore warrant critical review. The aim of this paper is to contribute a better understanding as to why low and zero carbon new build homes are not being built in any numbers in the UK through an exploration of construction industry perceptions around zero carbon homebuilding. The objectives of the paper are to:

- Compare the building standards for low and zero carbon homes in the UK and internationally;
- Investigate the drivers for low and zero carbon homebuilding;
- Identify the barriers and challenges in delivering low and zero carbon homes.

LOW AND ZERO CARBON BUILDING STANDARDS

International design and construction standards

Internationally there exist numerous labels for energy efficient homes, which include low-energy (Sweden), energy-plus (Germany), zero-net energy (USA), passive house (Germany) and sustainable homes (UK) (Williams 2012, Mlecnik *et al.* 2010). A 2008 European survey identified 17 different terms for low and zero energy homes (European Commission 2009). There are many different motivations for regulating or rating the energy efficiency of new buildings. Typically, countries with harsher winter climates have been the quickest to act in the implementation and uptake of mandatory and voluntary building energy efficiency standards. Sweden for example, has had national minimum building energy efficiency requirements since the early 1950's (Hjörth *et al.* 2011) and the Building Regulations in the UK have included standards for limiting heat loss since 1965 (McManus *et al.* 2010), whereas in Australia, energy efficiency requirements for new buildings were not implemented until 2003 (NatHERS 2011). Australia has been able to avoid regulating energy use in buildings for so long due to its climate and its richness of resources; fossil fuels are both plentiful, with no risk to supply, and cheap (Saman 2012). Many European nations first started to seriously consider the need for reducing their dependence on fossil fuels, and therefore improving energy efficiency, as a result of the energy crisis of the 1970's (Williams 2012). More recently, mandatory energy efficiency regulations have been tightened as a result of concern over climate change and its potential impacts (Goodchild and Walshaw 2011, McManus *et al.* 2010, Peterman *et al.* 2012).

In Sweden, the standards for energy efficiency have been equivalent to or better than level 4 of the UK Code for Sustainable Homes (The Code) since 2006. The energy efficiency requirements were tightened in 2009 and again in 2011. Future changes to the regulations are planned for 2015 and 2018-2020 for a move to 'Nearly Zero Energy Buildings' (Hjörth *et al.* 2011). Sweden is currently the only country in which energy efficiency certification is based on measured performance (carried out after 2 years of occupation). As a country that has led the way in terms of energy efficiency, this may be a sign of the future in the UK.

In France, the requirements for energy efficiency of housing are set out in the Thermal Regulations (RT2012). RT2012 requires a maximum primary energy use of only 50kWh/m2yr for all new housing (Grenelle Environnement 2012). A future target has been legislated for with a mandatory requirement for Energy Plus Houses by 2020, this has been established nationally, despite the varied climatic conditions that exist across France. In addition to this mandatory standard, the Haute Qualité Environnementale (HQE) is a holistic environmental standard under which there is a requirement for energy consumption to be 10% lower than prescribed within RT2012.

Within the residential sector in the USA, Energy Star for Homes is the most popular of the three primary voluntary green ratings systems (17% of new homes in 2008 (Reeder 2010)). Energy Star is focused on energy efficiency; however, indoor air quality requirements have been introduced as part of the 2011 update. Achieving Energy Star for Homes is a requirement within the other primary green rating systems; LEED for Homes and National Green Building Standard. An improvement of 15% over the national regulations is required to gain certification under Energy Star.

The vast nature of Australia and its devolved governing status together present issues for the setting of national building standards. The National Home Energy Rating Scheme (NatHERS) is a 10 star energy rating scheme which uses computer simulation to model primary energy loads and assess the thermal comfort of housing. Since 2010, it has been mandatory to achieve a 6* rating for all new housing. Prior to its introduction in 2003, less than 1% of new housing would achieve a 5* NatHERS rating (NatHERS 2011). Under the scheme, 69 climate zones have been defined, each with an individual energy consumption target. Unlike the majority of regulations within Europe, this rating excludes energy used for domestic hot water and lights it also excludes unregulated energy used by appliances.

There has been a proliferation of voluntary standards and sustainable building rating tools in recent years which assess buildings against a broad range of criteria; there has been criticism of some within the literature as, under certain schemes, buildings with only standard energy efficiency are able to gain 'green' certification (Byrd and Leardini 2011, Mlecnik *et al.* 2010).

UK STANDARDS FOR LOW CARBON HOMES

The most prominent sustainability label for housing in England is the Code for Sustainable Homes (CLG 2008). The Code is a voluntary sustainability rating tool in which homes can be certified from level 1-6; 6 being the most sustainable. Maximum CO2 emissions levels are mandatory for each of the six levels of the Code. The importance of energy efficiency within the Code is highlighted by the fact that the energy category is weighted to account for 36.4% of the overall points available. Since its inception in 2007, over 40,000 homes have been certified at post-construction stage; of these over 37,000 have achieved level 3 (CLG 2011a). All social housing attracting funding from the Homes and Communities Agency has been required to achieve Code level 3 as a minimum and some Local Authorities have introduced a requirement within policy to achieve a certain Code level. These borderline mandatory requirements account for its high degree of uptake; the private housebuilding sector has not bought-in to the Code to any significant extent on a voluntary basis; private developments account for less than 15% of post-construction certified homes under the Code (CLG 2011a) whereas they account for around 80% of all new build homes (Wilcox 2009).

'Zero carbon homes' will be a mandatory standard in the UK from 2016, announced in 2007, originally the standard was ambitious, requiring not only regulated energy (for heating, cooling, hot water, ventilation, auxiliary services and lighting) to be zero carbon, but also unregulated energy covering all home appliances (CLG 2007). Lowe and Oreszczyn (2008) commented on the ambitious speed and scale of the zero carbon policy and made recommendations to limit the targeted reduction of CO2 emissions. In the face of concern from the construction industry and with the deepening of the global financial crisis, the definition has been amended to include only regulated energy. Therefore, the definition for the purposes of this study will be that currently

proposed to be included within the 2016 amendments to Part L of the Building Regulations; broadly: “A new-build home from which there are zero net CO2 emissions from regulated energy use”. The means by which zero carbon can be achieved are flexible: compliance with a Fabric Energy Efficiency Standard (FEES); generation of on-site low or zero carbon energy (Carbon Compliance); and 'Allowable Solutions'. Allowable solutions allow for an element of local, near or off-site carbon offsetting (Zero Carbon Hub 2011). Figure 1 illustrates the changing definition for zero carbon and its relation to the Code.

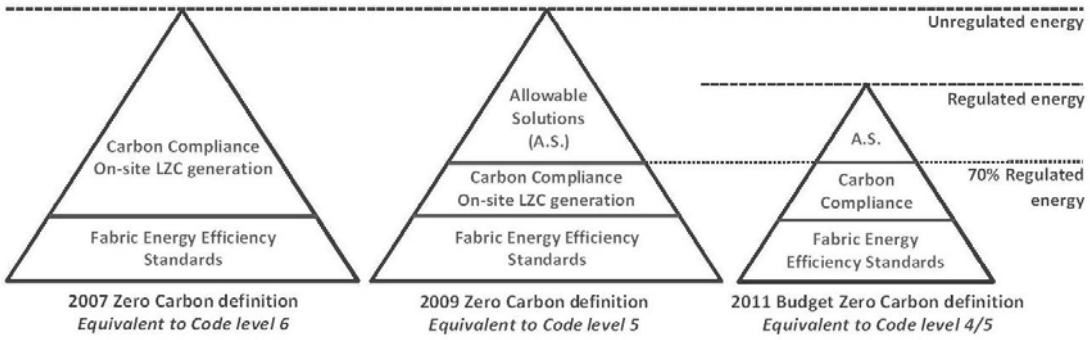

Figure 1: The changing definition of Zero Carbon (after Zero Carbon Hub 2011)

The international standards upon which a comparison is drawn focus on the energy efficiency of buildings in terms of their fabric; limits are set for maximum regulated energy usage in kWh/m2yr. The UK standards differ in their use of KgCO2/m2yr as a metric; however, the introduction of FEES as part of the zero carbon homes standard will provide a requirement for minimum levels of energy efficiency in kWh/m2yr.

DIFFUSION OF ENERGY INNOVATION WITHIN HOUSEBUILDING

The literature has shown that the take-up and diffusion of voluntary green building ratings systems has been slow and limited (Mlecnik *et al.* 2010), this is due to the status of the economy, financial motives and the structure of the construction industry (Peterman *et al.* 2012); the construction industry is formed of a complex supply-chain, through which the diffusion of new knowledge is not easy. Goodchild and Walshaw (2011) state that in the case of zero carbon homes, as a socio-technical system innovation has been discouraged by the lack of financial incentives. The literature has shown that there are conflicting views with regards to market demand; Lovell (2005) found that the housing market has failed to respond to increasing consumer demand for low energy homes. The Callcutt (2007) Review however suggests that there is a lack of demand for highly energy efficient homes due to homebuyers being poorly informed, and even for those that are cognisant of the benefits of energy efficiency, their preferences for price, size and location of a home typically outweigh any preference for energy efficiency. Lovell (2005) concurs with this and suggests that the industry has a tendency to stifle innovation because decisions in housing are not just based on cost and concludes that economic supply and demand theory is too simplistic to apply to the complex housing market with its myriad of socio-technical issues.

Osmani and O'Reilly (2009) undertook a study using a questionnaire survey within which responses were received from 41 of the top 100 housebuilders in England. The study sought to identify drivers for and barriers to zero carbon home building from the housebuilder's perspective. From the findings they categorise drivers for zero carbon homes into 4 groups: legislative, cultural, business, and financial; and barriers into a

further four groups: legislative, cultural, financial, and design and technical. Legislation was found to be both the strongest driver and the most significant barrier. The Callcutt (2007) Review supports these findings; stating that with the lack of a strong market driver, the Government need to legislate, however, unless this legislation is credible, clear, sustained and enforced, it may act as a barrier.

SKILLS SHORTAGES AND KNOWLEDGE GAPS

A recent research study looking at the energy usage of new homes against their design energy usage (Miles-Shenton *et al.* 2010) found that the homes studied used an average of 100% more energy. Equally concerning is a recent study of Building Control departments within two District Councils (Pan and Garmston 2012) which found that only 35% of the new homes applications analysed provided necessary proof of compliance with Part L of the Building Regulations. They conclude that this is due to both inadequate systems within the Building Control departments and poor provision of information by the builders. Both of these studies are potentially indicative of skills shortages and knowledge gaps within the housebuilding industry.

Glass *et al.* (2008) used the PEST model of analysis (political, economic, social and technological) to identify enablers and barriers in developing improved standards in new build construction. Amongst the categories of social and technological barriers, a number of issues around skills and knowledge are identified, including: skills shortages; migrant workers; need for CPD and education; lack of know-how; lack of research and development; poor client knowledge; and poor specification writing and estimating. Amongst their recommendations to tackle these and the other barriers identified are: the instigation of regional demonstration projects; tighter legislation and quality control; and the establishment of a 'pan-institutional think tank' to identify new educational routes and career paths.

The Academy for Sustainable Communities' report, Mind the Skills Gap (ASC 2007) presents findings from a study to assess projected gaps in supply and demand of the necessary skills for the delivery of sustainable communities. The results for different sectors are presented for both England as a whole and its nine regions, of which the South West is one. The study forecasts that the South West will be likely to encounter the second greatest skills gap of the regions identified, with the most significant deficiencies amongst planners, landscape architects, architects, urban designers, surveyors and developers.

The Callcutt (2007) Review confirms this forecast; it makes reference to a shortage in the professions which are not directly employed within the housebuilding industry, but who are essential to the successful delivery of housing; such as planners. Their recommendations to tackle this issue are that planning departments should be formed of multi-disciplinary strategic teams and that, as part of a co-ordinated training programme, planning team members should be seconded to and from private practice. The review also suggests that skills shortages in the housebuilding sector are, in part, due to the structure of the industry; a significant majority of firms in the sector have made use of contingent labour whereby they have no obligation to consider the long-term training of those staff.

The review of the literature has identified that the diffusion of voluntary energy efficiency measures for buildings has been slow (Callcutt 2007, Lovell 2005, Mlecnik 2010, Peterman 2012); the views of housebuilders in England on the drivers and barriers have been explored (Osmani and O'Reilly 2009), but not those of the wider

industry. The extant research has also failed to cover challenges that have been experienced in the delivery of low and zero carbon homes. The review of the literature has shown that there are existing skills shortages and knowledge gaps which might potentially be exacerbated through the introduction of the zero carbon homes standard.

RESEARCH METHODS

Mixed methods were employed within this research. A critical literature review was carried out to identify and compare international building energy efficiency standards and subsequently, a series of in-depth interviews were carried out in order to explore perceptions of the drivers, barriers and challenges relating to the delivery of low and zero carbon homes. Twelve semi-structured interviews were conducted, with the aim of scoping for broad themes. The interviews were conducted with professionals within the housebuilding sector in South West England and also with a small number of national-level experts in the field of low carbon homebuilding in the UK (Table 1). Whilst most of the interviews were carried out with construction professionals from South West England, the majority of these professionals have worked outwith the area and a number of interviews were carried out with national experts. The findings therefore have relevance beyond the regional context. The interviewees were selected using a combination of purposive and snowball sampling (Bryman 2012); participants with suitable experience in the field of low and zero carbon homebuilding were initially selected and they then suggested other appropriate interviewees. Bryman (2012) suggests that snowball sampling is well suited for use in qualitative research. The interviews comprised a series of open-ended questions developed for this research; 7 interviews were conducted face-to-face and 5 over the telephone. The first 2 interviews were transcribed and analysed in order to check internal validity and the interview questions were expanded at this stage. The qualitative data was analysed and coded through NVivo using thematic analysis (Bryman 2012).

Table 1: Interviewee categorisation

Organisation type	No. of interviewees	Position/ Role
Client	2	Housing Association Development Manager
Contractor	1	Chief Executive
Design consultant	2	Architect, Energy Consultant
Local Authority	5	Planning Policy/ Building Control Officer
Government Agency/Quango	2	National policy expert
Total	12	

FINDINGS AND DISCUSSION

Drivers for low and zero carbon building

The interviewees were asked to identify drivers for zero carbon homebuilding. Whilst not intending to quantify the findings due to the exploratory nature of the study, the emerging themes have been categorised into groups and the groups placed in order of significance (most significant first); drivers: legislative, economic, social responsibility and individual (Table 2).

Legislation was seen as the most effective driver for the delivery of low and zero carbon homes; this view concurs with the findings of the Osmani and O'Reilly study of housebuilders (2009). The clarity of direction is seen as a necessity for pushing

through the implementation of this challenging standard, this is further supported by the literature (Goodchild and Walshaw 2011, Peterman *et al.* 2012).

Table 2: Emerging themes - Drivers

Legislative	Economic	Social Responsibility	Individual
Climate Change Act	Cost of fuel	Fuel poverty	Positive action
Building Regulations	Prototyping	Moral drivers	Common sense
	Easier asset management	Limited resource use	Comfort
	Employment		Moral drivers
	Market demand		

Rising fuel prices have meant that homeowners are increasingly conscious of the cost of heating homes and this translates into an economic driver for low and zero carbon homes. In terms of financial drivers for a developer however, there were divergent views amongst respondents regarding the existence, or not, of market demand for low and zero carbon homes. Within the Osmani and O'Reilly study (2009), financial drivers were seen as the least significant theme whereas within this study they were seen as the second most significant theme. These divergent, and at times polar, views are symptomatic of the complexity of the housing market as a socio-technical system.

Social responsibility was one group of drivers identified for the volume delivery of low and zero carbon homes. With fuel poverty and energy security being issues of importance throughout the UK, a number of the professionals interviewed saw the need to address these concerns as a driver for zero carbon homebuilding.

The theme of individual drivers was identified as the least significant group of drivers within this exploratory study. Respondents suggested that comfort, common sense, morals and the desire to do something positive for the environment were all drivers for individuals.

Barriers and challenges for low carbon building

The interviewees were also asked to identify barriers and challenges for low carbon homebuilding. These comprise four groups (most significant first): skills and knowledge; legislative and governmental; economic and industry (Table 3).

By far the most significant barriers and challenges identified by the respondents were those relating to skills shortages and knowledge gaps. Interviewees' perceptions were that knowledge gaps existed for all parties involved in the delivery of housing, including planners and the build and maintenance teams. Skills and knowledge gaps were not identified as an issue within Osmani and O'Reilly's study of housebuilders (2009). However, both Callcutt (2007) and Glass *et al.* (2008) found skills and knowledge to be an issue of concern for the implementation of enhanced standards in new build construction and for housebuilding in general, though not specifically for zero carbon homes. A gap in the literature in respect to both understanding and addressing the skills shortages and knowledge gaps for the successful implementation of the zero carbon homes standard was therefore highlighted by this exploratory study. The level of awareness and knowledge of users and the general public were also identified as significant barriers and challenges. One respondent interviewed in the context of a new low carbon home development saw end user education, in terms of operating a low carbon home, as a much greater challenge than the education of the delivery team. The need to educate the occupants of low and zero carbon homes,

albeit an area with a lack of exploration in existing literature, is outside the scope of this paper.

Table 3: Emerging themes - barriers and challenges

Skills & knowledge	Legislative & Governmental	Economic	Industry
Knowledge - Build, O&M	Uncertainty re ZCH	Lack of market drivers and payback	Nature of housing market - volume housebuilding
Knowledge - Users	Moving the goalposts	Capital cost	Being context specific
Knowledge - Designers	Planning agenda	Promoting growth	Collaborative working
Skills availability			Cultural change
Hard to persuade people			New business models
Moving from demonstration to mainstream			Product availability

Amongst the respondents, there was a feeling that, although the government have affirmed their commitment to the zero carbon homes policy, with a track record for changing the goalposts, until there is legislation in place, the industry is reticent to make firm steps to prepare. These findings are supported by the literature (Callcutt 2007, NHBC 2010, Osmani and O'Reilly 2009).

Economic barriers were also identified; there is a perception amongst the wider industry that there are a lack of market drivers and financial payback for low and zero carbon homes; however respondents held conflicting views in both of these sub-themes. Osmani and O'Reilly (2009) found that the lack of financial incentive was seen as a major barrier by housebuilders. The issue here lies in the separation between those paying for and those receiving the benefit; the popular view holds that zero carbon homes do not attract a sales premium.

Barriers and challenges themed around the nature and culture of the housebuilding industry were identified by the interviewees. Amongst the themes identified were the need to work more collaboratively, flexibly and in a context specific way. These barriers differ from those identified within the study into housebuilders' perceptions (Osmani and O'Reilly 2009) where lack of confidence in green technologies and practice being based around current regulations were identified under their corresponding theme of cultural barriers. Another view of respondents within this exploratory study was that the current business model of the industry acts as a barrier.

CONCLUSION

This paper has compared a range of voluntary and mandatory energy efficiency standards for new build housing in the UK and internationally, reviewed the literature on the theory of diffusion of innovation within the housing sector, and, through interview-based research, explored stakeholder perceptions of why low and zero carbon homes are not being delivered. The comparison has shown that the zero carbon homes standard for the UK is progressive and challenging but one which the industry feels is achievable given the right support; clear legislation and sufficient skilled workers with appropriate levels of knowledge of zero carbon homebuilding.

The research into perceptions around the delivery of zero carbon homes has elucidated and identified a number of themes of drivers including: legislation, economic, social

responsibility and individual; and barriers and challenges including: skills and knowledge, legislative and governmental, economic and individual. The legislative drivers were seen to be critical to the delivery of zero carbon homes; to the extent that the UK Government's delay in providing a clear definition of zero carbon is seen as a barrier. The primary barriers and challenges to moving forward with the delivery of zero carbon homes, however, were those relating to skills shortages and knowledge gaps for those involved in planning, designing, building and maintaining the homes; this is where this research contributes to knowledge. There is a need for greater understanding of the necessary skills and knowledge for the effective implementation of the zero carbon homes standard and, further, strategies for addressing the skills shortages and knowledge gaps identified. The wealth of feedback from the interviews on skills and knowledge as a barrier and the lack of extant research on the subject of skills and knowledge for zero carbon homebuilding in the literature, confirm this as the focus for further research.

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