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Zero carbon home: Britain's house of the future (?)

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Abstract. One of the key issues that determine the wellbeing of young people in Britain is their prospect of living and raising a family in a house of their own. In an ideal scenario, a young professional couple should be able to purchase a comfortable and affordable home as they need it, but in the recent years, the affordability of new homes for young people has become a problem as house prices rose. Moreover, the British government is committed to reducing Britain's carbon emissions [1] , and for future home owners this means that new houses must meet strict criteria ensuring that they are equipped with energy saving features that make them eco friendly. Britian's ideal ecohouse of the future is a very high energy efficiency rating home, a zero carbon home. However, these requirements increase the building cost of new homes, which in turn can raise the house prices even further. This article surveys new energy saving solutions which are being implemented in British homes and evaluates their effectiveness and cost. Using desk top research as the method for this enquiry the authors attempt to sketch the image of the (possible) house of the future – a type of dwelling that new home buyers should be buying in years to come – if they can afford it.

Introduction

The key to understanding UK's vision of the future of British homes lies in the document issued by the UK Government that offers a summary of the UK's proposal for Zero Carbon Standard that was going to be implemented in the construction of new houses, zero (or near zero) carbon homes [2]. However, this vision of future house construction was distorted by the Government scrapping the plans to make all new homes zero carbon by 2016. The future of British homes currently remains uncertain, and the reader is thus left with an inconclusive vision of what kind of homes young British families will occupy in the future.

UK Government's initial plans to introduce zero carbon homes.

In 2006 the British Government announced plans to ensure that by 2016 all new homes built in Great Britain will be 'zero-carbon' [3]. Zero-carbon home is understood as a home that does not release carbon dioxide into the atmosphere. But what exactly is a zero-carbon home? John Tebbit explains: The definition is simple - a home must generate all its energy, including energy for heating, hot water, lighting and appliances, without adding carbon dioxide to the atmosphere. Depending on need, surplus energy can be exported and energy deficits can be met by importing energy, and the CO2 emitted by burning biomass must be compensated for by exporting zero-carbon electricity to replace grid electricity. Taking these factors into account, the net amount of emissions must be zero over the space of a year [4].

The first step towards making sure that the British Government policy became effective was the creation of the Code for Sustainable Homes as an assessment method used for evaluating the sustainability of newly build houses [5].

The Code for Sustainable Homes assessed a new building using the following nine sustainability criteria: energy/CO2, water, materials, surface water run-off (flooding and flood prevention), waste, pollution, health and well-being, management, ecology.

To explain, each of the above categories covers the following.

- 'Energy' refers to energy efficiency and CO2 saving measures.
- 'Water' covers internal and external water saving measures. To clarify,
- 'The internal water footprint is the volume of water used from domestic water resources; the external water footprint is the volume of water used in other countries to produce goods and services imported and consumed by the inhabitants of the country'[6].
- The category of 'materials' covers materials used to build the house, their sourcing and environmental impact.
- 'Surface water run-off' refers to measures that the construction company put in place in order to

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reduce the risk of flooding and surface water run-off (because the latter can pollute rivers).

- The assessment of 'Waste' includes the provision of storage that will be used for recyclable waste and compost as well as provisions for reducing, reusing and recycling construction materials.
- 'Pollution' refers to the use of insulation materials and heating systems that do not contribute to global warming.
- 'Health and well-being' category is concerned with good daylight quality provision, sound insulation, private space provision, accessibility of the house and its adaptability.
- 'Management' refers to a Home User Guide (a document that helps occupants to understand and operate their home efficiently), security measures and care taken to reduce the impact of construction.
- The category of 'Ecology' refers to the protection and enhancement of the ecology of the local area and efficient use of building land.

Images of assessment documents covering all nine sustainability criteria can be viewed here [7].

What makes a zero-carbon home?

Tim Pullen (2009) advises those who plan to build their own home on how to comply with the Code for Sustainable Homes [8].

Pullen (2009) explains that the Code for Sustainable Homes assesses the drawings and specifications for the planned house (before the actual building is constructed) and awards points up to 100 using nine design categories described above. The future building is awarded points for fulfilling the Code for Sustainable Homes requirements, and the total of awarded points translate into the Code for Sustainable Homes levels. A zero carbon house would be a house that achieved level 6 measured against those criteria. The correspondences between points and levels awarded is reflected in the table below:

Table 1. The Code for Sustainable Homes: correspondence of levels and points awarded for sustainability (Pullen, 2009)

The Code for Sustainable Homes level	The Code for Sustainable Homes Points
1	36
2	48
3	57
4	68
5	84
6	90

Out of the nine categories, compliance with Energy and Water criteria is mandatory, whilst others are merely recommended. However, in the case of Surface Water Run-off, Waste and Materials, there are minimum standards that must be met by those building a house.

The Code for Sustainable Homes assesses the design of the house, so it is important to get the design right in order to achieve maximum points for minimal investment. The Mandatory components (Energy and Water) account for 10.3 points, and other components account for 46.7 points.

Pullen gives examples of points that can be effortlessly achieved, as listed in the table below. Table 2 demonstrates that it is possible to gain points by making small and inexpensive changes to the design, as long as they are made visible for the assessor.

Table 2. Examples of points awarded by the Code for Sustainable Homes (Pullen, 2009).

Requirement	How the requirement can be fulfilled.	Possible points awarded
Home User Guide	A folder containing manuals for all the appliances and equipment (dishwasher, washing machine, central heating, etc.)	3.3
Clothes-drying space	Fixtures for a clothes line.	1.2
Secure cycle store	A lockable shed or bike racks.	2.4
Home office	Space for one person with a telephone point and a double power socket.	1.2
White goods	Stating in the specification that white goods will be A+ rated.	1.2

To explain, the term 'A+ rated white goods' refers to household appliances such as fridges, freezers, washing machines, dishwashers etc displaying a special label that reflects their energy efficiency rating in accordance with EU legislation. The energy label shows the level of energy efficiency of an appliance rating it from A+++ to G, with G being least energy efficient and A+++ most energy efficient [9]. Table 2 shows examples of recommended, non-mandatory features that earn sustainability points. As for the Mandatory Elements, they are non-negotiable and must be complied with.

To begin with, both internal and external daily water consumption must not exceed 105 litres per person, which constitutes a 30% reduction compared with the standard daily usage of 150 litres per person in the UK (Pullen (2009). Pullen (2009) indicates that the required reduction in daily water consumption can be achieved by making a provision for a greywater recycling system - for example, Aquaco Water Recycling Ltd offer Aquaco Residential Grey Water Recycling System (offered by Aquaco Water Recycling Ltd and priced at £1,995 each) that involves the collection of bath and shower water, filtering this water, disinfecting it and reusing it for toilet flushing [10]. Aquaco claim that since '[t]he quantity of water used for hand basins, showers and baths is similar to that used for toilet flushing … [i]n most buildings water consumption will be reduced by 50%.'[10]. Having said that, Pullen (2009) reminds that aerated taps and reduced-flow showers are other (possibly cheaper) ways to reduce water consumption. The Energy (mandatory) requirement is to achieve a 25%

improvement on previous standards. This can be achieved by using an insulated and airtight construction system, with a solar thermal system on the roof. Other construction systems will require the use of A-rated boiler and upgraded insulation (Pullen (2009). In case of surface water run-off, site waste management and sustainable materials, the future building must achieve a minimum standard. Pullen (2009) explains that surface water run-off can be addressed by either installing a rainwater harvesting system, using water-permeable hard surfaces for patios and drives or a rainwater soakaway. A rainwater harvesting system would cost around £3,500. It would eliminate the problem and also would achieve the reduction of water consumption to the daily limit of 105 litres per person. Happold (2015) explains that rainwater harvesting is a process of collecting rainwater – water that falls on a catchment surface (such as roof) – and storing it for use that is either independent form or supplemental to the main water supply[11].

Since rainwater is relatively clean, it requires usually only UV filtration as minimal treatment. Collected rainwater is intended for non-potable use: flushing toilets, vehicle washing, sprinkler and irrigation systems, washing machines (Happold (2015). For example, Kingspan Environmental report the following case study: when Louth County Council (Ireland) were looking for a low-cost, sustainable supply of water for 30 plus new houses, the company installed a Kingspan Envireau system in every house. Kingspan Envireau system, integrated with the main plumbing, collects rainwater, stores it in an underground tank and uses it to flush domestic toilets [12].

Kingspan Envireau System has two options depending on the practical solution needed: (1) The Gravity System and (2) The Direct System. The Gravity System includes an elevated header tank used to store filtered water after the main tank whilst the Direct System uses a pump to deliver water from the main storage tank. Direct System is used if a header tank is impractical [13]. Kingspan Envireau System's packaged components include: a polyethylene underground storage tank, an internal self cleaning rainwater filter, a stainless steel multi-stage submersible pump, an Envireau control panel and display, a wave guide depth sensor, a manhole cover [13]. Kingspan Envireau Rainwater Harvester 1,800L (including a header tank and suitable for roof sizes of around 60m^2) is offered for £2,955.60 [14] Water-permeable hard surfaces are those surfaces (permeable or porous) that allow water to soak through: porous concrete, asphalt and gravel or made from impermeable materials laid with gaps between blocks [15, 16]. The UK Government's report [16] analyses the accessibility and practicality of materials used for permeable surfaces. The summary of these findings is presented in Table 3.

Table 3. Permeable materials/surfaces: overview [16].

Surface/material	**Usage for homes**	**Availability/Accessibility**
Gravel	Widely used in driveways at present.	Available from builders' merchants and DIY superstores and most contractors can lay gravel driveways.
Reinforced grass and gravel	Not widely used in driveways. There is not a widespread knowledge of it.	Contractors generally do not know how to install them even though no special skills are required and some systems are available via builders' merchants.
Porous asphalt	This is not widely used in driveways, although is used in some car parks and roads and is used widely in sports areas.	Contractors generally do not know how to install it as specialist knowledge of the material is required for installation. Only asphalt batching plants can provide porous asphalt via suppliers (eg. Bardon and Tarmac).
Permeable block paving	These are not commonly installed in driveways at present although used in new developments for car parks and other areas.	Some contractors know how to install them. It is not easy to obtain permeable blocks as most merchants do not seem to stock them.
Open graded sub-base material	This material does not require a lot of effort to compact it and it behaves differently to normal sub-base because it can have a looser surface before the final surfacing layer is placed over it. Contractors therefore often do not like using it, because it is perceived as being much weaker than normal sub-base. The skills required to lay it are the same as for normal sub-base but there is an education requirement.	This material is required below most of the permeable surfaces. Even though it is required for use below concrete block permeable pavements that are more widely used in new developments finding the material can be difficult. The reason for this is that quarries produce materials they can sell. There is no real technical reason for not producing it. Some block paving manufacturers have dealt with this problem by setting up a network of quarries that will supply open graded aggregate (eg. Formpave and Marshalls).

		Open graded sub-base material is not available in merchants or DIY stores at present. However, some quarry products companies have plans to make it more readily available in builder's merchants.

In regard to soakaway, DIY Doctor explains: 'A soakaway is … a hole dug into the ground, filled with rubble and coarse stone which allows surface water to percolate back into the earth close to where it falls.'[17] A soakaway is part of a drainage system dealing with surface water (rainwater). There is a pipe leading into the soakaway, from the area where there is excess water. Soakaway construction uses few materials, so it is a low environmental impact solution to drainage, intended for areas of a drive or garden that are waterlogged, or with standing water building up against walls. This drainage system (suitable for granular soil, not clay, however) avoids the need for chemical treatments before water is returned into the eco system as the surface water is unlikely to become polluted before it returns to the ground. Details of a Soakaway Pit would include replaced turf, existing ground level, impervious layer, drain pipe, course rubble [17]. In terms of Site waste management, Waste & Resources Action Programme can help builders to deal with construction waste by providing a template explaining how to ensure the best practice and reach the target. Site Waste Management Plan Template workbook [18] explains how to use the Site Waste Management Plan Template. At an early design stage the constructing company can generate an indicative waste forecast using WRAP's Designing out Waste Tools for Buildings or Civil Engineering projects. Subsequently at the detailed design stage a more detailed waste forecast can be generated using WRAP's Net Waste Tool [16]. Further on three points are guidance on actual waste management and recovery actions: actions relating to on-site waste management, segregation and recycling. Examples include skips labelling and establishing a plasterboard take back scheme [16]. During construction all data related to generated waste are entered into the Waste Totals table and the report on waste management is being created.

During construction the following types of materials are being dealt with:

- Surplus materials imported to site
- Surplus materials generated on site;
- Waste materials imported to site
- Waste materials generated on site
- Imported materials, which are brought to the project for inclusion into the permanent works;
- Generated materials, which exist on the project (topsoil, sub-soil, trees, materials from demolition works)

In addition, the contractor manages waste reduction, segregation of waste, disposal of waste, financial impacts of waste disposal and recording of processes associated with waste management. Pullen (2009) explains some further figures relating to achieving different Code levels, compared to previous Building Regulations, as summarised in Table 4.

Table 4. Energy and Water use and Code levels (Pullen 2009).

	Code Level 3	Code Level 4	Code Level 5 and 6
Energy use	Code Levels 3 aims for a 25% (5.8 points) 'dwelling emissions' improvement on Building Regulations	Code Level 4 aims for a 44% (9.4 points), 'dwelling emissions' improvement on Building Regulations	Code Level 5 and 6 aims for a 100% (16.4 points) 'dwelling emissions' improvement on Building Regulations and zero carbon (17.6 points).
Water consumption	Levels 3 and 4 requiring 105 (4.5 points)	Levels 3 and 4 requiring 105 (4.5 points)	Levels 5 and 6 require a maximum usage of 80 litres per person per day (7.5 points)

Code Level 6 – Zero carbon home

Code Level 6 is achievable only if the home is completely zero carbon (i.e. emits no emissions of carbon dioxide (CO_2) into the atmosphere at all). A builder must do many additional things to obtain the points required for level 6 as they will need to achieve 90% of everything in the Code, including:

- Energy efficient appliances and lighting;
- Supplying accessible water butts;
- Reducing surface water run-off as much as possible;
- Using highly environmentally friendly materials;
- Minimising construction waste;
- Maximum, accessible provision for recycling;
- Improved daylighting, sound insulation and security;
- Building to the Lifetime Homes standard;
- Assessing and minimising the ecological impact of the construction of the home [19].

Examples of zero carbon homes

Only those buildings that demonstrate a zero carbon standard can reach Code level 6, and below is the explanation how CHP, a housing association, managed to reach that level (according to their claims) [20]. They used the combination of

- super insulation,
- water efficient products,

- low carbon renewable energy generation
- rainwater harvesting.

The ten houses in Chelmsford that demonstrate a zero carbon standard and reached the highest Code level 6 include the following:

- Heating and hot water from communal biomass district heating.
- Photo-voltaic cells on the roof.
- Special building fabric in walls and roof.
- Triple argon glazed windows.
- Timber structure with insulated panel and heat recovery mechanical ventilation.
- Rainwater harvesting for flushing WC's and washing machines [20].

In another example Lana Clements reports on 'Britain's first completely 'energy-positive' home that is capable of generating more energy than it uses and exporting it the National Grid' Clements (2015) [21]. The house featuring reduced energy demand, renewable energy supply and energy storage was designed at Cardiff University as part of the Wales Low Carbon Research Institute's (LCRI) SOLCER project by Professor Phil Jones (the Welsh School of Architecture). The house is supposedly completely free of energy bills thanks to the following features:

- thermal insulation
- reduced air leakage
- low carbon cement
- structural insulated panels
- transpired solar collectors
- external insulated render
- low emissivity double glazed aluminium clad timber frame windows and doors.

The building features solar generation and battery storage to power heating, ventilation, hot water system, electrical power systems, appliances, lighting and a heat pump (Clements 2015). 'The house, situated in Pyle near Bridgend, took a total of 16 weeks to build', ITV reports [22]**.** Another example of a zero carbon home, 'award-winning eco-home in Balsall Heath, Birmingham UK' is presented by DinevThemes (2015) [23].

The future of zero carbon homes

In 2015 the news came that the '[r]egulations to force all new UK homes to be 'zero carbon' from 2016 have been dropped by the Conserative government'[24]. "The Government does not intend to proceed with the zero-carbon Allowable Solutions carbon-offsetting scheme, or the proposed 2016 increase in onsite energy efficiency standards."[25]. The main reason behind this is that building zero carbon homes are too expensive. 'According to Communities and Local Government department figures, it costs up to an extra £40,000 on top of standard build costs for a four-bedroom detached house to reach level 6 of the code for sustainable homes' [26]. This would make a house unaffordable for an average family, unless the purchase of such a house was subsidised by the government. The change of government policy on zero carbon homes (HM Treasury, July 2015 Fixing the foundations: Creating a more prosperous nation, Presented to Parliament by the Chancellor of the Exchequer) [1] leaves the future of a zero carbon house uncertain.

Conclusion

In 2012 there were only 34 houses in Britain built to the standard required by The Code for Sustainable Homes Level 6. They generate their own electricity and their owners earn around £1,000 annual cash back due to their photovoltaic energy generation. If the Government insisted on the initial scheme of building only zero carbon homes by 2016, this would not be realistic because building such constructions is not practical – each one of these projects is unique. The change of Government's plans notably affected companies that embarked on the development of technologies which were supposed to be used in zero carbon homes. However, it seems that, despite the glorification of zero carbon sustainable lifestyle, it is not sustainable financially and zero carbon homes could be only constructed and/or purchased if supported by generous financial government schemes.

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