Title: ENERGY PERFORMANCE OF ZERO CARBON HOMES IN UNITED KINGDOM

Subject: Management

Type of Paper: Dissertation

Words: 11753

ABSTRACT

The perception of various standards associated with voluntary energy efficiency within United Kingdom has been limited. Due to which the government has recognized the need for the introduction of the schemes with the help of legislation with the aim of achieving the target of converting all the houses in United Kingdom to zero carbon homes till 2016. However, as 2016 approaches, very few zero carbon homes are being delivered. The purpose of this study was to explore the barriers associated with the mass development of the zero carbon homes within United Kingdom. The objectives of this study were to evaluate the drivers of the zero carbon homes within United Kingdom. Along with that the objective of the study are also to formulate a suitable mechanisms for the policy and practice that will support the development and delivery of zero carbon homes within United Kingdom.

CHAPTER 1: INTRODUCTION

Introduction

Currently, we are facing some serious challenges associated with the high consumption of energy and the environment. The changing global environmental and energy scenarios are closely interlinked with one another. The issues associated with the consumption and supply of energy are tightly linked with the environment as they have a direct impact over the environment such as air pollution, ozone depletion, radio-active waste, and global warming (Lepkova et.al, 2014). The building sector can play a major role in tackling these issues, as the construction industry alone is responsible for consuming 40% of the primary energy resources, and most importantly 30% of the total Carbon Dioxide (CO_2) emissions.

The energy and environmental situation of United Kingdom is also experiencing strains and the building sector is inflicting even a larger burden in comparison with the global levels. The per capita CO_2 emissions in United Kingdom, over 18 metric ton (mt) that is much higher than the world's average per capita consumption of less than 5 mt. In United Kingdom the demand for electricity has seen a major growth due to the development of the construction projects within United Kingdom. In United Kingdom the residential construction sector is among the biggest electricity consumers within the state. The residential sector accounts for more than 50% of the total national electricity consumption, which has resulted in to the development of the various factors such as; low tariffs, increase electricity demand, high economic growth, and burgeoning population (Kapsalaki, & Leal, 2011).

According to the statistics in the coming years the British residential sector will experience a significant growth, as the population of United Kingdom is increasing at the rate of 2.5% per year and only 24% of the British nationals have their own homes. Whereas, according to the statistics almost two-third of the population is under the age of 30 years, suggesting that United Kingdom will be require to build 2.32 million new homes by 2020, in order to meet the needs of this growing population. Thus, for tackling the environmental and energy challenges in the coming the building sector of United Kingdom needs to needs to move towards sustainable building. The development of zero-energy homes (ZEHs) could be a useful sustainable solution for UK residential sector.

Background of the Study

Until recent decades, energy was inexpensive in the UK and hence energy efficiency was not a prime consideration in the design of homes or in the equipment used in them. For example, until the 1970s, the price of heating oil was less than £l/gal (often only pennies a gallon). At these low prices, the cost of heating a home with an oil-fired boiler or furnace was low relative to income for most people. Likewise, electricity prices were lower, so efficient appliances or lighting were not needed. However, with the advent of higher energy prices in the late 1970s, home energy costs suddenly rose significantly, and hence energy efficiency started to become a factor in home design and in the design of equipment used by homeowners. Two major factors began to influence energy consumption in homes (Annunziata et.al, 2013). First, by the 1980s, residential building codes began to call for higher insulation values and better windows for new homes, which reduced heat loss in winter and kept the houses cooler in summer.

Second, there was a movement underway to design and build homes that used passive solar to help in heating and lighting. Thermal mass was used to capture and store heat during the day and to release it at night, thereby reducing the load on the primary heating system. Large, south-facing windows were installed so that plenty of daylight could enter the house, reducing the lighting load. Homes that were built to the better codes and that used these passive solar designs had considerably lower energy loads and costs. At roughly the same time as energy efficiency in the home was becoming a concern, the use of PV and solar thermal panels became more common, as the technology of these systems became more available and affordable. So-called "solar-powered" homes began to make an appearance, especially after the Federal government started to offer rebates to purchasers of PV panels (Hamdy et.al, 2013).

This early "boom" in solar power did not last, due in part to the end of Federal subsidy for solar systems and the dramatic drop in energy prices in the late 1980s, Likewise, with heating oil back below £l/gal, some impetus for passive solar design disappeared. By the 1990s, though building codes had improved, very few homes had any kind of passive solar design element or on-site energy generation system. However, a new UK government program was about to begin that would encourage consumers and manufacturers to reduce energy consumption in home electronic products. .

In the early 1990s, the UK Department of Energy (DOE) and the UK Environmental Protection Agency (EPA) began their joint program for the development of energy efficient houses in

United Kingdom. At first only for computers and computer monitors, it was quickly expanded to include other office products, HVAC equipment and eventually all types of home appliances (washers, ranges, refrigerators, etc.). Energy Star labelling informed consumers how much energy a particular device normally consumed in a year, and hence helped them to select products that were more efficient. Significantly, in 2000 the program was expanded to include actual houses.

Finally on Dec 2006 the British government introduced zero energy homes in United Kingdom, and promised that the by 2016 all the homes in United Kingdom will be built based on this concept. ZEH is a term widely known for residential buildings with zero net energy consumption and zero CO_2emissions. There is however not any unanimous definition for ZEHs in the literature. One of the oldest definitions is the one provided by Esbensen, & Korsgaard, (1977) when they described an experimental zero energy house in Denmark as a "dimensioned to be self-sufficient on space heating and hot-water supply during normal climatic conditions in Denmark".

Furthermore, in a study for zero energy houses in Netherlands undertaken by Gilijamse, (1995), he stated that "A zero-energy house is defined as a house where no fossil fuels are consumed, and annual electricity consumption equals annual electricity production". A more detailed description of the concept of the ZEH was provided by Iqbal, (2004) when he stated that "Zero energy home is the term used for a home that optimally combines commercially available renewable energy technology with the state of the art energy efficiency construction techniques. In a zero energy home no fossil fuels are consumed and its annual electricity consumption equals annual electricity production. A zero energy home may or may not be grid connected". Another focused definition is provided by Torcellini et.al, (2006) as: "a residential building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies". In the case of zero energy homes, the renewable energy generation can also be done off-site. However, this approach should only be adopted under the circumstance in which the on-site renewable systems are not reliable and sufficient enough for supporting the energy requirements of the building as highlighted in Fig. 1.1 below.

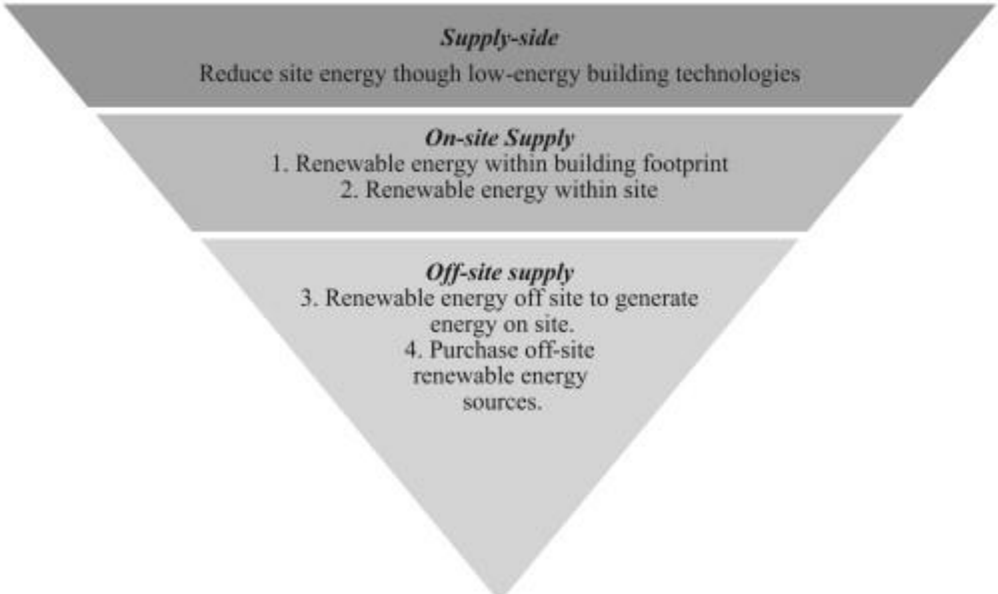

Fig. 1.1: Renewable energy supply hierarchy in ZEH.

Zero Energy Homes would cut the demand for utility-scale electricity production or transmission projects within homes itself. These projects, though a source for local jobs, face opposition from "NIMBISM", even when the energy sources for these projects are renewable. Each month, a net-zero homeowner would see smaller utility bills than a similarly sized conventional home, since his on-site production is reducing or eliminating (depending on the month) the need to purchase off-site energy. Even if the home has supplemental heating from a wood or propane stove, it would require less of the other fuels since a zero carbon home is so well insulated and tightly sealed. For instance, if the home was retrofitted to net-zero, then instead of using 1 or 2 cords of wood to supplement an oil furnace prior to retrofit, the "new" home may only need or Vi of a cord. Money formerly spent on energy could be used for any other purchase, invested or simply saved (Kibert, & Fard, 2012). Also, a net-zero or near net-zero home requires no or little off-site energy, and hence the homeowner is shielded from energy cost fluctuations. A significant portion of a homeowner's energy cost is for heating, which in United Kingdom, usually means purchasing fossil fuels. According to the latest RECS, 4.8 out of 5.5 million homes in United Kingdom burned fossil fuels for their main source of space heating in 2009: heating oil (2.3 million), natural gas (2.2 million), propane (0.2 million) or kerosene (0.1 million) (EIA, 2009).

Aims of the Study

The aims of this study are to:

- Evaluate the various drivers of zero carbon homes in United Kingdom
- Identify the challenges and barriers faced by builders in the development of zero carbon homes
- Formulation of suitable mechanism, for policy and practice supporting the development of zero carbon homes in United Kingdom

Purpose of the Study

The purpose of this study is exploring the barriers associated with the mass development of the zero carbon homes within United Kingdom. In this study the researcher will conducted an investigation of the perceptions of professional that are involved in the commissioning, design, construction and regulation of housing regarding zero carbon homes within United Kingdom.

Objectives of the Study

The objectives of this study are the evaluation of the drivers of the zero carbon homes within United Kingdom. Along with that the objective of the study are also to formulate a suitable mechanisms for the policy and practice that will support the development and delivery of zero carbon homes within United Kingdom.

Significance of the Study

In recent years, there has been much debate on whether the world's climate is changing, and whether the activities of mankind are a leading cause for this change. What is certain is that concentrations of greenhouse gases (carbon dioxide, methane, and nitrous oxide) have increased in the past hundred years. These gases trap outgoing heat radiating from the surface in our atmosphere, and keep our planet warm enough to support life. However, this increase in their concentration has led to a small yet potentially significant increase in the average temperature of the planet, aka global warming. Climatologists think that global warming is the reason for changes in our climate, and many believe that the burning of fossil fuels and the resulting release of greenhouse gases is the direct cause. Man's increasing consumption of fossil fuels to produce energy is therefore most often cited as the cause for climate change. If nothing changes, our energy consumption will continue to increase through population growth and industrialization. The emission and concentration of greenhouse gases will continue to rise, global temperatures increase, and climate change become more o f a problem. It is clear that reducing energy demand in NE's residential sector will have a relatively high impact on reducing overall energy demand. In addition, it will yield a relatively greater reduction in greenhouse gas emissions compared to other regions of the UK because, as seen in figures 6 and 7 below, a higher percentage of residential energy in NE vs. the UK average comes from on-site fossil fuel combustion (73.5% vs. 53.9%).

The significance of this study is very high as this study focuses over the development of legislation in support of the housebuilders who are the ones responsible for building of zero carbon homes. According to "The Energy Performance in Buildings Directive:, the responsibility for the development of a legislative framework are on the on the individual member states; zero carbon homes and zero carbon buildings are the UK's response to this Directive. There needs to be flexibility in these legislation in order to allow the countries to individually develop legislation as per their own contextual conditions. According to Mlecnik (2012) this confusion is a result of the diversity of the definitions internationally, this diversity in the definitions serves as a major obstacle for the implementation of "The Energy Performance in Buildings Directive". Thus, it is basically due to this tightening legislative backdrop, that the zero energy building projects have failed to be developed on a large scale.

CHAPTER 2: LITERATURE REVIEW

Zero Carbon Homes in United Kingdom

Zero carbon homes is a standard first announced to the UK construction industry in 2007, at which point the UK Government expressed an intention of constructing all the new homes and converting the current homes to zero carbon homes by the end of 2016 (DCLG, 2007). This originally was a very ambitious standard, in which the houses do not only eliminate the emissions from regulated energy (for auxiliary services, hot water, ventilation, heating, cooling, and lighting) to be accounted for, but also those from unregulated energy (for cooking and plug-in appliances) (DCLG, 2007).

The Zero Carbon Hub is an open/private association that has been and keeps on being integral to the advancement of the meaning of zero carbon homes in the UK. Their 2014 recommendations recommend the zero carbon homes standard will contain three components for agreeability: a Fabric Energy Efficiency Standard (FEES); on location energy era utilizing low or zero carbon innovations (Carbon Compliance) and 'allowable arrangements' (Zero Carbon Hub, 2014). Allowable arrangements accommodate nearby, close or off-site carbon counterbalancing, for example, a group renewable energy plan (Zero Carbon Hub, 2011). Somewhere around 2007 and 2014, the proposed meaning of zero carbon for the standard has been liable to two noteworthy changes; firstly, the presentation of allowable arrangements in 2009 (Parliament UK, 2009) and furthermore, the evacuation of the necessity to record for unregulated energy in the 2011 financial plan.

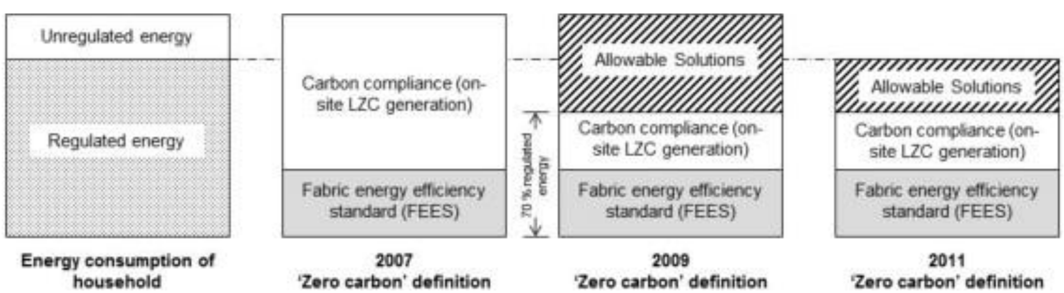

Fig. 2.1: The Evolution of the official *zero carbon* definition in the UK (developed from Zero Carbon Hub, 2011).

The Government was at first censured for the driven speed and size of the zero carbon approach (Lowe, & Oreszczyn, 2008) and suggestions were made to breaking point the focused on lessening of CO2 emanations. Notwithstanding, all the more as of late, concerns have been communicated that the standard may be further 'diluted' before coming into power. There has been feedback inside the scholastic writing that the proposed energy efficiency necessities of the zero carbon homes standard are frail in light of the fact that the prerequisite is excessively liberal with respect, making it impossible to the allowance for the buy of energy from off-site sources rather than conserving energy (Marszal et.al, 2011).

Context for Zero Carbon Homes in United Kingdom

The Code for Sustainable Homes (the Code) (DCLG, 2008) is the most prominent voluntary sustainability label for housing in England. The Code is a holistic sustainability rating tool in which homes are rated against indicators in nine categories. Homes can be awarded a star rating between levels 1 and 6, with 6 being the most sustainable. The 'Energy and CO_2 emissions' category is weighted to account for 36.4% of the overall points available across the nine categories and increasing minimum standards for CO_2emissions are mandatory for each of the six levels of the Code (DCLG, 2010). Private developments account for only 18% of post-construction certified homes under the Code (DCLG, 2013b) whereas they account for around 76% of all new build homes (Marszal et.al, 2011). Fig. 2.2 illustrates this point; the proportion of all new build homes is shown by sector, as is that of all Code certified homes. It is evident that a very small proportion of the homes built by the private sector have voluntarily gained Code certification.

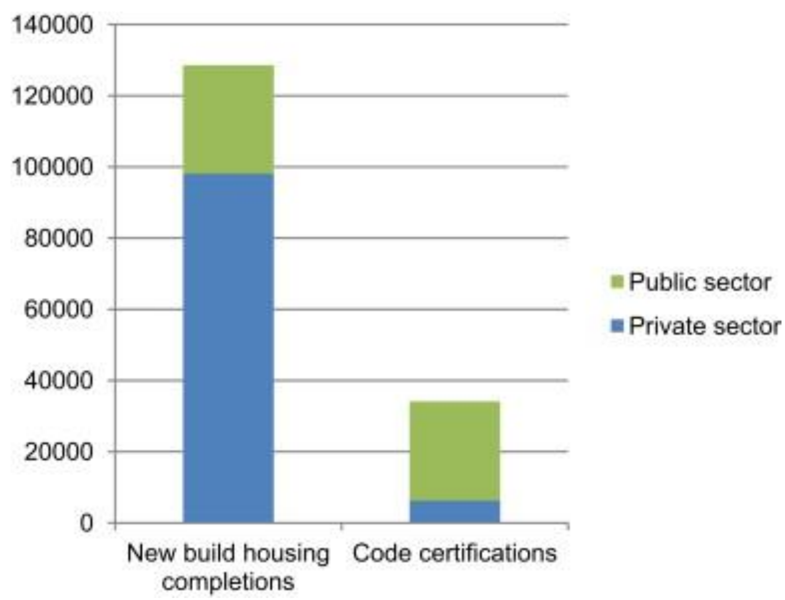

Figure 3 Fig. 2.2: Total new build housing completions and Code certifications 2011 (developed after DCLG, 2012; Wilcox and Pawson, 2012).

When it was first conceived, the *zero carbon* standard was equivalent to the highest level of the Code (level 6) in terms of energy and carbon emissions. The removal of the need to account for unregulated energy and the introduction of allowable solutions have reduced the on-site energy requirements for a *zero carbon home* to somewhere between those for Code levels 4 and 5. In 2014 a further exemption to the *zero carbon homes* standard was announced to the UK Parliament; small developments will not be required to meet the standard (Pearson, 2014). Although the detail of this exemption is unknown, it is of concern to 'green building' advocates as it represents another weakening of the forthcoming standard, thus reducing the potential carbon emission savings.

In England and Wales, the Building Regulations set out legal requirements for building work in relation to both new and existing buildings in order to ensure they are 'safe and accessible and limit waste and environmental damage' (DCLG, 2014a). Ways in which the Regulations can be met are set out within a series of Approved Documents. Approved Document Part L relates to 'Conservation of fuel and power' and is formed of four parts: Part L1A, new dwellings; Part L1B, existing dwellings; Part L2A, new buildings other than dwellings and Part L2B, existing buildings other than dwellings. It is anticipated that the *zero carbon homes* standard will be incorporated within a 2016 amendment to Part L1A of the Building Regulations.

There have been recent moves to identify ways in which to rationalise non-statutory demands placed on new build housing through the planning process in the UK; initially through the Harman Review (Local Housing Delivery Group, 2012) and more recently through the Housing Standards Review (DCLG, 2013c). Subsequently, in 2014, a ministerial statement announced that the Code would be 'wound down' and many of the requirements under the Code consolidated into the Building Regulations (DCLG, 2014b). Although a consolidation of overlapping standards has been welcomed by industry, concerns have been expressed regarding both the potential negative effect on the quality of homes as a result of the removal of the Code and omissions in the transition to the Building Regulations only approach (Leckner, & Zmeureanu, 2011). A technical consultation on the Housing Standards Review is in progress (DCLG, 2014c), when complete, a Planning Statement will be made and from that point it will no longer be possible for local planning policy to reference the Code. In light of concerns regarding the removal of the Code, BRE (formerly the Building Research Establishment, BRE is an independent consultancy which undertakes research in all aspects of the built environment in the UK) is planning to develop a new voluntary standard for housing in the UK to cover such issues as climate resilience, occupant wellbeing, efficiency of resources, biodiversity and energy efficiency.

One further voluntary standard which is getting to be more normal in the UK is the Passivhaus standard. Built in Germany in the mid-1990s, to date, more than 30,000 structures have been constructed to this voluntary standard. The standard obliges structures to be composed and built with to great degree strict levels of airtightness, super protection, restricted warm spanning and mechanical ventilation with warmth recuperation (MVHR). Together, these warm efficiency measures ordinarily lessen the warmth demand of a house to such a level as to invalidate the requirement for a customary warming framework. It has been proposed that the Passivhaus standard could structure an establishment for a more powerful zero carbon homes approach in the UK, following a 'fabric first' approach (Leckner, & Zmeureanu, 2011), in spite of the fact that this is challenged by the Zero Carbon Hub who state that this methodology is not cost ideal (Zero Carbon Hub and Sweett Group, 2014). A comparison of potential *U*–values, level of airtightness and specific heat demand for *zero carbon homes* with those for the Passivhaus standard is shown here (Table 2.1).

Table 2.1: Comparison of fabric energy efficiency requirements: Z*ero carbon homes* and Passivhaus (Heffernan et al., 2013 developed afterBRE, no date and Zero Carbon Hub, 2009).

	Zero carbon homes	Passivhaus
Specific heat demand (kWh/m^2/yr)	≤39 (apartment/terraced)	≤15
	≤46 (detached/end terrace)	
***U*-Values** (W/m^2 K)		
Walls	0.18	≤0.15
Floors	0.18	≤0.15
Roofs	0.13	≤0.15
Windows	1.4	≤0.8
Airtightness (ach @ 50 Pa)	3	≤0.6

Economic Factors Encouraging Growth of Zero Energy Homes

There are several factors that are encouraging the construction of more net-zero and near net-zero energy homes in the United Kingdom. First, there is simply a greater demand by homebuyers for homes that are very energy efficient. Likewise, demand for on-site renewable energy systems is increasing (Attia et.al, 2012). The combination of these two trends results in an increase in demand for Zero Energy Homes. Second, costs for renewable energy systems (especially PV) are decreasing, making them affordable to a larger segment of the home-buying public. Third, incentives continue to promote the construction of energy efficient homes. Finally, energy prices continue to rise.

Increased demand

Demand for homes that are energy efficient and for residential renewable energy systems are both up. As an indication of the growing demand for energy efficient housing, the percentage of new, single family homes built in the UK that qualified for the Energy Star rating reached 25% for the first time in 2010. The popularity of residential renewable energy systems has also increased, especially over the past few years, with annual growth rates between 33% and 103% since 2005 (da Graça et.al, 2012). An energy efficient house coupled with a renewable energy system could result in a net-zero energy homes, hence Zero Energy Homes are also increasing. A combination of economic factors have come together to encourage this growth, including a decrease in PV system cost, more wide-spread incentives to lower construction costs and earn income from power generation, higher energy prices, and lower borrowing costs.

Decrease in capital costs

Building to net-zero standards will cost more than building to local code, if only because of the added cost of the renewable energy system. Ever since PV systems first became available to residential customers, the major hindrance to their adoption was their cost. As recently as the late 1990s, a 5-kilowatt DC PV system cost as much as £40,000 installed and was therefore cost prohibitive to most homeowners. However, prices have been declining, making PV systems more affordable. The net installed cost fell an average of 4.6% per year over the period. Leasing a PV system is an alternative to buying, and has grown in popularity in the past couple of years.

Homeowners who lease need little to zero cash upfront to have a PV system, just a good credit history. Two of the homes included in this research used leased PV systems.

Incentives Continue to Reduce Costs

While costs for PV systems were falling, incentives have fluctuated during the same period. State and local incentives have generally declined, but this has been offset by the increase in Federal incentives, stemming from the elimination the cap of £2000 per residential system on the Federal incentive tax credit (ITC). The result is that in 2010, the average cost for installed residential PV, after incentives but before including income from renewable energy credits (RECs), was just £3.60/W, a historic low (Barbose et.al, 2011). The cash Zero Energy Homes owners will receive for their RECs (or "SRECs", Solar Renewable Energy Credits) is a newer incentive and yet another input into the financial analysis of a Zero Energy Homes. States regulate their SREC markets, enabling producers of SREC to sell them to buyers. Many states hold auctions for RECs and/or SRECs several times per year, where the prices for these transferable credits in dollars per megawatt-hour are set.

These auctions are the mechanism used to ensure producers always receive some financial reward for "minting" their SRECs. Hence, depending on supply and demand, the price of these credits can fluctuate, though some states have set minimum prices for RECs to ensure some income to producers. Massachusetts, for example, has a minimum price of £300/MWh. For a 3.6 kW DC system in Lawrence MA, the PVWatts estimator program projects a production of 4 MWh per year. The homeowner would make at least £1200/yr. from the sale of his or her SRECs, a substantial income.

Energy prices continue to rise

As shown in figure 2.2 above, energy prices have been on the rise since the 1970s. Homeowners are consequently motivated to reduce energy consumption and even generate their own in order to keep their energy costs under control.

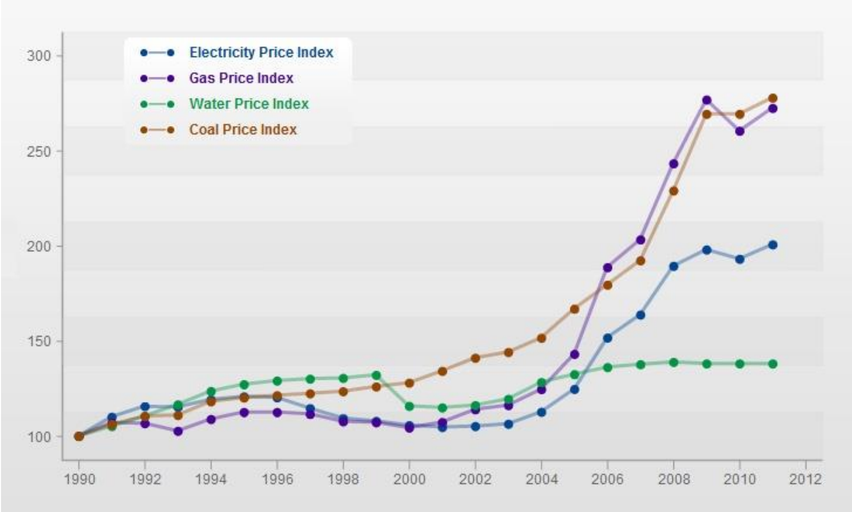

Figure 2.3: Rise in Energy Prices in United Kingdom

Mortgage Rates Remain Historically Low

Mortgage rates have been trending down since peaking in the 1910s as shown in the figure below. Lower rates can significantly lower the monthly cost of owning a home, and make the additional cost of installing more energy efficient measures and/or a renewable energy system more affordable.

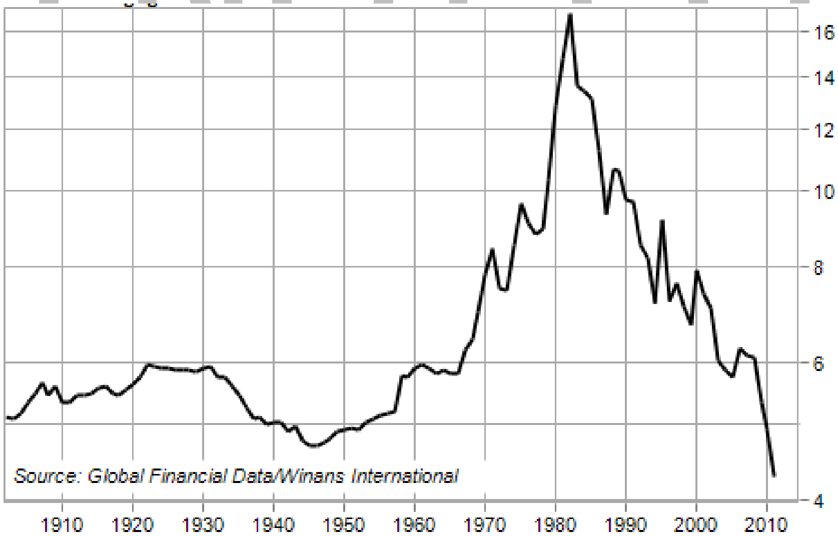

Figure 2.4: Mortgage rate in United Kingdom

Diffusion of Energy Efficiency innovation within HouseBuilding in United Kingdom

The construction industry is formed as a complex supply-chain, through which the diffusion of new knowledge is not straightforward. *Zero carbon homes* have been described as a form of

socio-technical system (Deng et.al, 2011); a socio-technical system being an interconnected network of social institutions and material technologies (Lovell, 2007). McLeod et.al, (2012) state that the take-up and global diffusion of green building ratings systems has been slow and limited. The status of the economy and financial motives have been cited as contributing factors which result in the low levels of take-up of voluntary energy efficiency measures (Mohamed et.al, 2014). Goodchild and Walshaw (2011) also state that in the case of *zero carbon homes*, innovation has been discouraged by a lack of financial incentive. They assert that due to 'the inertia of design and production systems' these financial incentives would need to be large.
A 2005 exploration study by Lovell, & Lovell found that the housing market has neglected to react to expanding purchaser demand for low energy homes and that the industry tends to smother development, because of the way that choices in housing are not recently taking into account expense and the housing market has extensive force. Lovell infers that monetary supply and demand hypothesis is so short-sighted it couldn't be possible apply to the more intricate housing market with its heap of socio-specialized issues. The Callcutt Review (Callcutt, 2007) proposes there is an absence of demand for profoundly energy productive homes because of home buyers being inadequately educated, and that, regardless of some home buyers being cognisant of the profits of energy efficiency, their inclination at the cost, size and location of a home commonly exceed any inclination for energy efficiency. The audit expresses that with the absence of an in number market driver, the UK Government need to enact. Notwithstanding, it was cautioned that, unless this enactment is sound, clear, managed and authorized, it may go about as a boundary (Callcutt, 2007). To summarize the more extensive writing on dissemination of energy efficiency advancement refers to financial hindrances and the intricacy of the industry as the essential reasons that change is slow and constrained. The writing additionally highlighted divergent perspectives as to the presence, or not, of market demand (Lovell, 2007).

CHAPTER 3: METHODOLOGY

Research Method

For this research study the author selected qualitative research paradigm. Qualitative research or qualitative methodology refers to a group of research methods based on linguistic-semiotic used mainly in social sciences. It is usually considered all the different qualitative techniques to survey and experiment. That is, open interviews, focus groups or technical observation and participant observation. It assigns numeric values to statements or observations, in order to study with statistical methods possible relationships between variables.

The reason behind the selection of quantitative research methodology is its ability to generalize the results to a particular population through statistical techniques of sampling. By contrast, qualitative research does not insist on representation. Facing its problems of external validity through various strategies, including the most common prolonged stay in the country (in anthropology), "triangular" results with quantitative data three or adoption of structural representativeness criteria: include in the shows members of the main elements of social structure on the phenomenon of study (Anfara, 2014).

Research Design and Instruments

Exploratory research design was adopted. Exploratory sresearch design was aimed at exploing the variables that were not identified before. As the aim of this research is to explore the perceptions of the housebuilders working in the construction industry in relation to the development of the zero carbon homes, the researcher conducted nterviews for data collection and analysis (Kothari, 2011). Exploratory Study is primarily a search for information in relation to a predefined problem. This raw data must be addressed in order to get out new ideas (or Findings), intervenes at this level exploratory analysis via data processing volumes (data crunshing) and research of correlated elements (between where there is a link for example define behaviors deviation of clients), organization and consolidation of these elements through techniques including statistical (data Mining) (Blumberg, 2011).

The major aim of this study was to explore the perceptions of the housebuilders working in the construction industry in relation to the development of the zero carbon homes. For this purpose the researcher conducted semi-structured interviews, in which the participants were the professional involved in the construction, designing, commissioning and regulating of the housing in UK, who were primarily working inside the South West of England. The reason behind the selection of semi structured interviews is that they provide a greater degree of flexibility than structured, because they are based on planned questions, which can be adjusted to respondents. Its advantage is the ability to adapt to subjects with enormous possibilities to motivate the party, clarifying terms, identify ambiguities and reduce formalities. Along with that semi structured interviews provides the researcher with the capability of designing the questions for the interview in advance, with a particular order and contains a set of categories or options for the subject to choose. It is applied rigidly to all study subjects. It has the advantage of systematization, which facilitates the classification and analysis also shows a high objectivity and reliability. Its disadvantage is the lack of flexibility that involves the failure to adapt the subject to interview and a shallower depth in the analysis.

Sampling of the Study

For this study the researcher utilized purposive sampling, which involves the selection of participants based on their value to the research rather than at random (Rubin, &Rubin 2005), was considered most appropriate.

Interviewees with experience of the design and construction of low and zero carbon homes were initially selected using convenience sampling. Along, with that the researcher will also use snowball sampling which Bryman (2012) suggests is well suited for use in qualitative research. Bryman (2012) comments that within interview studies, the number of interviews tend to be 15±10 due to factors of time, resources and the law of diminishing returns. Warren (2002) states that, for the purpose of academic publication, between 20 and 30 interviews are required. A target of 30 interviewees was therefore sought due also to the heterogeneous sample group, in order to make it possible to identify any similarities and differences within and between the sample categories. In total, 34 interviews were conducted from the 45 professionals who were contacted to take part; this constitutes a response rate of 76%.

Data Collection

Data for the study was collected from the sample of 45 selected participants, 34 interviews were conducted from the 45 professionals who were contacted to take part; this constitutes a response rate of 76%. Hughes and Murdoch (2001) identify three overarching categories of roles within the construction industry: clients, consultants and constructors. They also identify the category of regulator for those ‘involved by virtue of regulatory functions’ (p. 158). Within previous research in this area (Osmani and O’Reilly, 2009) only the views of volume housebuilders, who cross over the categories of client and constructor, were explored. Therefore, with the aim of gaining the views of the wider industry involved in the design, construction and regulation of new homes, professionals were selected from the following six categories: developer; contractor; architectural consultants; design consultants (e.g. consulting engineers and quantity surveyors); local authority and government agency/quango (quasi-autonomous non-governmental organisation). The number of interviewees within each category is shown in Table 3.1.

Table 3.1: Interviewee categorisation.

Organisation type	**No. of interviewees**	**Private: Affordable**	**Position/Role**
Developer	5	2:3	Development Manager/Developer
Contractor	5	1:4	Regional Director/Director
Architectural consultant	7	6:1	Architect/ Director/Sustainability Manager
Design consultant	7	1:6	Consulting Engineer/Quantity Surveyor
Local authority	5	–	Planning Policy/Building Control Officer
Government agency/ QUANGO	5	–	Policy expert/Design Manager
Total	**34**	**10:14**	

The interviewees typically had experience of working on housing projects in both the private and affordable housing sectors, but with a majority of their workload within a single sector. The primary sector in which interviewees worked is indicated in Table 2 for all interviewees except those within the local authority and quango categories. Of the 24 interviewees in the remaining four categories, 10 worked primarily within the private sector and 14 worked primarily within the affordable housing sector. All interviewees had experience of working on multiple schemes of ten homes or more.

All interviewees were provided with the interview questions in advance of their interview to allow for preparation. The interviews comprised a series of open-ended questions developed for this research. The majority of interviews were conducted face-to-face (25) and the remainder (9) were conducted over the telephone. Notes were taken during the interviews and the majority (30) were digitally voice recorded with the consent of the interviewees. Each interview was transcribed and the data were analysed using NVivo 9 qualitative data analysis computer software.

Data Analysis

A combination of thematic and matrix analysis was employed for the analysis of the qualitative data. Thematic analysis is amongst the most common methods of qualitative data analysis (Bryman, 2012). Within this study, the term 'theme' is used to represent a category or grouping identified and selected by the authors; the themes selected have all been identified by at least two interviewees, care has been taken to ensure that all themes are distinct from each other. The themes were developed both from the data and using an a priori approach (Ryan and Bernard, 2003); that is, from the literature and the 'characteristics of the phenomenon being studied' (p. 88) built upon the researchers' prior knowledge. Matrix analysis, as introduced by Miles and Huberman (1994), was used to support and strengthen the thematic analysis.

The coded data have been analysed and interpreted both overall and within and across the interviewee categories. Whilst not intending to rely heavily on quantifying the findings of this qualitative study, the themes identified in relation to each of the questions have been placed in order of significance. The significance of the themes has been rated both in terms of the number of interviewees who identified a theme or sub-theme and also in terms of the semantics used within the interviewees' responses.

CHAPTER 4: RESULTS OF THE STUDY

Drivers For Zero Carbon Homebuilding

In this section of the study the respondents were asked to identify the drivers associated with zero carbon homebuilding. The themes identified from the literature and data are: legislative, economic, social responsibility, individual and industry (Table 4.1). Under each of the themes a number of sub-themes have also been identified from the data.

Table 4.1: Identified themes – Drivers.

Theme	***Sub-themes***	***Example quote***
Legislative	Building Regulations Climate Change Act Planning Funding requirements The Code for Sustainable Homes	*'I think unfortunately legislation is one of the few things that will actually get zero carbon building in; because people have to do it'* [Design Consultant #2]
Economic	Cost of energy Market demand Need for affordable homes Trialling Funding requirements Prestige Incentives Energy security	*'The next one then is market drivers so that's the demand, so if it's coming from the end users and the people who are going to buy my product or if there's a demand for it, or if I believe there is a marketing angle; the prestige of having the first ones, or moving the agenda on, if it's something that I can attract a premium for my development for the prestige of it'* [Quango #2]
Social responsibility	Fuel poverty Moral drivers Imperative to act Sustainable development	*'Well, given the way the resources are being used up on the planet, I think we've got no choice but to look at these avenues and they'll probably get more and more efficient and improve'* [Developer #3] *'Drivers…the fuel poverty. I suppose the environment; I suppose those are the two big drivers to be honest with you'*[Developer #5]

	Limited resource use Reduce environmental impact	
Individual	Low running cost Public awareness Positive action for the environment Moral drivers Comfort Aspiration	*' I think in the last 2 or 3 years, we have started to experience homeowners starting to question now 'has the builder put the right insulation in?' whereas, a few years ago, they didn't really notice, didn't care, didn't bother, you know, not interested, whereas now people are more aware of it and I think it's the cost of fuel'*[Greenwich Council]
Industry	Being seen to be green Fashion Housing associations	*'it is a driver in itself, we want to be seen as green, we want to be seen as building green houses'* [Martin-construct]

Legislation was seen as the joint most significant theme of drivers for the delivery of *zero carbon homes* alongside the economic drivers. Under the theme of legislation a series of sub-themes was identified, of these the Building Regulations were seen as the principal driver for zero carbon homebuilding, being identified by 20 interviewees as a driver. Enhanced requirements in order to obtain funding, such as those for affordable housing, were also seen as a driver. This sub-theme of 'funding requirements' also sits under the economic driver theme.

Lower running costs for a zero carbon home were identified as a driver by 17 of the interviewees, across all of the interviewee categories. As far as the financial drivers are concerned, the respondents had a divergent view regarding the existence of the market demand of the zero carbon homes. Among the interviewees the social responsibly was identified as one driver that was associated with the volume delivery of *zero carbon homes*. A significant minority of interviewees identified fuel poverty as a driver for the delivery of *zero carbon homes* (10); respondents from most interviewee categories identified this sub-theme, with a concentration in the contractor group.

The theme of individual (householder) drivers was identified as a secondary group of drivers within this study. These are perceived drivers, from the householder's perspective, identified by the professional interviewees. There are elements of cross-over between the social responsibility drivers theme and the individual drivers theme including sub-themes relating to moral drivers and environmental impact reduction. The strongest sub-theme identified by the interviewees was low running costs, which has an overlap with the primary economic driver of cost of energy. Respondents suggested that comfort, aspiration and public awareness were also all drivers for individuals.

The least significant theme of drivers was industry drivers; that is drivers from within the industry. There were very few references to drivers within this theme from the interviewees in comparison to the other four themes. However a small number of interviewees felt that there were drivers from the industry such as: being seen to be green, fashion and Housing Associations (leading by example).

Challenges and Barriers Associated with Zero Carbon Homebuilding

The interviewees were asked to identify barriers and challenges for zero carbon homebuilding. The sub-themes of barriers identified have been grouped into five themes: economic, skills and knowledge, industry, legislative and cultural (Table 4.2).

Table 4.2: Identified themes – Barriers and challenges.

Theme	***Sub-themes***	***Example quote***
Economic	Capital cost Scheme viability Lack of market demand Perceived risk Land values Perceived cost Home valuations 'Green' overpricing Section 106/CIL	*'Short-term, the big barriers are going to be the capital cost and the return on the investment. Simple pound shilling and pence, it doesn't make economic sense certainly not for developers because they're just not able to, at this moment in time anyway, recoup that in the cost of the housing'*

		[Quango #2]
Skills and knowledge	Knowledge – occupants Knowledge – build team Knowledge – design team Skills availability Public awareness Knowledge – maintenance team Knowledge – planners Fabric first Moving from demonstration to mainstream Awareness of workforce Poor competency	*'We're going to have a problem where people eventually move into these houses and they're not going to know half of these systems and why they're there and how they work'* [Contractor #5]
Industry	Availability of products Lack of collaborative working Unproven/inappropriate technology Failing to be place specific Hard to persuade people Lack of drive from housebuilders Volume housebuilding Business models Resistance to change Design process Complexity Every project is a prototype	*'There's always a reluctance from developers I would say to do more than the minimum, not all I'm not going to tar all with the same brush, but some of the main ones, you know, it's about maximising profit and ticking the box, so that's still quite a challenge'* [Quango #5]
Legislative	Uncertainty re ZCH policy Planning agenda Persuading Government sustainability will not stifle growth Moving the goalposts Current Building Regulations	*'I wouldn't say that lack of clarity over direction is a barrier…It is a reason for not making progress, so what we need is a clear definition for zero carbon and a clear definition for allowable solutions so that the housebuilders can invest in research and development and for their supply chain to do the same'* [Quango #3]

Cultural	Housebuilding industry culture Householder culture Aesthetic culture	*'The culture of the industry is a barrier, but also the culture of the occupiers'* [Contractor #4]

Economic barriers were identified as the most significant theme by the interviewees. The capital cost of delivering *zero carbon homes* was identified as the strongest sub-theme within the study with 25 of the 34 interviewees identifying it as a barrier. The issue of scheme viability was another commonly identified sub-theme. Tying in with the sub-themes of land values and home valuations, interviewees perceived a tangible issue with how to make delivering *zero carbon homes* financially viable. There was a perception amongst the interviewees within this study that there is a lack of market demand for *zero carbon homes*. Although respondents held conflicting views in this respect, some interviewees felt there is an element of market demand, although they were generally unsure of the level.

A further primary group of barriers identified by the interviewees was skills and knowledge. Interviewees' perceptions were that knowledge gaps existed for all parties involved in the delivery of housing. The level of awareness of the public and knowledge of occupants were identified as a significant barrier. The barrier 'occupant knowledge' was identified by a significant majority of the interviewees (20), a higher number of references than were made to the knowledge of both the design and build team acting as a barrier.

Barriers and challenges themed around the way of the housebuilding industry were recognized by the interviewees. Amongst the sub-themes distinguished were the needs to work all the more collaboratively, flexibly and in a spot particular manner. Interviewees inside this study recognized the current plan of action of the industry as a boundary. A further hindrance distinguished in connection to the housebuilding industry was its latency.

Barriers presented by legislation and government were identified by the interviewees. Amongst the respondents, there was a feeling that, although the government have affirmed their commitment to the *zero carbon homes* policy, the industry is reticent to make firm steps to prepare until there is legislation in place. The issue of the impact of changes in Government on legislation was also raised; one interviewee called for cross-party support for *zero carbon homes*.

It was suggested that the industry cannot be expected to invest in designs, products and research if there is no certainty of future legislation.

The theme of cultural barriers was seen by the interviewees to be the least significant of the themes of barriers and challenges. Three sub-themes were identified under this theme: housebuilding industry culture, householder culture and aesthetic culture.

Support Mechanisms for Zero Carbon Homebuilding

The interviewees were asked to propose support mechanisms for the delivery of *zero carbon homes*. The support mechanisms identified have been grouped into four themes: education, training and awareness; legislation; financial and industry (Table 4.3).

Table 4.3: Identified themes: Support mechanisms for zero carbon homebuilding.

Theme	***Sub-themes***	***Example quote***
Education, training and awareness	Public awareness Occupant education Industry education Industry training Low carbon champions Design guides Client awareness Post build studies	*'education, it's understanding how you don't just put a PV panel and that's what makes it environmentally friendly, it's knowing the process and engaging with professionals'* [Architectural Consultant #1]
Legislation	Building regulations Robust planning policy framework Clarity in definition for ZCH Cross party support Incentives Stricter requirements for public land	*'I think there are a few things that are key and the first thing I think is around getting that definition nailed down and defined and the details of it defined and a commitment to translating that into Building Regs'* [Local Authority #4]

Financial	Incentives Develop market demand Low cost solutions Funding Mortgage solutions Payback mechanism Economies of scale	*'I think the easiest way, if from a financial point of view, if the Government somehow sort of had a tax regime that made it beneficial. I think you will find a lot more people doing that.'* [Developer #5]
Industry	Off-site construction Collaborative working Simple design solutionSelf-build Standardised specifications Context specific design Availability of materials Redesign & broaden standard housetypes	*'collaboration and understanding from the very earliest stages'* [Design Consultant #4] *'I will draw an analogy to the car industry – everything in car sales is now based on fuel efficiency etc. and the production process is efficient. We need to build modular homes, more custom housing, we need to change the way we build'* [Contractor #4]

Most of the ideas for the ways in which the delivery of *zero carbon homes* could be better supported were identified under the theme of education, training and awareness. The strongest sub-themes were increasing public awareness and occupant education; these address the most significant barriers identified under the skills and knowledge theme. Interviewees identified the need for improved awareness and education for a range of people involved in procuring and delivering new homes. One way of increasing awareness that was suggested by a number of interviewees was through the introduction of zero carbon champions within key organisations, such as local authority planning and building control departments.

Under the theme of legislation interviewees suggested clarity in the definition for *zero carbon homes*; a robust planning policy framework and stricter Building Regulations as ways in which to address the barriers previously identified. Interviewees stressed the need for the UK Government to go beyond confirming their commitment for *zero carbon homes* and provide the detail of the regulations in order that all those involved in the delivery of housing can prepare and progress. A number of ways in which the public sector could support the integration of zero carbon within the housebuilding process were identified, including design guides, design panels or legislation, but with an emphasis on the need for a clear and consistent approach.

Under the theme of financial support mechanisms, interviewees identified a number of sub-themes including: incentives develop market demand, low cost solutions, funding and mortgage solutions. The provision of incentives was the most commonly identified sub-theme; interviewees' suggestions for incentives included reductions in council tax; incentives through the planning system; subsidies and tax incentives. Interviewees were not however supportive of the idea of financial disincentives. Some interviewees discussed existing initiatives such as the feed-in-tariff as a way to incentivise zero carbon homebuilding. Others returned to the issue of market demand, suggesting that when householders become aware of the benefits of *zero carbon homes*, demand for the product will start to develop.

A number of sub-themes were identified under the theme of industry support mechanisms, including: off-site construction, collaborative working, self-build and context specific design. A number of interviewees felt that the industry requires a more significant change than simply perpetuating traditional methods of construction but making it more energy efficient. They saw the need for a move towards more off-site manufacture for improved quality and attention to detail; others saw the need to reduce waste as a driver also guiding construction in the direction of off-site manufacture. A number of interviewees also suggested an increase in self-build methods of procurement which tend to complement off-site manufacture. The proposal to encourage more self-build methods of procurement is made not only as a means of tackling the barriers identified within the volume housebuilding industry, but also as a way of engaging occupants in the process of delivering new homes as a long-term solution.

Analysis and Discussion of the Results

Drivers for Zero Carbon Homebuilding

Overall, interviewees were able to identify an average of nearly five drivers each. Contractors were able to identify the most drivers on average, followed by design consultants and architectural consultants. Developers were able to identify the fewest drivers on average (Table 4.4). The primary themes of drivers were legislative and economic; the secondary themes of drivers were social responsibility and individual. Industry drivers were identified as the least significant.

Table 4.4: Drivers – No. of sub-themes identified per interviewee from matrix analysis.

[a]	*Private/affordable housing sector* [b]	Legislative	Economic	Social responsibility	Individual	Industry	**Total**
Con 1	*P*	2	1	1	1	0	**5**
Con 2	*A*	2	2	1	2	0	**7**
Con 3	*A*	2	2	2	0	0	**6**
Con 4	*A*	3	1	3	1	0	**8**
Con 5	*A*	2	2	1	2	1	**8**
AC 1	*A*	1	1	1	1	0	**4**
AC 2	*P*	2	2	0	0	0	**4**
AC 3	*P*	2	1	0	0	0	**3**
AC 4	*P*	3	2	0	0	0	**5**
AC 5	*P*	2	3	1	3	2	**11**
AC 6	*P*	0	2	1	1	0	**4**
AC 7	*P*	0	2	1	1	0	**4**
DC 1	*A*	0	0	0	2	0	**2**
DC 2	*P*	1	0	3	0	0	**4**
DC 3	*A*	3	2	1	1	1	**8**
DC 4	*A*	1	1	0	1	0	**3**
DC 5	*A*	1	3	0	0	0	**4**
DC 6	*A*	2	2	1	1	1	**7**
DC 7	*A*	0	3	2	3	1	**9**
Dev 1	*A*	0	0	1	0	0	**1**
Dev 2	*A*	1	0	1	0	0	**2**
Dev 3	*P*	0	1	1	1	0	**3**
Dev 4	*P*	1	2	0	2	2	**7**

Dev 5	*A*	0	0	2	0	0	**2**
LA 1		1	1	1	0	0	**3**
LA 2		2	2	0	0	0	**4**
LA 3		1	1	0	0	0	**2**
LA 4		2	1	1	0	0	**4**
LA 5		1	1	1	1	0	**4**
Q 1		2	1	0	1	0	**4**
Q 2		2	3	0	0	0	**5**
Q 3		2	0	0	0	0	**2**
Q 4		0	1	0	1	0	**2**
Q 5		0	0	2	2	0	**4**
Total		**44**	**46**	**29**	**28**	**8**	**155**

Full matrices showing individual interviewee's responses per sub theme can be found in Heffernan (2013).

a.Con=Contractor; AC=Architectural Consultant; DC=Design Consultant; Dev=Developer; LA=Local Authority; Q=QUANGO.

b. P=Private sector; A=Affordable housing sector.

Interviewees within the contractor category held the strongest perception of legislation as a driver, whereas interviewees from the developer category held the weakest opinion of legislation as a driver. There was consensus amongst the remaining interviewee categories that legislative drivers are currently very significant; primarily the forthcoming changes to the Building Regulations, but also the impending European requirements within the EPBD. This view concurs with the literature; clarity of direction is seen as a necessity for pushing through the implementation of this challenging standard (Callcutt, 2007,Goodchild and Walshaw, 2011).

The divergence of the developer group in respect of failing to identify legislative drivers is not isolated to this theme of drivers; this interviewee category identified the fewest drivers overall when compared to the other interviewee groups. This is perhaps indicative of the fact that developers currently do not see significant motivation to deliver *zero carbon homes*. This is supported by a number of interviewees who expressed the view that until stricter legislation is in place, *zero carbon homes* will not be delivered in quantity.

The highest number of drivers was identified under the economic theme (Fig. 4.1). However, when semantics were taken into account, legislative drivers were perceived to be more significant (Fig. 4.1). Interviewees believed that the increasing cost of energy has started to make homeowners conscious of the energy efficiency of their homes. As a result, they suggested that this has the potential to act as a driver and develop market demand for *zero carbon homes*. This supports the literature which found that the cost of energy has begun to act as a driver in the case of homeowners choosing to make existing homes more energy efficient (Caird et al., 2008). However, within this study, there were divergent views as to the presence or absence of market demand for *zero carbon homes*. These divergent, and now and again polar, perspectives are symptomatic of the multifaceted nature of the lodging business; when considering acquiring a home, property holders organize various other criteria over its vitality effectiveness (Lovell, 2005). Osmani and O'Reilly's (2009) investigation of housebuilders' sentiments recognized monetary drivers as the minimum critical subject, while, inside this study financial drivers were seen as a standout amongst the most noteworthy themes. The distinction in the discoveries of these studies can maybe be clarified by the heterogeneity of the specimen gather inside the current study, contrasted with the homogeneous gathering of private division housebuilders inside the past study. When the views of the developers are isolated within the current study, the economic drivers are seen as the joint second most significant drivers amongst the interviewee category. However, it is noted that there is a low level of consensus amongst the developer group for any theme of drivers. The interviewee group with the strongest perception of economic drivers was the architectural consultants.

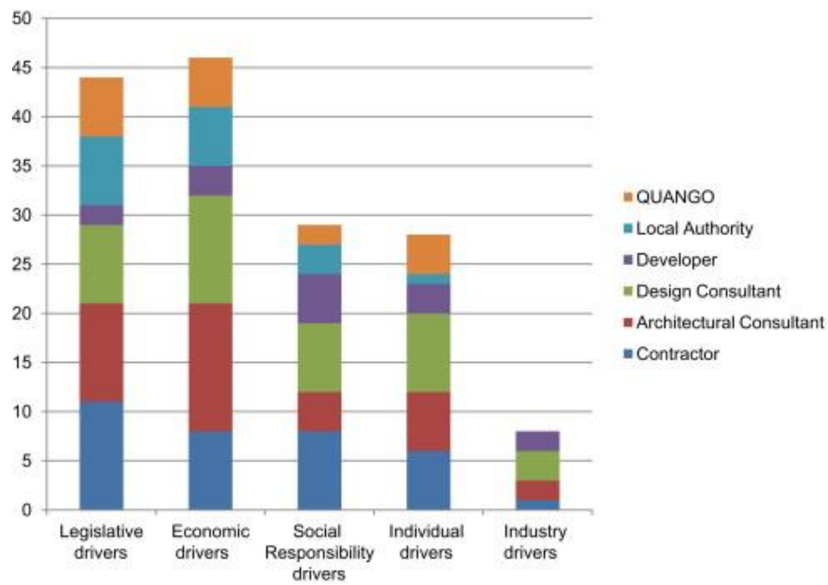

Fig. 4.1: Drivers – Sum of sub-themes from matrix analysis.

It is estimated that around 18% of households in England are now living in fuel poverty, this was therefore of concern to many interviewees and thus identified as a driver under the theme of social responsibility. Indeed, this was the strongest theme of drivers identified by the developer group. However, they were not the group with the strongest perception of social responsibility as a driver; the contractor group was able to identify the highest number of drivers in this theme on average. That this theme was perceived by the developer group as the most significant reason to start to deliver *zero carbon homes* is probably due to that group comprising a small majority from the not-for-profit housing sector (3 of 5) for whom addressing the issue of fuel poverty is of concern.

Challenges and Barriers Associated with for Zero Carbon Homebuilding

Interviewees were able to identify more sub-themes for this question than any other by a significant margin (Table 4.5). The overall average number of barriers and challenges identified was over eight per interviewee. Further, the barriers identified exceed the drivers not only in number, but also in magnitude, this is indicative that the interviewees perceive the delivery of *zero carbon homes* to be problematic at present.

Table 4.5: Barriers – No. of sub-themes identified per interviewee from matrix analysis.

[a]	*Private/affordable housing sector* [b]	Economic	Skills and knowledge	Industry	Legislative	Cultural	**Total**
Con 1	*P*	1	1	2	0	0	**4**
Con 2	*A*	4	4	5	0	0	**13**
Con 3	*A*	2	3	4	3	3	**15**
Con 4	*A*	3	0	1	0	2	**6**
Con 5	*A*	4	3	1	0	0	**8**
AC 1	*A*	0	1	0	1	0	**2**
AC 2	*P*	3	2	3	2	1	**11**
AC 3	*P*	2	0	2	0	2	**6**
AC 4	*P*	0	2	1	0	0	**3**
AC 5	*P*	4	2	5	1	0	**12**
AC 6	*P*	4	2	4	0	0	**10**
AC 7	*P*	1	2	1	0	0	**4**
DC 1	*A*	1	4	2	0	2	**9**
DC 2	*P*	2	3	2	0	1	**8**

DC 3	*A*	2	5	3	2	0	**12**
DC 4	*A*	2	5	2	1	2	**12**
DC 5	*A*	3	3	2	0	0	**8**
DC 6	*A*	3	3	2	1	1	**10**
DC 7	*A*	4	0	0	2	0	**6**
Dev 1	*A*	2	4	2	0	0	**8**
Dev 2	*A*	0	3	0	0	0	**3**
Dev 3	*P*	4	2	0	0	0	**6**
Dev 4	*P*	4	2	2	1	0	**9**
Dev 5	*A*	2	3	1	1	1	**8**
LA 1		1	2	0	0	0	**3**
LA 2		0	3	1	0	0	**4**
LA 3		1	0	0	0	0	**1**
LA 4		2	2	0	1	0	**5**
LA 5		1	3	3	1	0	**8**
Q 1		1	4	5	0	0	**10**
Q 2		2	7	1	2	0	**12**
Q 3		5	1	3	1	1	**11**
Q 4		4	5	0	2	0	**11**
Q 5		1	5	5	2	1	**14**
Total		**75**	**91**	**65**	**24**	**17**	**272**

Full matrices showing individual interviewee's responses per sub theme can be found in Heffernan (2013).

a.Con=Contractor; AC=Architectural Consultant; DC=Design Consultant; Dev=Developer; LA=Local Authority; Q=QUANGO.

b. P=Private sector; A=Affordable housing sector.

There was a strong level of consensus across the interviewee categories for the theme of economic barriers and challenges; the group with the strongest perception of economic barriers was the contractor group and those with the weakest perception of the economic barriers were the Local Authority interviewees. Interviewees cited increased costs (real and perceived) of building a zero carbon home as a barrier to their delivery. However, a recent report (Zero Carbon Hub and Sweett Group, 2014) states that the increased cost of building a zero carbon home (over 2013 Building Regulations standards) is around £3700–4700 for a semi-detached or mid-terrace house. This is a significant reduction from the forecast additional costs when the standard was first announced of up to £36,000 per home (over 2006 Building Regulations standards and based upon the stricter anticipated definition at the time) (Savills, 2007).

Osmani and O'Reilly (2009) identified that the low amount of finance was seen as a major barrier for the development of zero carbon homes by the housebuilders. In the case of zero carbon homes, the perception of the interviewees is that housebuilders pay a premium to deliver homes that provide their future occupants with the benefit of reduced operational costs, but the housebuilder is then unable to attract a premium for their higher quality product. Some interviewees placed the responsibility for this impasse with the mortgage companies and the Royal Institute of Chartered Surveyors (RICS, whose role it is to provide 'Professional Standards' for the valuation of all financial assets, including homes). Together, they fail to acknowledge the value of energy efficiency, despite reports that low energy housing has been able to attract a premium of between 9% and 20% (Lovell, 2005) and that around a quarter of households would be prepared to pay more for an energy efficient home. Indeed, a study of transaction prices for homes in The Netherlands identified homes were able to attract a 10% premium with an 'A' rated EPC compared with the average 'D' rated home and a further 5% discount was evident for 'G' rated homes. It is therefore surprising that homes cannot currently be valued at a premium to reflect the additional capital costs and that homeowners are not allowed to borrow more based on their reduced operational costs; if this were the case it is envisaged that housebuilders would start to build more *zero carbon homes*.

The theme of skills and knowledge barriers received the largest number of references when compared to the other themes. However, the economic barriers were perceived to be of greater magnitude. Despite being identified as a primary theme of barriers within this study, the knowledge and skill gaps were no identified as major issues within the study. However, in the studies of both Callcutt (2007) and Glass et al. (2008) knowledge and skills were identified as a major source of concern associated with the implementation of the enhanced standards within the construction of zero carbon homes. Of greater concern to the interviewees than the skills and knowledge of the designers, contractors and regulators was that of the building occupants. Interviewees had faced challenges in handing over homes incorporating new technologies to occupants and thus identified the need to educate the occupants of *zero carbon homes* in how to operate them effectively and efficiently. Interviewees also cited the need for potential purchasers to be made aware of the *zero carbon homes* standard and the imperative for change. The Attitude-Behaviour-Choice (ABC) model has been widely adopted within the literature on climate change in relation to lifestyle and behaviour (Shove, 2010), the potential purchase of a *zero carbon home* being one such behaviour.

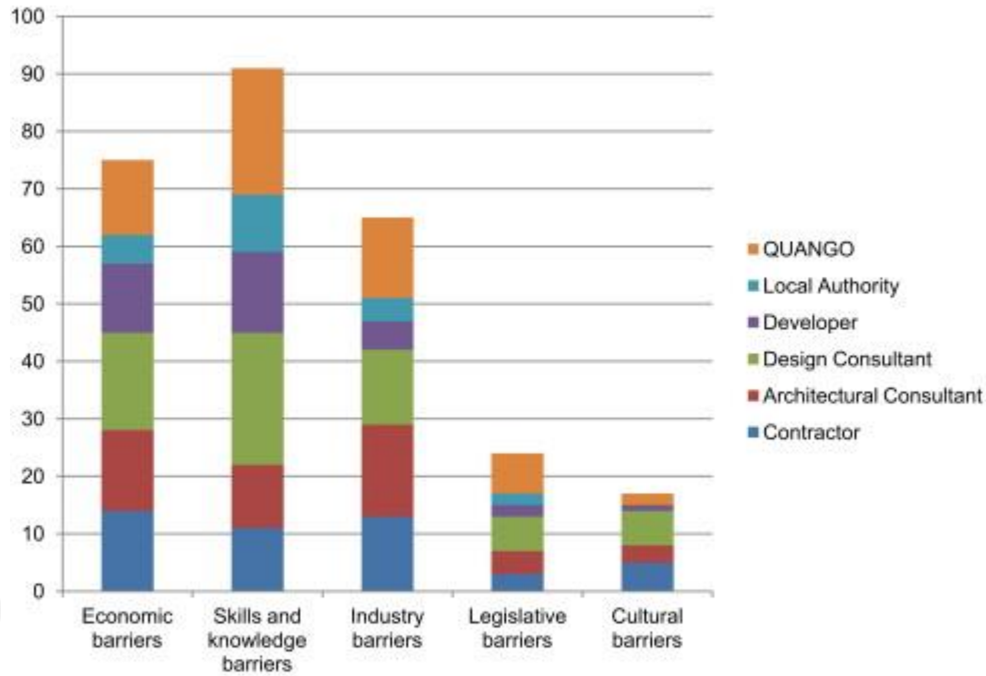

Fig. 4.2: Barriers – Sum of sub-themes from matrix analysis.

Industry barriers were identified by interviewees from all categories (Fig. 4). Concerns were expressed that the overreliance on volume housebuilders in the UK is flawed as it fails to deliver homes that meet the occupants' needs. This supports the assertion of the RIBA (2009) that two thirds of homebuyers would not be prepared to buy a new home, because '*many volume housebuilders are only catering for the needs of a minority of prospective homebuyers'* (p. 6). Concern has been expressed regarding the lack of diversity in the UK housebuilding sector as this exacerbates the issue of lack of resilience in the housing market (Parvin et al., 2011 and Wallace et al., 2013). The interviewees suggested that, in the UK, both homeowners and the housebuilding sector should learn from the self-build dominated housing delivery models in Europe to move forward. One interviewee stated that in mainland Europe, housing is '*seen as an object of choice and engagement rather than a market'*. This supports the current interest within both the literature and policy for the expansion of the self-build housing sector within the UK (DCLG (Department of Communities and Local Government), 2011. There were the barriers, which were not identified by this study, regarding the perceptions of the housebuilders (Osmani and O'Reilly, 2009). The previous studies conducted on this topic we based on the views of the housebuilders only, the results of the study showed that the interest of most of the housebuilders are associated with the maintenance of their dominance in the market. This is quite prominent as these differences a clearly visible in the findings of this study. The previous studies revealed lack of confidence being shown by the housebuilders in green technologies being based around current regulations under their corresponding theme of cultural barriers. The view of the interviewees that the housebuilding industry suffers from inertia is supported by the literature; Goodchild and Walshaw (2011) suggest there is a strong resistance to change in the design and production systems for new housing and as such, the incentives to change need to be of an equivalent magnitude.

This shows the reluctance of the construction industry of taking a step forward in the development of zero carbon homes within United Kingdom, until the legislation in place is due in part to the Government's propensity to make unexpected changes to policy. A simple illustration of

One example of this was in 2011/12 with changes to the feed-in-tariff; these findings are supported by the literature (Osmani and O'Reilly, 2009). Indeed, the lack of consistency across Europe has been cited as a barrier to the implementation of the EPBD (Mlecnik, 2012). The concerns of the interviewees over the lack of certainty and clarity of the standard have been proven well-founded by the recently announced exemptions from the *zero carbon homes* standard for 'small' developments.

CHAPTER 5: CONCLUSIONG AND FUTURE RECOMMENDATIONS

Conclusions of the Study

This dissertation has explored the perceptions from the wider construction industry in the UK of zero carbon homebuilding. The dissertation concludes that although drivers for the delivery of zero carbon homes exist, the identified barriers and challenges exceed the drivers in both number and magnitude. As a result, the diffusion of innovation for energy efficiency has been slow, and the private housebuilding sector is failing to respond to the non-mandatory stimuli for the delivery of zero carbon homes. The primary drivers were identified as being legislative, such as the Building Regulations and the Climate Change Act, and economic, such as the increasing cost of energy. The primary barriers and challenges identified were economic and skills and knowledge. These included the increased capital cost, scheme viability, public awareness, and knowledge of occupants. Industry barriers were also identified, including the nature of the housebuilding industry and resistance to change. There were divergent views amongst interviewees regarding market demand, however, it was agreed that there is a need to stimulate greater demand as a mechanism to support the delivery of zero carbon homes. Uncertainty in the forthcoming legislation was identified as a barrier which needs to be addressed by the Government.

The paper has also formulated support mechanisms for the delivery of zero carbon homes, ranging from establishing a robust planning policy framework to encouraging the financial sector to support the delivery of zero carbon homes through mortgage lending which acknowledges the reduced operational costs of a zero carbon home. The Government and industry should work together to support delivery, as no single solution will independently suffice to increase the delivery of zero carbon homes.

The urgency to act is increasing as 2016 draws closer; it is therefore necessary for the Government and industry to prioritise raising public awareness of the benefits of and need for zero carbon homes. The over-reliance on the volume housebuilding sector for the delivery of the vast majority of homes should be addressed by encouraging alternative methods of delivery that are more likely to meet the zero carbon homes standard. Finally, certainty and clarity in the definition of the zero carbon homes standard should be provided to allow the industry to better prepare for this significant step to help reduce the impact of new build housing on climate change.

Recommendations for Future Research

The Zero Carbon Community Project of United Kingdom would greatly benefit from research that collects energy consumption information on each home's lighting, appliances & MEL, HVAC, and DHW system s. Energy consumption monitoring at this level would allow for a higher fidelity analysis of each home's energy consumption and direct comparisons between the performance of various types of technologies (ASH P vs. GSHP, for example). Other recommendations include capturing hourly indoor and outdoor temperatures of all homes; monitoring performance measures for at least 24 consecutive months; and automating the collection of performance measures as much as possible. Homes in future studies should contain an eMonitor or similar system - or circuitlevel monitoring device to measure electrical energy consumption, and, as applicable, in line meters to measure consumption of other fuels used at each house (e.g., natural gas). The eMonitors worked very w ell in the current research and provided excellent minute-by-minute energy use information on the circuits/equipment they monitored. Four out of twenty homes had them installed, and these allowed the author to compare the performance of specific system s.

Similarly, the author relied on utility b ills and/or homeowner-provided usage data for other fuel consumption measurements. Meters installed in-line to furnaces, hot water heaters, cooktops and any other non-electric devices in the homes would greatly improve the accuracy of measured fuel consumption for those devices. The author believes that collecting the consumption information and analyzing the performance of the technologies used these homes would be of great service to the entire net-zero energy community. Specifically, builders and manufacturers would receive (verifiable) feedback on their technology's performance in the field, policy makers would be able to direct incentive monies towards more effective technologies, and energy modelers would have real-world data to help refine their models. Ultimately, future zero carbon homes and near net-zero energy home buyers would be able to make more-informed decisions on the type of system s and equipment to install in their homes. Likewise, indoor and outdoor temperature data loggers should be installed in every home for the duration of the monitoring period. In the current project, they provided not only climatic information for those houses, but very valuable insight on how the homeowners used (or did not use) their installed HVAC systems. This turned out to be one of the clearest examples of occupant behavior "deviating" from predicted and affecting energy consumption.

Monitoring the temperatures at all homes for the complete duration of future projects is likely to provide more insights into occupant behavior affecting measured performance. A s for the monitoring period, future researchers should make this uniform for all homes and it should last for at least 24 months. Having all homes monitored for the same time period will simplify the normalization process, while 24 months of performance measures will help reduce the impact of one-time mechanical failures (like House Q 's pool pump issue in the current research) and weather-related data gaps (like the missing w eek of House O 's production from the nor'easter in Oct 2011). Even longer periods (three years or more) would be better, as the longer the period, the more chances of measuring the performance of each house in a variety of climatic situations and occupant behavior patterns. However, homeowner involvement may be more difficult to maintain for longer periods, making the collection process problematic. The last methodology recommendation is to automate energy performance and temperature measurement collection as much as possible. This will ensure that a complete set is collected promptly each month, standardize the monthly measurement periods (a large issue with using utility bills), save the researcher several hours each month spent in communications with the homeowners, and minimize time spent travelling to each home. Even i f not completely automatic, having monthly measurements available on-line (e.g., eMonitors and PV web-based monitoring system s) will enable the researcher to collect the information him- or herself and thereby possibly avoid errors made by the homeowners (such as misreading an inverter).

REFERENCES

- Annunziata, E., Frey, M., & Rizzi, F. (2013). Towards nearly zero-energy buildings: The state-of-art of national regulations in Europe. *Energy*, *57*, 125-133.
- Attia, S., Gratia, E., De Herde, A., & Hensen, J. L. (2012). Simulation-based decision support tool for early stages of zero-energy building design. *Energy and buildings*, *49*, 2-15.
- Bryman, A., 2012. Social Research Methods, fourth ed. Oxford University Press, Oxford.
- Callcutt, J., 2007. The Callcutt Review of housebuilding delivery. DCLG, London (Department for Communities and Local Government).
- da Graça, G. C., Augusto, A., & Lerer, M. M. (2012). Solar powered net zero energy houses for southern Europe: Feasibility study. *Solar Energy*, *86*(1), 634-646.
- DCLG, 2008.TheCodeforSustainableHomesSettingtheStandardinSustainability for NewHomes.DCLG,London.
- DCLG, 2010.CodeforSustainableHomesTechnicalGuide.DCLG,London.
- DCLG, 2012.Codeforsustainablehomesandenergyperformanceofbuildings: cumulativeandquarterlydataforEngland,WalesandNorthernIrelandupto end ofMarch2012:tables.Availableat: .https://www.gov.uk/government/sta tistics/code-for-sustainable-homes-and-energy-performance-of-buildings- data-march-2012. (accessed 30.07.14).
- DCLG, 2013a.CodeforSustainableHomes:Background.Availableat: .http://www. planningportal.gov.uk/buildingregulations/greenerbuildings/sustaina blehomes/background. (accessed 31.07.13).
- DCLG, 2013b.Codeforsustainablehomesandenergyperformanceofbuildings: cumulativeandquarterlydataforEngland,WalesandNorthernIrelandupto end ofMarch2013:tables[online] .https://www.gov.uk/government/publica tions/code-for-sustainable-homes-and-energy-performance-of-buildings-data- march-2013. (accessed 1.08.13).
- DCLG, 2014a.Providingeffectivebuildingregulationssothatnewandaltered buildings aresafe,accessibleandefficient. Availableat: .https://www.gov.uk/ government/policies/providing-effective-building-regulations-so-that-new- and-altered-buildings-are-safe-accessible-and-efficient. (accessed 9.07.14).

- DCLG, 2014b.WrittenMinisterialStatement:BuildingRegulations.[Online]Avail-able at: .http://www.parliament.uk/documents/commons-vote-office/March_ 2014/13%20March/4.DCLG-Building-regs.pdf. (accessed 5.06.14).
- DCLG, 2014c.HousingStandardsReview:TechnicalConsultation.Availableat: .https://www.gov.uk/government/uploads/system/uploads/attachment_data/ file/354154/140911__HSR_CONSULTATION_DOCUMENT_-_FINAL.pdf. (accessed 23.10.14).
- Deng, S., Dalibard, A., Martin, M., Dai, Y. J., Eicker, U., & Wang, R. Z. (2011). Energy supply concepts for zero energy residential buildings in humid and dry climate. *Energy conversion and management*, *52*(6), 2455-2460.
- Esbensen, T. V., & Korsgaard, V. (1977). Dimensioning of the solar heating system in the zero energy house in Denmark. *Solar Energy*, *19*(2), 195-199.
- Gilijamse, W. (1995). Zero-energy houses in the Netherlands. *Building Simulation '95, Madison, Wisconsin, USA.*
- Goodchild, B.,Walshaw,A.,2011.TowardszerocarbonhomesinEngland?From inception topartialimplementation.Hous.Stud.26(6),933–949.
- Hamdy, M., Hasan, A., & Siren, K. (2013). A multi-stage optimization method for cost-optimal and nearly-zero-energy building solutions in line with the EPBD-recast 2010. *Energy and Buildings*, *56*, 189-203.
- Iqbal, M. T. (2004). A feasibility study of a zero energy home in Newfoundland.*Renewable energy*, *29*(2), 277-289.
- Kapsalaki, M., & Leal, V. (2011). Recent progress on net zero energy buildings.*Advances in Building Energy Research*, *5*(1), 129-162.
- Kibert, C. J., & Fard, M. M. (2012). Differentiating among low-energy, low-carbon and net-zero-energy building strategies for policy formulation. *Building Research & Information*, *40*(5), 625-637.
- Leckner, M., & Zmeureanu, R. (2011). Life cycle cost and energy analysis of a Net Zero Energy House with solar combisystem. *Applied Energy*, *88*(1), 232-241.
- Lepkova, N., Zubka, D., & Jensen, R. L. (2014). Financial investments for zero energy houses: the case of near-zero energy buildings. In *Global Sustainable Communities*

Handbook: Green Design Technologies and Economics (pp. 217-253). Butterworth-Heinemann.

- Li, D. H., Yang, L., & Lam, J. C. (2013). Zero energy buildings and sustainable development implications–a review. *Energy*, *54*, 1-10.
- Local HousingDeliveryGroup,2012.AReviewofLocalStandardsfortheDeliveryof NewHomes[Online]Availableat: .http://www.nhbc.co.uk/NewsandComment/ Documents/filedownload,47340,en.pdf. (accessed 7.02.13).
- Lovell,H.,2005.SupplyanddemandforlowenergyhousingintheUK:insights from ascienceandtechnologystudiesapproach.Hous.Stud.20(5),815–829.
- Lovell,H.,2007.Thegovernanceofinnovationinsocio-technicalsystems:the difficulties ofstrategicnichemanagementinpractice.Sci.PublicPolicy34(1), 35–44.
- Lowe,R.,Oreszczyn,T.,2008.Regulatorystandardsandbarrierstoimprovedper-formance forhousing.EnergyPolicy36,4475–4481.
- Marszal, A. J., Heiselberg, P., Bourrelle, J. S., Musall, E., Voss, K., Sartori, I., & Napolitano, A. (2011). Zero Energy Building–A review of definitions and calculation methodologies. *Energy and Buildings*, *43*(4), 971-979.
- McLeod, R. S., Hopfe, C. J., & Rezgui, Y. (2012). An investigation into recent proposals for a revised definition of zero carbon homes in the UK. *Energy Policy*, *46*, 25-35.
- Miles, M.B., Huberman, A.M., (1994). Qualitative Data Analysis: an Expanded Sour-cebook. Sage, Thousand Oaks, California.
- Mlecnik, E.,2012.Defining nearlyzero-energyhousinginBelgiumandTheNeth-erlands. EnergyEffic. 3,411–431.
- Mohamed, A., Hasan, A., & Sirén, K. (2014). Fulfillment of net-zero energy building (NZEB) with four metrics in a single family house with different heating alternatives. *Applied Energy*, *114*, 385-399.
- Morelli, M., Rønby, L., Mikkelsen, S. E., Minzari, M. G., Kildemoes, T., & Tommerup, H. M. (2012). Energy retrofitting of a typical old Danish multi-family building to a “nearly-zero” energy building based on experiences from a test apartment. *Energy and buildings*, *54*, 395-406.
- Osmani, M., & O'Reilly, A. (2009). Feasibility of zero carbon homes in England by 2016: A house builder's perspective. *Building and Environment*, *44*(9), 1917-1924.

- Torcellini, P., Pless, S., Deru, M., & Crawley, D. (2006). Zero energy buildings: a critical look at the definition. *National Renewable Energy Laboratory and Department of Energy, US*.
- Warren,C.A.B.,2002. ‘Qualitativeinterviewing’. In:Gubrium,J.F.,Holstein,J.A. (Eds.), HandbookofInterviewResearch:ContextandMethod.Sage,Thousand Oaks,California.
- Zero CarbonHub,2011.AllowableSolutionsforTomorrow’s NewHomes:Towardsa workableframework.ZeroCarbonHub,London.
- Zero CarbonHub,2014.ZeroCarbonHomesandNearlyZero-EnergyBuildings:UK Building RegulationsandEUDirectives.ZeroCarbonHub,London.
- Zero CarbonHub,SweettGroup,2014.CostAnalysis:MeetingtheZeroCarbon Standard.ZeroCarbonHub,London.
- Kothari, C. R. (2011). *Research methodology: methods and techniques*. New Age International.
- Blumberg, B., Cooper, D. R., & Schindler, P. S. (2011). *Business research methods*. McGraw-Hill Higher Education.
- Anfara Jr, V. A., & Mertz, N. T. (Eds.). (2014). *Theoretical frameworks in qualitative research*. Sage Publications.

Appendix 1

Interviews

I want an eco-house solar, but many solar hot water heating systems could already see to have temperature sensors comparing the temperature in the cylinder with solar panel and set up the pump when there is a gain. In the system, if they say it's sunny in the morning and the cylinder is heated and becomes cloudy and the pump slows but remains active, could actually cold water?

A: In the past, Govt. used to collect renewable solar energy to operate independent of temperature. The box is the solar panel is double glazed and well insulated indeed. It was used to be the answer, however, a distance of yes. There could be water cooled to 5 degrees C if you put in the solar panel at an initial temperature of 65 ° C if the weather was cold, below -5 ° C outside, but the habit to add another 5-20c in almost all circumstances. But in general, including a tank when the boiler thermostat is cut to 55 by detecting water half bottle of C5-10 Cooler the bottom, where we go out. Even if this were to happen remotely overall efficiency of the system is generally above our competitors. Our research at the University of depreciation is stimulated by not having the cost of electricity parasitic network (for 2 motorized valves, solar controller is 24 hours a day, and a pump).

Since 2008, all Govt. solar heating systems now come with a specially designed PV (solar electric) solar pump controller pumps. We expect to further boost the performance of solar panel, maybe add 1-10% more energy per day than before. However we have not yet had independent testing our solar systems to confirm this expectation! Interestingly, some of the conventional solar panels can also be equipped with this particular solar controller also (in addition to a photovoltaic panel should solar pump sand), but few actually do it again.

What is solar energy? How does solar power?

A: Solar energy is the solar radiation. Solar energy includes visible solar radiation around 55%, which we can see. Most of the solar radiation that remains is infrared radiation. A small amount is ultraviolet radiation. Solar hot water panels (solar thermal) work in the visible and infrared radiation, so they use up more spectrums. Radiation strikes the dark interior of a solar panel those heats. This time the water is heated. Another use of solar radiation is to make solar electricity. Govt. also used, but only in small quantities to supply the solar pump. However, per unit of energy produced, solar electricity is about four times more expensive than for solar hot water. Also, you need about four times more roof area to do the same amount of solar electricity. So make solar water directly as it does Govt. rather than electricity is logical. There are some videos on YouTube to watch. Can I stop now!

I foresee a green building and want to buy a solar panel for it. During the winter months, when most of the hot water will be produced by the boiler, what happens if there is enough sun to set the solar pump heating systems "in action? When there is not enough thermal energy to heat water enough so that when the hot water tank which reduces the temperature back there?

A: The solar pump runs only on solar energy as photovoltaic electricity. So it's solar controller. Furthermore the pump is turned on and off by the sun do not drive it when the panel is warmer than the bottom of the hot water tank, solar pump also contains a high pressure bypass if the solar panel or frozen pipes. In response to your question, however - it is better not to have the hot water system all day; it's a waste anyway and does not allow for optimal solar performance. Most boilers have separate timers for this, but not all. Ideally, the time add heat to the boiler hot water after 16 hours. Second, even in winter a little hot water is Govt., not all by the boiler as you say. Third - solar thermal panel is well insulated and therefore remain raise the temperature of the water entering as it picks up heat from the sun and not the air. Fourth - 100% sun and a water inlet temperature of 50 ° C and the air temperature to freeze our mathematical model (based on extensive testing at the University) suggests that water still leaves the panel at least 10C warmer than when it entered.

Its solar water-heating system heats the water in the upper part of the cylinder, rather than down. Did it an advantage?

A: The pump solar water heating system draws water from the bottom of the bottle with hot water passes through the solar panel and delivery, the sun heats the top of the cylinder to be pedantic . This type of solar circulation brings huge benefits. Floating solar hot water there, and kept warm place (with delivery of heat exchange to the bottom panel) mixing together of the bottle to get hot water but still slightly warm up. When you open the hot water is drawn up so that it is the place where hot water is needed to be. We deliver via a solar hot water tank in the days of half sun. Most of the other, and provide a full solar hot water tank. You choose.

What is the maximum temperature of the hot water by solar panels solar panels that can reach?

It is theoretically possible and water vapour to 100 if I had to change the solar pump on a hot sunny day: A. But please do not do that. With the pump once we have made so far 87C independent tests throughout our solar system water in the UK. But at 130C internal solar panel if left to dry in the sun, it is possible, but not Hapen in the normal operation of solar panels, as always pumped keep temperatures.

My family is the hope of building a self-zerocarbonhouse in the coming months and would be interested in solar system installation Adiy Govt... However, I prefer to have a system of piping water storage tanks and pulse prevent cold water completely. After some unpleasant past experiences water tanks - Leak and wildlife deaths among them - my prejudices on the subject is strong enough to govern alone solar heating in this room! Is it possible to adapt to your system without a storage tank?

A: The principle of the use of solar hot water, solar technology is usually any store water as and when the sun shines and then use it later, so a hot water tank as you know, always needed, but we would also like to end the cold water tank (although no longer works as a dove / bat / rat / Santa trap when kept covered). Govt. high pressure solutions of solar water heating now include: the use for heating a low pressure hot air tank through which a heat exchanger of high pressure at the top which is then pre-fed through a mixer valve Thermostatic high pressure cylinder or solar boiler combined loan.

What is the lifetime of the solar pump and it comes with a warranty?

A: expected life of the whole solar water heating system is 20 years minimum. The warranty performance is 5 years, although some products, such as polycarbonate glazing actually come to us with 10 years guarantee. I expect the solar pump must be replaced before age 20, however, since it is the only moving part and moving parts are most prone to wear. We use a relatively expensive but deliberately reliable pump. The motor is a DC brushless motor. The use of a brushless instead of brushing reduces engine wear and increases the service life several times.

What power produced by the photovoltaic solar panel?

A: W maximum 5, usually less, is the production of PV. Peak of the solar pump output is about 0.7 litres per minute maximum. Again, generally less than that, perpendicular sunlight.

I'm a little worried about the charge pumping photovoltaic systems available. Do you have engineering data that could be used to determine if I tend to be a problem with the duration and type of pipe that could be used for the installation of solar panels?

A: Please do not worry. Photovoltaic solar pump is actually too big for the job. This is part of our deliberate design as a way to get her a long life. Not only has a long life DC brushless motor, but the head of the solar pump itself has been significantly dated by the mounting of an internal pressure of bypass which opens at about 1 bar where appropriate freeze pipelines. Without this, the solar pump could provide about 5 bars, which is well beyond the maximum º allowable pressure for the panel.

Hydraulic pressure this limitation is fine for a total length of pipe 30 feet of our own 6mm micro bore pipe. If you want to go, then you need to increase the diameter of the pipe on the side that provides cold solar water heater panel. If you use a 15 mm diameter for all this, then any return micro bore hose can be up to 30 feet long!

The great thing about our micro bore tube is that it's much better than conventional tubes to reduce the distribution of heat loss. Firstly, the surface area is about half pipes, so that less solar energy is lost. Second, the volume of 6 mm diameter is about one-fifth volume of 15 mm pipe, so that losses "of the dead leg" (solar hot water pipes sitting uselessly store panel between) are reduced to a minimum. Another way to see this benefit is that you can place the solar panel heating cylinder further with our system compared to conventional solar installations, if you want.

I like the idea of renewable solar energy to 100% of its solar panels, but I fear that if I relied on solar PV can be a tendency for the solar energy system "flight" slowly convection and / or pumping PV slowly when rising water temperature reached after losses in the

transfer not mean it is not economical to run through the shop. This is completely unfounded?

A: No problem. Convection through micro bore hose 6mm (even without our pump valves to prevent this from happening) would be remote.

Tape information indicates the solar panel is not damaged by frost, but not excess water from hoses too - has a pressure valve?

A: No problem, the rubber expands when it freezes. Our tube (two solar panels and used for distribution to and from it) is a specially formulated silicone rubber. They may extend to more than 100% by volume. Water expands only 4% of the freezing. So freezing is easily accommodated - with much stretch let go. There is therefore no need for a pressure relief valve in the piping or a solar panel.

I have a bungalow with a coverage area of flat ground. I want a solar thermal panel for it, because I try to turn my house to house low zero carbon atoms, or at least one that is carbon neutral. The upper sloping roof could be used to support a solar panel, but does not get the sun all day. The flat roof receives full sun from dawn to dusk. Pipe installation would also be easier from the flat roof as it could be carried out under the tiles to avoid drilling. Is it possible that solar unit standing on the roof? Have their own weight, besides water, enough to keep if the mounting brackets attached to a wooden frame?

A: The flat roofs are great for solar hot water, but make sure it will not take off in the air and the solar panel will not sit in a puddle. You need a support frame angle. We can do it at any angle you want. Typically 30 degrees horizontally performance maximize total - but may have an excess of the summer. Generally, people choose 45 degrees or 60 degrees at certain solar can sacrifice excess was slightly smaller gain valuable winter when the sun is at a low angle. The weight itself is not enough to prevent leakage! In some more A-frame roof dishes facilities used 3.2 ton stainless steel son of effort (for bowers) maintain the solar panel that is tight end and roof penetrations.

You provide a lot of valuable information, but solar return time, you just said, it may be shorter. Do you have any estimates of energy savings and solar time to recovery for its solar panels in particular?

A: The issue of the amortization of solar energy is complex and involves many different variables, not least the type and cost of fuel that the system is moving. Others:

- latitude in which they live and installation of solar panel
- microclimate
- orientation and height of your solar panel
- the thermal efficiency of the boiler - if you have one
- how much solar hot water supplied actually used
- Price petanque energy today that has a solar panel
- inflator future price of the annual energy applies each year
- funding costs or the loss of interest on the capital expended in the installation
- how much the cost of solar panels that you consider a capital value of boost the value of your home

It is a cost-benefit calculation easier sun?

Impossible. All this makes giant calculation assumptions capitalization leaves on the other and a great opportunity for financial fraud. For example, a home seller prompted unhappy solar panel (in the context of a competitive analysis of solar energy in 1999) applied a price inflation of 13% of fuel for the displaced fuel and claimed that their solar panels also recorded in the heating core, accelerating the recovery of solar investment by a factor of about three! At that time, 13% of the fuel pump price seemed too high, but not now.

We recently ordered a preliminary investigation leading to a potential Govt. savings plan in terms of benefits and environmental costs. Maximum savings in the UK may be overestimated, not least since VAT on domestic fuel is only 5%! Mains gas costs about a third of the electricity, even with the recent price increases. We believe that the sector gas (no more expensive packaging gases, where savings can be more) that should not exceed € 100 in fuel economy. Maybe you can save another 10 pounds or more per year in what we call the extension of the life of the boiler as it can last longer if you use less. For electricity (peak hours) savings can be around £ 150 PA these are only very approximate figures.

The environmental benefits (e.g. CO2 savings) to use solar panels to heat water, which do not run directly to you like saving money, but the CO2 savings can be calculated / estimated as the as silver, using various methods. Some are optimists and pessimists. Using mid-range figures estimate these can also be about 50 pounds PA (displaced gas) and maybe £ 100 for electricity displaced by solar energy. Remember, these environmental assessments - which come on top of any solar power save money. I hope this gives you an idea of why I cannot start a solar depreciation figure nowhere on the basis of some email lines and I hope you agree that'd not trying to be evasive. He did not let me know your answer - or calculations.

What about solar panels for under floor heating?

There is usually a very good application for solar heating for practical reasons. We recommend that the solar thermal is mainly used to heat water for washing and bathing since the time of the year when the under floor heating is required usually coincides with the time when there is less sun - in winter and night. This is not a good load matching / request.

Do you have a solar panel at home?

A: Yes, I have a solar panel, but not on the roof of the main house. This is because the centre of the city of Chester, where I live, is in a conservation area. As a result, we are probably one of the few houses in the UK to have an outhouse with a 100% solar hot water. The solar panel is not level, but still does the job well. It faces west, but its main problem is the illumination of shading. A great council ugly block of the tower (the unity of the environmental strategy which is based there before!) ECLIPSA was until noon to seven months. Trees also shade in spring and autumn, when in the sheet. But we still have solar hot water heated to 70 ° C for hands and paddling pool in summer.

How does the system make Govt. emerge on the side of the secondary tests 8 sets of solar water heater?

The trials were set up to see how different solar water heating systems (only thermal solar panels not only) could heat a cylinder of 150 litres, not a standard litre cylinder 120. Our home solar panels were not in evidence, originally. At the last minute a solar heating supplier abandoned and we were asked to provide a system comprising a solar panel Govt. But we are faced with a quandary ... Our standard Govt. system is designed to heat a cylinder 120 standard litres, so that what we do? The options are: (1) not to participate, (2) to a greater special panel 25%, (3) to install two panels and there was no limit on the size or panel (4) to provide a standard panel size and take the flak.

We choose option 4 (install a solar panel that was slightly in size according to the rules that we would play) and face a lot of criticism, mainly based on the simple misrepresentation of the paper. In terms of reliability, the eight solar water heating sets were installed as part of these tests within six months; five of them were broken, some more than once. Govt. was one of three solar thermal systems that do not break down, perhaps indicating that simplicity is bonus reliability. Although he was undersized for this system "beauty contest" Govt. solar water heater came halfway above the 8 panels in terms of annual carbon savings.

The transition to a carbon footprint by measuring square meter, the report also shows that solar flat plate, Govt. regularly come near the top (less than 2%) in terms of carbon savings per square meter.

In terms of carbon recovery is the question of why should we have to buy extra electricity grid to save heating fuels like gas because they bought a solar panel? We believe that the issue of reinstatement carbon should be treated at the strategic level in Europe. Govt. also eliminated the carbon footprint associated with an average of 17% for flat plate solar panels and surprisingly conventional solar panels, using the ratio of the calculation method, 23% of vacuum tubes (solar panels vacuum tubes).

It is Govt. PV (photovoltaic) pumping something? No, for the reason above. Solar photovoltaic pumping is Govt. is old plot about 20% more durable on the basis of this side by side test report technology. Govt. is water heating system solar panel zero carbon. Most others are simply low-carbon technology in your electricity bill tends to increase with a solar panel that is used to replace the gas or oil as fuel, with the consequent increase in the greenhouse effect occurs. So why Govt. is about 20% more durable.

What about members of the Association of the solar trade? Why do some members dairy STA Govt.?

Interestingly, the previous question used the word "trick" because recently, a former member of the Solar Trade Association (of which we are not already a member, more details in a moment) tried to stop us from winning an important contract for solar warming over a school of building make a series of strange and misleading claims, including a statement that Govt. was a publicity stunt.

We strongly oppose this view and all requests were removed quickly and without reservation.

We believe Govt. is an innovative solar water heating has been proven over 10 years as a carbon technology intelligently and effectively zero. Independent tests validate its operational zero carbon recovery instead of about 20%. He also won awards for innovation and the DTI yet to achieve.

The Compact Oxford Dictionary defines something like "a trick or device designed to attract attention instead of filling a useful role."

Govt. is not a gimmick, but a cute device that is designed deliberately to perform conventional solar more sustainable can never fed. As for attention, too, have the right to express the benefits of our technology, but to do that, we received a fine STA illegally times to make claims to reintegrate fully valid carbon. The fine was cancelled.

Govt. seems to have attracted attention, even hostile, to a competitor who seemed unwilling or perhaps unable to deliver our sustainability criteria and seemed concerned that we wanted to use, unwanted "patch" may be. Well, too bad. We will compete - tough but fair. As to the question usefulness in previous tip definition, it is our opinion that Govt. plays a valuable role in the fight against global warming, offering zero private sector solar public water / carbon instead of carbon- Solar.

This discussion raises the unfortunate issue of open hostility of some members of the Association of the solar trade. If readers have comments or evidence "spoiled" or misleading behaviour STA members are interested in adding their experiences to our records - please let us know!

We have not been members of the STA since 2007. In terms of influence, but we cannot verify this figure, we believe they are less than half of all UK national solar thermal panel installations made by STA members and not consider that members of the STA as particularly valuable, except that the British government is considered the place to go to specific facts about the solar thermal industry. We hope that readers do not consider our non-membership of the STA as problematic: there was a story of what can sometimes be almost Kafkaesque behaviour STA about our business model and our technology.

Here are three examples.

1. The apparent double standards on access to members. Last year, the association, who were members of several years, refused to renew our membership, arguing that our solar panel has to pass a particular test in the European Standard EN 12975 solar panel called a rule containing more ten test panels. (This rule is widely regarded as up to date and the date of the review of the NEC, which is the main body setting standards in Europe.) However, the objectives of this test panel are not particularly relevant to the particular form that our technology is used, a fact which was confirmed independently by a testing laboratory in Austria called Arsenal research. So instead of letting this solar panel test, it came with us, the evidence was so close to the original as possible, but it was, in fact, relevant, and which was approved by the solar panel. So all relevant evidence in EN 12975. Note that happened regarding the relevant evidence, rather than simply abandon it, at the time of exclusion, the solar panel approved redesigned pass a test, but relevant. However, the STA insisted our exclusion. It's odd, because the more you look at this; the most inconsistent approach makes us STA. For example, our research on irrelevant evidence (and exceptions thereto) compared to other solar technologies reveals that, for years, solar panels type vacuum tubes are exempt, again on the grounds or may not be relevant for some, but different test in EN 12975. It should be noted, and apparently incompatible, who evacuated tubes can apparently be certified to EN 12975, but are not required to send these items not more relevant evidence and it is interesting that they are not forced to spend even relevant evidence refurbished (like the solar panel does). It's probably no coincidence that several member companies of the Board STA distribute vacuum tubes. This is probably a coincidence, moreover, that one of the main suppliers of vacuum tubes that was on the STA board for years, sponsored Solar Key mark, the super-European standard solar panel. This is based on EN 12975 and independent inspections of factories. Interestingly, just last fall Solar Key mark invented these retrospective exemption vacuum tubes, even if it had taken place over the years. As seems to be the case of STA member companies may be exempted from the irrelevant evidence according to EN 12975, unless they are Govt., in this case, they are excluded from membership. The fact that before we offered the Govt. two members of the Board of Directors of ATS companies have tried to develop patents, but not marketed, apparently, "bury" ?? Instead, it is interesting, but it’s also assumed that are not appropriate to this discussion.

2. 86K pounds of public money has been allocated to the development of a training course for installers of solar panels (called solar BPEC courses). Channelled by the STA, its author has been entrusted to a previous company STA Chairman called Filose. Early versions of this excluded from our coverage just technology in the most questionable grounds that it was not well proven technology forces us to develop our own product and run our own seminars at our expense, to prevent technology Innovative being misunderstood and install correctly.
3. Attempt to censorship. A few years ago, the STA £ 1000 fine for not we change our promotional literature, and because they wanted us to republish DTI funded independent research shows that conventional solar technology had an operational carbon recovery with an average of 17% Sensor plans and 23% for vacuum tubes facilities household size. We called the seven solar companies involved, most of which were on the ATS board at the time. While it is our policy to compete fairly and openly on the issue of carbon budget, and we see this as an important issue of sustainability, and that consumers need to know, now, we pull our punches - deliberately. Not named one of the companies involved in these tests because, being a small fish in a big pond, just stand our ground in this area is not worth it: it costs us too much. The fine £ 1,000 was eventually cancelled by being imposed illegally, but resist the fine, of course, cost us much more than that.

Although not already in the STA actively support the concept of trade associations. In addition to being members of the Council Micro power, a targeted body working on national policy issues affecting micro generation, we are also active members of the Association of renewable energy. The CSR is by far the largest trade association in the UK renewable energy representing a range of solar thermal technologies, including solar panels that Govt. So, we are members of one and the largest reputable trade association in the UK. STA boycott is amazing - but quite understandable in the commercial context.

Should I replace my hot water tank with a special solar tank when installed Govt. solar panels, simply because it is not well insulated?

Usually, no. When installing a solar panel installation Govt., your money could be better spent on the purchase of one or two sliding insulating jackets at £ 10 each. Then you can have money left in the budget cylinder other energy efficiency measures. Of course, there may be additional good reason to replace a cylinder in place in certain circumstances.

I use only my existing cylinder with a solar panel installation Govt.?

No, you have a choice. To dispel any misunderstanding: you are very free to use a larger cylinder if you want a Govt.: You do not have to use your existing cylinder. You can choose to have more at the time of the solar system, panels or cylinder later.

If I change cylinders then what options I have with Govt.?

Several. The choice depends on individual circumstances, but here are some general questions. The first option is size. Usually it's a good idea to go when installing solar panels, which will store more hot water. Then it can be directly or indirectly of a cylinder (that is, a heat exchanger, also called a coil). You can also use a solar with solar panels. We just had the approval of the DCLG (the building rags people) use Govt. to heat from a heat exchanger on a high pressure cylinder G3, but not start this time.

It is a continuous flow through solar panels, rather than in circulation (when things get too hot) a valid concept?

Yes. To control the potential overheating, in addition to using "downstream"?? Said mixer thermostatic valves on top of a cylinder in appropriate places, such as in the shower or on the top of the cylinder places Niche solar thermal design can use several others "upstream"?? Approaches. Ancient solar Pansl generally use a solar controller to turn off the solar pump when the top of the bottle solar hot water reaches a certain temperature, generally in the range of 65-85C.

But, do not remove heat from the solar panel gets hotter and hotter, usually more than 130 C in full suns. This exposes the solar panels closed around a "solar stagnation" that brings very high temperatures and pressures, engineering and constraint considerations inevitably limits the absorbent surface design solar radiation that is made of metal circuit. Stagnant high pressure also reduces piping design a system, break whenever superheated vapour release. Another option is to remove the top challenge pressure and drain the panel at high temperatures with a design of low pressure pipes with open ventilation. This reduces the pressure, but the high temperature challenges.

We have therefore chosen to continuous low temperature and low pressure pumping, safe design. In particular, if the solar heating system uses a very small cylinder and then to avoid boiling or overheating in the summer, the system deliberately recycles water to the solar panel, especially in the afternoon, so it was cool to if you are on summer vacation, for example, solar panel system does not boil. This approach to export heat only works in places where the sun does not shine all the time (like Earth) and where its intensity is quite varied panel (so not recommend?? solar panels "monitoring").
For balance, it might be useful to say that conventional solar pilot pumps solar panel feed pump, which is another way of not receiving all the available heat is off. Anyway, the solar heat is not stored in the end point where the cylinder could boil, which is good for any point of view of safety.

Is the performance of the solar collector per square meter much importance?

Greatly if you live in a shed with a roof that is less than 2.6 square meters, which is a range of typical size of a solar thermal system. In terms of design, we have relegated efficiency per square meter below sustainability, which is at the top. Doing a little larger panel is our special approach. I may be missing something important in life, but its fun to see a couple of extras slate roof? Customers solar panels shed load pay extra for a solar panel water heating system that is more efficient per square meter may end up paying £ 1,000 more to see additional square meter of slates on a roof. I prefer to spend £ 1,000 extra to see a beautiful painting on the wall of my living room, or maybe the savings to invest in new initiatives to reduce carbon footprint.

Do the solar panels pay the initial cost?

Who knows? Maybe not, unless the carbon savings from solar energy are measured in terms of cash and save money. The financial calculation is a nightmare ... First, capital expenditures. Consult price paid, less any subsidies, less any possible resale value if you think that the facility could add value to your home. I hope that the final amount will be lower here saying £ 4,000, preferably much less. Call this the total net capital expenditure. Second savings. Look savings from solar energy actually used as taps or showers divided by the efficiency in the delivery of hot water is actually delivered (what is it? A percentage usually in the range from 15% to 70%) of a gas boiler or other water heating system. Then an energy conversion calculation money, the result is generally unlikely to exceed £ 100 could be much less. Perhaps adding an "extension of the life of the boiler" in terms of money depending on your boiler probably a few percent more time before the packages because less fuel will be made if each year. Add any carbon savings solar rebate check the government gives it is currently lacking. The total is here your gross savings. Third, expenses or loss of income. Add the costs of owning and maintaining the system parts and workmanship. Add electricity to the pump and the controller, if they use the network. Does your home insurance increased slightly due to higher costs for reconstruction? If so, then add the increase. Having a solar panel just slip on a strip of plus local taxes? I hope not. If you purchased the panel using the funds that were in a bank account, then you must look for lost interest, less the taxes you have saved. Here are their total gross expenditures. Fourth, subtract your expenses from your gross savings. What remains, in terms of money is your net income. Finally, divide your net capital expenditures for the increase in net income. This gives the payback on solar years assuming the price of fuel and all other assumptions made no change with time. If they do.... (When was the last time you make a recovery calculation on a computer, diamond ring car anyway?) Panting...

Of course, in addition to money, is the issue of return of energy, not just money. Make a solar panel uses energy, just like the rest of the solar components. (And some solar panels, but not Govt. use extra energy to work well). How long it takes to pay for the energy used to manufacture solar panels and related components Govt.?

We asked the University of Bath this question and the answer is encouraging. In just a year and a half he was raised upon the credit of the energy, according to their calculations. The equivalent figure recovery period (PV) solar power is 4.2 years. So in terms of energy recovery Govt. is better by a considerable margin. We do not know the exact position on the premises of conventional solar panels, but as components generally require more heavy is probably reasonable to assume that the recovery period would somewhat that surprisingly short Govt. year and using the time recovery of solar energy.

Regarding the issues of recovery of the financial investment of our solar system water, the calculations of the University of Bath is that 30% of the initial cost of a solar system pays thermal course of his life. So need the balance (70%) to be funded by grants or increase the value of your home, OT a combination of revenge to reach equilibrium. Naturally, there were a lot of assumptions underlying the calculation of the University of Bath, including the installation of

solar panels Govt. costs £ 3,523, which gave 815kWh of solar energy per year, which displaced more this, and the cost of electricity 12p per kWh, and the cost of the gas 3.5p / kWh.
The reference of the University of Bath for these figures is a document entitled: Integrated micro-generators EVALUATION: Methods and Applications, SR Allen, GP Hammond, H. Harelip, CI Jones, CM and AB Winnett McManus, University of Bath, Bath . BA2 7AY. Published in 2008.

Do largest solar thermal system designs installed several parties?
True. We are in the field of sustainability, carbon savings for your money, and delivery of solar energy with minimal carbon recovery will not sell Clobber. Try to minimize the environmental impact of renewable energy technologies that inevitably means fewer parts. As to think locally and buying solar panels on site, all our pipes, pumps and solar panels are manufactured in England and pay patent royalties in Scotland. And inevitably solar additional zero carbon costs: we provide a cheap pump and specially designed solar and photovoltaic, not a bronze pump imported 20 pounds and a length of cable to connect to the national grid. It is our particular philosophy of being in the business of solar energy, to offer what we consider to be a truly sustainable way of working. The energy savings in business many British Isles Offer different business models in the industry to choose from. Most people choose to reduce their carbon footprint in fact it is very good for all of us.

Why not solar panels are sold at half price? We want an inexpensive solution DIY solar.
Because of this most unfortunately the flight route: the enormous cost of entering the market with new solar hot water products in an industry where, in some places mentality permeates gold rush. For example, there is an 86K pounds solar training manual water funded that is currently used in many plumbing schools in the UK. Some universities have recognized its limitations, but some do not. Based largely on manual outdated 10 years ago with a bad "old sun sunburst gold”?? Approach contains many inaccuracies and recycles many myths about being the sun is only capable of operating in a very limited niche technology. I went on a training course for solar installers based on it in the CAT (Centre for Alternative Technology), where the coaches were well-intentioned, but the course did not hide our technology in a balanced way.

Unfortunately this manual was used to train and accredit grants, even 1,000 plumbers, some of which can now be poorly specified or badly set up our technology on the basis of this manual. We must provide recycling for 1,000 plumbers! How will we fund this? We are a small business and it takes a lot of time and effort (including lost family vacation) to keep records refute shabby like these. The good news is that there is some light on the horizon: latest building standards of thermal solar panels have been recognized as Haing attracted too narrow, and other tests are underway, including self-reference bad government documents to create a false consensus that Govt. is too marginal to be bothered with. Up to the UK and Europe to develop a transparent approach to regulation and innovation, these shenanigans classification require luck and money. Money can come only from users who adopt the principles of the new technology. Sorry for this. We can get a little frustrated too. Hope this helps to move the debate forward.

Appendix 2

UK wants to set an example as a pioneer in the fight against climate change. Your Plan for Transition to Low Carbon aims to reduce emissions to 2020 greenhouse gases by 34% below 1990 levels measures are very diverse and in some cases pioneers: increase in electric cars and efficiency fuel vehicles, installation of smart meters in homes, thermal insulation of houses, construction of zero energy buildings , etc.

UK wants to reduce 2020 emissions of greenhouse gases by 34% below 1990 levels

The British capital is leading this bet and one of his goals is to become a low carbon city. Your consistorial responsible instituted last year, a Low Emission Zone to keep out of the city center to the most polluting vehicles. Another recent measure ten districts become "low carbon zones". The London City Hall will invest at least 220,000 Euros in each area to take various measures of energy efficiency and reducing CO2 emissions. An estimated 13,000 households, 1,000 shops and businesses, 20 schools, a hospital and several places of worship and community centers will benefit from this initiative.

The project includes assistance for low-income families who install thermal insulation systems or solar panels. Several educational programs explain to the neighbors how to reduce energy consumption or how to use smart meters.

London is not the only metropolis in the world that aims to reduce CO2 emissions. The race to become a low carbon city is well located several contenders. Copenhagen in December will host the World Summit on Climate successor to Kyoto, has announced its goal of becoming the first capital of the world "zero emissions" of CO2 in 2025. The increase in wind power and generalization of electric and hydrogen cars are some of its strengths. But maybe in their own country who have come forward. The small port town of Frederikshavn (25,000 inhabitants) wants to be the first city in 2015 based on 100% renewable energy.

Sweden has shown for years its environmental awareness. Several cities have taken ambitious environmental plans, as Växjö. This town of 80,000 inhabitants has been proposed, since the nineties, away from fossil fuels by 2050. Today, thanks to the exploitation of forests, 57% of its energy needs (84% of heating and more than one third of the electricity) from renewable sources. The city has reduced its CO2 emissions by 25% in ten years.

Elsewhere in the world do not want to fall behind. The Australian city of Adelaide aims to achieve"carbon neutrality" between 2020 and 2025. The city of Phoenix (Arizona) announced

their intention to become the first carbon neutral American villa. Its managers invest billions of dollars to reduce emissions of greenhouse gases by 70% in three or four years.
The Canadian city of Vancouver and the US state of California have reached a partnership agreement to develop "economic development zones low carbon". Their leaders will encourage the use of green technologies to reduce CO2 emissions and increase the number of workers in the "green" industry.
Copenhagen has announced its goal of becoming the first capital of the world with zero CO2 emissions in 2025
Several Mexican cities are candidates for a pilot study "Towards Low Carbon Competitive Cities", which aims to improve the standard of living of its citizens. The population of Barcelona Sant Cugat del Vallès is considering creating the first residential community of Spain with a balance of zero CO2 emissions.
Asia also wants to add to these initiatives. Japan announced in 2007 its target of reducing by 60% and 80% CO2 emissions by 2050 and become a "low carbon society". To do this, push for various measures that include support for environmental technologies, the assumption of a system of emissions trading domestic or carbon taxes. In China, several institutional leaders have acknowledged their interest in sustainably manage the high speed urbanization in this country. The implementation of low carbon measures would be one of the initiatives that could be carried out.
The construction of new cities with futuristic and environmental criteria is another attempt long term. Those responsible for Dongtan, China, or Masdar in Abu Dhabi (United Arab Emirates) have made it a priority the reduction of CO2 emissions. In Europe, the responsible Commission selected 30 cities, within the Strategic Energy Plan (SET) to achieve that by 2020 become "smart cities". Measures creating areas of low carbon or the use of new green technologies and renewable energy are contemplated.
The issue of low carbon cities will be discussed at an international congress to be held in Porto (Portugal) during the month of October. Your manager, the ISOCARP (ISOCARP / AIU) notes the need for urban planning to make reality such initiatives.

Case Study: Miller Zero

Many skeptics said that it couldn't be done in an efficient and affordable manner however Miller Homes have officially launched the first carbon zero homes to be built by a large house builder on a live development.

Having mentioned throughout this article, achieving carbon zero homes by 2016 is ambitious too says the least. However Miller claims that they have established "the blueprint for 21st Century homes across the UK." (Miller.co.uk)

The chief executive of Miller Homes issued a statement stating that, "the house building industry has a responsibility but also an opportunity to help reduce our carbon footprint. Rather than just waiting until we had to implement the Code, we decided to get a head start on understanding the cost implications alongside learning how to possibly build the homes of the future with Miller Zero." (*Tim Hough CE)*

I felt it was important to evaluate and examine these homes of innovation to achieve an understanding of how a carbon zero homes might work along with the technologies and costing. Miller themselves admitted it was a huge learning curve for them, as "wanted to know what the development costs would be….and additionally, how much consumers would be prepared to pay for homes created to the Code for Sustainable Homes". *(www.millerzero.co.uk)*

(Miller Zero, The Pinnacle, Basingstoke)

To achieve "Code level 6 (i.e. carbon zero) this home is super-insulated with the external walls built using H+H's200mm Vertical Elements. The Elements themselves have excellent thermal insulation properties = 0.11 W/mK with a compressive strength of 3.0 N/mm2. The Vertical Elements in combination with 200mm Webber herm insulation and render achieved a U-value as low as 0.09 W/m2K; excellent levels of air tightness were also achieved to help meet the mandatory heat loss parameter required for Code 6 Homes of 0.8 W/m2K. This is aided by the fact that the Vertical Elements' larger panel surface areas of aircrete mean fewer joints, higher levels of air-tightness and of course, improved speed of build. The Vertical Elements are lifted into place using a "cast in" lifting eye at the head of each 2.4m-high Element, which enabled the contractor to build the house in only one and a half weeks. The Elements were installed very specifically by using a layout drawing prepared and supplied by H+H UK, which clearly identified where each element should be placed. H+H also supplied drawn details and information specifically concerning significantly reduced linear thermal bridging, possible with the use of H+H aircrete material." *(www.hplush.com)*

The regional managing director Ian Beal, was also very keen to challenge the industry's belief that timber-frame is the only material which can the challenging height of level 6 (carbon zero) of the code. Miller decided to test this theory to the test and choose aircrete to manufacture the house, specifically to challenge the 'timber-framed only' for 'zero carbon' myth.

Questionnaire

1. What field of construction are you in?

- Energy/Environmental/Building consultancy
- Government body
- Environment (Non Governmental organisation)
- Housing developer/contractor
- Housing Association
- Renewable energy
- Other (please specify)

2. How aware are you of the following?

	Very aware	Aware	Not aware
• The Code For Sustainable Homes			
• The Zero Carbon Policy			
• Sustainable Development			

3. How important does your organisation view the issue of sustainability?

- Extremely important
- Important
- Unimportant
- Extremely unimportant

4. As of 2016 all new builds will have to be 'zero carbon', however the current definition of zero carbon allows a carbon output between one third to a half of the total carbon emissions from a home. Do you believe that zero carbon is therefore misleading?

- Strongly agree
- Agree
- Disagree
- Strongly disagree

5. The 'zero carbon' target for 2016 represents a reduction between 44-60% of carbon dioxide emissions depending on dwelling type compared against 2006 Building Regulations. When do you feel that this target can be reached?

- 2016 (on target)
- 2017
- 2018
- 2019
- 2020

Do you agree that the following factors are barriers to achieving the 2016 zero carbon targets?

Strongly Agree Agree Disagree Strongly disagree

- Time
- Finance
- Clarity of definition
- Consumer demand
- There is no barrier

Reports show that building a 'zero carbon home' could cost in the region of up to 40% more than traditional homes built to 2006 Building Regulations, but save up to 50% of utility bills. Does this seem worth it?

- Excellent value for money
- Good value for money
- Poor value for money
- Not worth it

As of 2016 a contractor will be able to offset carbon Emmons through 'allowable solutions' which secure carbon savings away from site which could not be achieved on-site. This will result in making a payment to contribute to other carbon-saving developments. Do you believe that this is an easy way out of complying with zero carbon and therefore defeats the rationale of building zero carbon homes?

- Yes
- No