CARBON COMPLIANCE

Setting an appropriate limit for zero carbon new homes

Modelling 2016 using SAP2009 Technical Guide

Purpose of this guide

In February 2011, the Zero Carbon Hub published its final report on the appropriate limit for Carbon Compliance for zero carbon new homes from 2016. The dwelling modelling carried out for this work used a slightly modified version of SAP2009. This guide provides the procedure for allowing currently available industry tools to be used to calculate the '2016 design performance' of dwelling designs. This output can then be compared with the proposed 2016 standard, recognising the calculated value is a 'design performance' and the recommendation is expressed as an 'as built performance'.

Carbon Compliance Report Recommendations

From 2016 the 'built performance' emissions from new homes should be required not to exceed the following limits:

- **10 kg $CO_{2(eq)}$ /m^2/year for detached houses** [1]
- **11 kg $CO_{2(eq)}$ /m^2/year for attached houses (semi-detached, terraced etc)**
- **14 kg $CO_{2(eq)}$ /m^2/year for low rise apartment blocks (block averaged)**.

The Carbon Compliance standards are quoted as 'built performance'. Further work is needed to identify the scope and scale of the potential gap between designed and built performance of new homes, and put in place measures to close the potential gap.

The report recommends there should be an option to achieve compliance on a development (rather than only dwelling-by-dwelling, excepting attached units) by reference to the aggregate of the limits which would otherwise apply to the individual dwellings on that development. Further work is needed to define the detail of this mechanism.

The precise Carbon Compliance figures will need to be rebased in due course when the compliance tool for 2016 (SAP or equivalent) is available, which will (among other things) incorporate updated 2016 carbon emissions factors.

The full report can be accessed on the Zero Carbon Hub website.

[1] These recommendations apply to *built* performance, whereas the 2006 Regulations relate to *designed* performance. For this reason the recommendations cannot be directly compared with current standards. However, in addition to any improvement achieved by moving from designed to built performance, the % improvements on the 2006 standard would be approximately:

- 60% for detached houses
- 56% for other houses
- 44% for low rise apartment blocks

How to compare modelling results for 2016 using SAP2009

The following procedure should be followed:

1. Model dwelling in SAP2009
2. Output proposed dwelling (DER) SAP sheet
3. Go to section 12a (CO_2 emissions for individual heating systems inc micro CHP) or 12b (CO_2 emissions for community heating scheme)
4. Carry out the following 'hand calculation':
    a. Replace the CO_2 emission factors with the appropriate value from Table 1
    b. Multiply the energy consumption by the applicable new CO_2 emission factor
    c. Sum these emissions
    d. Divide by the dwelling total floor area (SAP box [4])
5. This is the '2016' carbon emissions from the dwelling. You can now compare this result against the recommended 2016 Carbon Compliance level for the dwelling type (see recommendations). However, be aware that it is recommended that the Carbon Compliance standards refer to 'built performance' rather than 'design performance'. Further work is needed in this area. The potential gap between design and built performance is unknown but could range from 0 to 6kg or more and depends on a range of factors including dwelling design, product performance, and construction. See also Note 5.

An example is provided below.

Fuel	**2016 carbon emissions factor ($kgCO_{2(eq)}$/kWh)**
Grid electricity	0.527
Electricity generated on-site	0.527
Mains gas	0.227
Wood pellets	0.037
Wood chips	0.015
Biomass community heating	0.019

Table 1: *2016 carbon emission factors used in ZCH CC work*

Example: Semi-detached house, gas boiler + PV

12a. Carbon dioxide emissions - Individual heating systems including micro-CHP

	Energy kWh/year		Emissions Factor		Emissions (kgCO2/year)		
Space heating - main system 1	3303.51	x	0.198	0.227 =	654.09	(261)	749.90
Water heating	2406.04	x	0.198	0.227 =	476.40	(264)	546.17
Space and water heating			(261) + (262) + (263) + (264) =		1130.49	(265)	
Pumps, fans and electric keep-hot	175.00	x	0.517	0.527 =	92.48	(267)	92.23
Lighting	342.18	x	0.517	0.527 =	176.91	(268)	180.33
Energy saving/generation technologies:							
PV emission savings (negative quantity)	-1435.68	x	0.529	0.527 =	-759.47	(269)	-756.60
Total carbon dioxide emissions				∑(261)...(271) =	638.40	(272)	812.03
Dwelling Carbon Dioxide Emissions Rate (DER)					8.36	(273)	10.64

Compare against recommended 2016 Carbon Compliance level for dwelling type

Important notes:

1. When assessing apartment blocks, block-averaging (as per para 4.14 in Part L 2010) should be applied to the carbon emissions figures for individual apartments within the block prior to comparing to the 2016 carbon compliance level. In addition the Task Group based their recommendations on the use of site-averaging, but the procedure for allowing this to take place is yet to be developed.
2. Fuel factors are not used
3. The values for solar radiation for the purposes of PV energy output calculations used within the Carbon Compliance modelling work were provided by BRE and are listed in the modelling assumptions paper (available from the Zero Carbon Hub website). They differ slightly from the values used within SAP2009. However, the impact is marginal, affecting results by approximately -0.1kgCO_2/m²/yr compared to the outputs of SAP2009.
4. The Carbon Compliance levels are recommendations to Government. The final values may differ.
5. The Carbon Compliance levels will be re-based should changes occur in the assumptions underpinning the analysis undertaken by the Task Group. Types of assumptions include: developments within SAP, carbon emission factors, findings from the work on closing the potential gap between designed and built performance, more extensive modelling which identifies robust technical concerns for specific house types. Rebasing is intended to ensure that compliant designs developed now remain compliant in 2016 – even if this requires that the 'target' actually changes.
6. Whilst further work is required in the area of design vs built performance, effectively what it means is that a 0.18W/m²K U-value wall (assumed in SAP) needs to actually achieve 0.18W/m²K in practice; and likewise for other building elements, services and low and zero carbon technologies.
7. The procedure above for translating 2009 SAP outputs into something comparable to the 2016 carbon compliance targets utilises the current regime for determining compliance based on a single National weather region for England (except for cooling and summertime overheating calculations). An alternative approach would be to use Regional weather. The pros and cons of each approach can be found in the report *National or Regional Weather: Implications for Carbon Compliance*, available from the Zero Carbon Hub website. The approach taken in regulations will be determined by Government and may or may not impact the design outcomes.
8. After achieving Carbon Compliance (and the minimum Fabric Energy Efficiency Standard), the full journey to Zero Carbon requires all residual emissions from regulated and non-regulated energy to be mitigated via Allowable Solutions. A procedure to calculate the non-regulated emissions can be found in the Appendix to this Technical Guide.

Sending feedback to the Zero Carbon Hub

One of the Task Group's recommendations is that further modelling work should be undertaken on a wider variety of dwelling types than could be carried out for the analysis used by the Group. Therefore the Zero Carbon Hub would like your feedback on testing your dwelling types to the proposed carbon compliance standards. Please send this to info@zerocarbonhub.org with the title 'Carbon Compliance Feedback'.

Appendix: Calculating non-regulated emissions

An estimate of the '2016' residual emissions and Allowable Solutions costs can be made by carrying out the following calculations:

A. Calculate the non-regulated carbon emissions (appliances & cooking) by:

   i. For elec oven, elec hob:

   $\{275 + (55 \times N) + 207.8 \times (N \times TFA)^{0.4714}\} \times 0.527$

   ii. For elec oven, gas hob:

   $\{137.5 + (27.5 \times N) + 207.8 \times (N \times TFA)^{0.4714}\} \times 0.527 + \{280.5 + (48.15 \times N)\} \times 0.227$

   iii. For gas oven, gas hob:

   $\{481 + (96.3 \times N)\} \times 0.227 + \{207.8 \times (N \times TFA)^{0.4714}\} \times 0.527$

   Where N = number of occupants, defined in SAP2009 (Table 1b) by:

   For $TFA \leq 13.9$, $N = 1$

   For $TFA > 13.9$, $N = 1 + 1.76 \times \{1-\exp(-0.000349 \times (TFA-13.9)^2)\} + 0.0013 \times (TFA - 13.9)$

   TFA = SAP box [4]

B. To calculate total residual emissions for the dwelling, add the value calculated in step [A] to the value calculated in step [4] above, multiplied by TFA:

   (value calculated in [A]) + {(value calculated in [4]) x TFA}

C. To obtain an estimate of the cost of mitigating the residual emissions, to achieve a Zero Carbon home, the total residual emissions for the dwelling need to be multiplied by the price of Allowable Solutions. The Task Group used an estimated price of £75/tonne$CO_{2(eq)}$/m²/yr over 30 years (defined within the December 2009 Zero Carbon Homes Impact Assessment[2]):

   (value calculated in [B]) x 0.001 x 75 x 30

Continuing the example in the main text above:

[A] Non-regulated emissions, assuming all elec cooking:

$\{275 + (55 \times 2.39) + 207.8 \times (2.39 \times 76.32)^{0.4714}\} \times 0.527 = 1489$ kg$CO_{2(eq)}$/yr

[or 19.51 kg$CO_{2(eq)}$/m²/yr]

[B] Total residual emissions:

$1489 + (10.64 \times 76.32) = 2301$ kg$CO_{2(eq)}$/yr

[or 30.15 kg$CO_{2(eq)}$/m²/yr]

[C] If Allowable Solutions were priced at £75/tonne$CO_{2(eq)}$ over 30 years, the cost of this element would be:

$2301 \times 0.001 \times 75 \times 30 =$ £5,177

[2] DCLG, Zero Carbon Homes Impact Assessment (December 2009), http://www.communities.gov.uk/publications/planningandbuilding/zerocarbondec09