GHA position paper
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Code for Sustainable Homes (CSH): Technical comments re levels 3 and 4 - energy

The Good Homes Alliance is very supportive of the drive by Government to reduce CO_2 emissions and views the Code for Sustainable Homes as an important part of this. However, the GHA also understands the problems of introducing new codes and that often problems only occur as a new code is tested. We are actively involved in identifying these problems and suggesting ways to address them, to help ensure that the Code is upheld as a useful and trusted mechanism for achieving carbon reduction in new housing.

We have identified two major initial problems regarding meeting CSH levels 3 and 4.

Problem 1 – Electric vs gas space heating:

In all new dwellings, it is much easier to achieve CSH levels 3 and 4 by using electric on-peak heating than by the more carbon efficient option of gas heating. The reason for the problem lies with the fuel factor used to calculate the Target Emissions Rate (TER) which forms the basis for the reductions required for the Dwellings Emission Rate (DER). The fuel factor was enshrined in Part L 2006 and was a compromise position negotiated at that time and does not reflect the true carbon content of fuels. It is set at 1.47 for electric heating, compared to the base case of 1 for gas. As made clear by CLG recently, the fuel factors "purpose is to provide some relief in the target applicable to dwellings that are off the gas grid or in blocks of flats where a gas service to each apartment is not a preferred choice. The fuel factor means that if the chosen heating fuel is more carbon intensive than gas, the TER is increased (eased)" *CLG: Building Regulations Energy Efficiency Requirements for New Dwellings, July 2007*)

However, what is somewhat surprising is the effect this has at higher levels of CSH. Many buildings which achieve level 3 of the Code for Sustainable Homes using electric heating will have greater CO_2 emissions than those same buildings with gas heating, at Building Regulations levels. In on example a flat has 18% greater emissions at CSH level 3 than the same flat with gas built to 2006 Building Regulations. The GHA has even seen calculations for CSH level 4 electrically heated buildings which have greater CO_2 emissions than similar sized buildings designed to Building Regulation standards using gas.

Furthermore it appears that when using gas for heating with certain compact building types, such as flats and terraced housing, it is actually not possible to reach CSH level 4 *at all* just through fabric improvements (such as very high levels of insulation and very low air permeability) with solar thermal hot water heating. However by swapping to electric on-peak, despite the higher carbon emissions, these buildings can make code level 4. So where developers are obliged to achieve CSH level 4, they are likely to specify electric heating, as the only practical, cost effective solution.

Finally, the consequence of this for building fabric improvement, is that while at Building Regulations levels it seems that electrically heated buildings have to achieve a building shell at least as thermally efficient as if these were gas heated, at CSH levels 3 and above, electrically heated buildings can achieve the same CSH levels as gas heated buildings, with less thermally efficient fabric. This means that the building will always be less energy efficient than an equivalent gas heated building, whatever the energy source. As the cost and difficulty of retrofitting energy efficient thermal shells is significant, the UK is thereby losing a great opportunity to reduce emissions.

Problem 2 – Large and small-scale buildings and efficient building forms

It is easier to achieve Building Regulations and CSH levels 1-4 if the building is bigger, and the building form is less efficient. Due to the % reduction scale, small and efficient building forms are penalised, and developers are driven to increasing inefficiency of building form. Furthermore, large houses in high value developments will meet high CSH levels more easily than smaller units in denser developments. This runs against the desire to push the high CSH standards in denser, lower cost housing, and means that efficient affordable housing will require expensive and complex renewables to meet high CSH levels, whereas expensive inefficient housing will not.

GHA Position

In order to address the two urgent problems identified above, the CSH should

1. Treat all fuels equally (i.e. based on carbon emissions) for levels 3 and above.
2. Use absolute energy use figures measured in kWh/ m^2/ year and absolute carbon emissions per year, measured in CO_2/ m^2/ year, possibly with some relation to occupation density.
3. Include a monitoring requirement for a fixed percentage of new homes, to test whether the designed performance is actually delivering the required CO2 savings.

The two problems listed above are in addition to the more general concerns we have about certain aspects of the code, particularly the target of autonomous zero carbon new homes, the timescale for changes, and the unknown implications for air quality and human health.

GHA Standards - Membership Requirements

The GHA is proposing membership requirements of **3++.** This refers to CSH level 3 as a basic code aim, but with two additional requirements:

The first plus is the requirement for a fixed maximum Carbon target ($CO_2/m^2/yr$) and/or a fixed maximum Energy target ($kWh/m^2/yr$) according to building type. These will ensure only the best solutions are chosen which will reduce energy and carbon in absolute terms.

The second plus is the requirement to monitor homes post occupation for at least 2 years, to compare the designed with the actual performance.

The GHA is also developing further social requirements that will enhance the community and personal well being of occupants.

Appendix 1 – Calculations about CO2 emissions

How it works in theory

The calculation of carbon emissions from dwellings for the code for sustainable homes is as follows:

1. For the building you are assessing, work out how to meet the 2002 B Regs using the elemental methods (U Values but now also to include y values for non-repeating thermal bridges), air permeability etc

2. Convert this into kg of CO2 per m2 of building using SAP appendix R, which will give you C_H (CO2 for heating and hot water) and C_L (CO2 for lights – max 30% Low Energy)

3. Multiply by the fuel factor (gas = 1, electric = 1.47, oil = 1.17 etc)

4. Reduce by the amount required in 2006 regulations (ie 20% for new houses), or as the regulations put it multiply by 1 – improvement factor (which for 2006 regulations is 0.2). This gives you the Target Emission Rate (TER) The equation in full is
TER = (C_H x fuel factor + C_L) x (1 – improvement factor)

5. This is CSH level 0. To achieve levels CSH levels 1 – 4 then multiply again by 1 – improvement factors, which for CSH levels 3 and 4 are 0.25 and 0.44.

6. This is called the DER (Dwelling Emission Rate). It then has to be shown how this DER is to be achieved by the proposed thermal shell and air permeability, ventilation system, heating system and hot water system in the actual building.

The GHA have run several calculations on different building types and have found that at Code levels 3 and 4 all building types have worse CO2 emissions using electric heating than using gas. This is an obvious outcome of the fuel factor.

How it works in practice

The Building Regulations were designed to ensure that the building shell fabric was significantly improved whether electric or gas heating was used. This we have found to be largely correct. The following example shows how the Building Regulations and the CSH work themselves out as per our main text.

Mid Terrace Flat example:

Taking a typical 2 storey mid terraced house from a real planning situation, with 79m2 internal floor area, we get the following Target Emission Rates according to Building regulations

Building regs compliant

Heating and Hot Water system	TER kg/m2yr
Gas	19.89
Elect on pk	28.03

We then calculated how to achieve the TER in the case of the Gas heated building by adding sufficient insulation and reducing air permeability. We applied the same insulation and air permeability to the electric heating case and came up with the following result:

Building regs compliant

Heating and Hot Water system	TER kg/m2yr	DER kg/m2yr	% saving over TER	CSH level
Gas	19.89	19.53	2%	0
Elect on pk	28.03	30.09	-7%	-1

In this case, electric on-peak heating needs slightly more insulation (or better air tightness) to make it pass Building Regulations than the building with gas heating, which is good, as this building has worse carbon emissions. If at a later stage the building is converted to a more carbon efficient heat source then the thermal shell will be no worse (in fact slightly better) than the gas case.

Now let's look at a very well insulated case, say one trying to reach CSH code level 4.

Highly insulated

Heating and Hot Water system	TER kg/m2yr	DER kg/m2yr	% saving over TER	CSH level
Gas	19.89	12.6	37%	3
Elect on pk	28.03	15.28	45%	4

We have done as much as possible in terms of insulation and air permeability in the case of the gas heated building. However we cannot actually achieve a Dwelling Emissions Rate that reaches CSH level 4 because at this level there are no more energy/ carbon savings to be made from the shell of the building. We have reduced the emissions from the shell to zero. However with the same insulation and air permeability levels as the gas heated building, an electrically heated building achieves code level 4.

If we consider how to achieve level 3 with Electric on peak heating it becomes clear from the mathematics that in the case of this building the CO_2 emissions will be worse than the building regulations base case for gas.

Code 3

Heating and Hot Water system	TER kg/m2yr	DER kg/m2yr	% saving over TER	CSH level
Gas	19.89	14.92	25%	3
Elect on pk	28.03	21.02	25%	3

Or put another way, if developers want to make code level 3, they can build a less insulated shell if they adopt Electric on peak heating.

Small and large buildings:

A similar exercise off a real planning proposal shows how it is easier to achieve higher code levels with larger buildings:

A number of types of dwellings were analysed and a gradation of effects between the smallest and the largest was observed. The extremes were as follows:

	Total floor area m2	Stories	Type
Flat 8	65	1	Mid north flat
House 27	173	3	Large detached

The target emissions were as follows

	TER kg/m2yr GAS	TER kg/m2yr Electric
Flat 8	20.7	29.2
House 27	20.9	Not calculated

A basic construction was assumed. This was:

U Values in W/m2K	Walls 0.20 Floors 0.10 Roofs 0.15 Windows 1.4 Doors 1.4
y values	0.04 or 0.06 at complex details
Air permeability	$2m^3/m^2/hr$ @ 50 pascals
Ventilation system	MVHR (not Q rated)
Fuel	Mains Gas

This construction was applied to both examples with the following results:

	Total floor area m2	% reduction from Part L 2006	CSH Level
Flat 8	65	13	1
House 27	173	20.7	2

A number of measures were then considered to improve the carbon and CSH performance of the buildings. These were as follows:

key	measure
INS1 + Q	Roof 0.1, permeability 1, windows & doors 1.0, y 0.04, part Q for MVHR
SOL1 + Q	2.4m2 south flat plate, Mains pump, store to optimize solar, part Q for MVHR
SOL1 + INS1 + Q	all of above
SOL2 + INS1 + Q	as above but 4.8m2 flat plate , with PV pump

These measures were then applied to both buildings with gas as the heat source, with the following results:

	% saving over TER	% saving over TER	CSH Level	CSH Level	Kg CO2/ yr	Kg CO2/ yr
	Flat 8	House 27	Flat 8	House 27	Flat 8	House 27
TER	0	0	0	0	20.7	20.9
BASE	13	21	1	2	18	16.6
INS1 + Q	24	36	2	3	15.8	13.4
SOL1 + Q	30	35	3	3	14.4	13.6
SOL1 + INS1 +Q	33	41	3	3	13.8	12.3
SOL2 + INS1 +	39	45	3	4	12.7	11.6

It is clear from this that the larger unit can achieve the higher code levels more easily with less cost. Indeed it is not possible for the flat to achieve level 4 even with the extreme measures given, and even though this is almost a passive house standard of build. It is not possible to reduce carbon emissions further from the space heating as these have already been taken to zero. It is also not possible to take further hot water heating reductions and would any way be impossible in most cases for such a large solar thermal array to be positioned on a building of multiple flats.

In this case the small building has no option but to go for electric heating unless some form of CHP is being considered.

Flat 27 electric and gas options:

	% saving over TER	% saving over TER	CSH Level	CSH Level	Kg CO2/ yr	Kg CO2/ yr
	Gas	Electric	Gas	Electric	Gas	Electric
TER	0	0	0	0	20.7	29.2
BASE	13	14	1	1	18	28.5
INS1 + Q	24	27	2	3	15.8	24.4
SOL1 + Q	30	35	3	3	14.4	13.6
SOL1 + INS1 +Q	33	40	3	3	13.8	19.9
SOL2 + INS1 +	39	46	3	4	12.7	15.9

Here we find what we found in the mid terrace example, that only with electric can level 4 be achieved even though at this level the emissions are worse than the gas heated flat at level 2. At code level 3 the electrically heated flat could have 18% higher CO2 emissions than the gas heated flat at Building regulations standard.

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