Water and the Code for Sustainable Homes

The Code for Sustainable Homes is designed to reduce water consumption as well as CO2 emissions from a dwelling. But, as Cath Hassell of ech$_2$o explains, this will not necessarily be the outcome in homes built to meet levels 5 and 6.

It is now over a year since the Code for Sustainable Homes (CSH) was introduced in the UK with the target of "Zero Carbon Homes by 2016[1] and much has been written about it since, especially with regard to meeting the energy aspect. Far less has been written about water and yet water is also is a compulsory part of the CSH with regard to both the consumption within dwellings and the management of stormwater run-off from the site.[2]
There is no doubt that the CSH is broadly welcomed by those practitioners who have been designing and building sustainable homes for many years. Developers are now talking about how to meet the CSH in a way that they never did with EcoHomes, and the fact that all dwellings (private sector as well as public sector) now have to be rated (even if it is a zero rating!) and that dwellings will be checked post-construction as opposed to merely post-design, all adds to the effectiveness of the CSH. However, the way that water is rated under the CSH makes it too easy for design professionals to make water-illiterate choices. The result is that the carbon load of the water used in many "sustainable homes" will increase and lower mains water usage is far from assured.

Making the sustainable use of water mandatory under the CSH has been driven by varying factors; including the drought that occurred in 2006 in the South East of England, and the fact that climate change and population increase will lead to greater stress on the UK's water supplies. Although carbon emissions from the water supply industry are only 0.6% of total UK emissions, when domestic hot water use is added, the figure rises to 5%.[3] Therefore, it is especially important to reduce the amount of 'hot' water consumption in dwellings.

Any sustainable water strategy should reduce the load on the mains water supply, while at the same time it should not increase the carbon load of the water supplied. This is not as easily achievable as at first appears. Using alternative sources of water, a solution championed as a major factor in any sustainable water strategy and rewarded under the CSH, usually increases the carbon load of the water used in the building. On average in the UK it takes 1.2 kWh of (mostly) electrical energy to supply and treat 1m^3 of mains water, which results in 0.7 kg of CO_2 emissions per m^3 of mains water used. Specifying alternative sources of water such as greywater or rainwater often results in water that has a higher carbon load than mains water as more energy has been used to clean and/or pump it to appliances and there are no economies of scale to take advantage of. And, as under the CSH, specifying greywater or rainwater allows higher flow rates at taps and showers to be specified, more mains water usage can result.

Assumptions about water use from the CSH water calculator:

- a five minute shower usage
- a bath 40% full
- a 60/40 usage split between a shower and a bath if both are fitted
- Just over 5 minutes use per day at basins and sinks
- 4.8 WC flushes per day
- the property will have connections for a washing machine and dishwasher. If no particular appliance is specified a default figure is used of 49 litres per load for the washing machine and 13 litres per load for the dishwasher
- inefficient water softeners will add to the water load and are therefore penalised
- there is no penalty for en-suite bathrooms as having access to a second bath or shower will not result in greater usage.
- • Water use from swimming pools, an outdoor jacuzzi, hot tubs and water features is not calculated as part of an individual's daily usage as the mandatory part of the CSH is concerned with internal water consumption only. However, you cannot get the available outdoor 1.5 points credit for installing water butts if you have a pool, jacuzzi etc.

How water consumption is calculated

The CSH has minimum daily allowable usage per person at every level: 120 litres at levels 1 and 2, 105 litres at levels 3 and 4 and 80 litres at levels 5 and 6. Since January 1st 2008, Level 3 of the CSH has been mandatory for Housing Association properties and projects on English Partnership land. By 2010 all new dwellings (private as well as public) must reach level 3, and by 2016 all new dwellings must reach level 6. Therefore, this article will concentrate on meeting levels 3 - 6 of the CSH.

The water calculator used to show compliance with the CSH, makes a series of assumptions about the usage per person for appliances within the dwelling, as listed in Box 1 (above). As with any such calculation method the result obtained is only as good as the assumptions behind it. It is important to remember that just as a CSH Level 6 house

Core set of flow rates and capacities used in this article:

WC

- 4/2.6 litre dual flush – both Twyfords and Armitage Shanks have a dual flush WC rated at these flushing volumes. The low water use allows more flexibility to increase flow rates or capacities at other appliances.

Shower

- 13 litres/minute – rated as a "water efficient product" under the BMA's water efficient product labelling scheme.[4]
- 8 litres/minute - Hansgrohe produce a high specification shower head at this flow rate.
- 5 litres a minute - currently the lowest rated shower head available on the UK market.

Taps

- 1.7 litres/minute spray taps in the bathrooms – (otherwise even levels 3 and 4 are unachievable by water efficient measures alone!).
- 4 litres/minute at the kitchen sink - the minimum the author we considers acceptable.

Bath

- Undersized baths with a capacity of 160 litres for levels 3/4.
- Small shaped baths with a capacity of either 116 litres or 97 litres for levels 5/6.[5]

Washing machine and dishwasher

- To simplify matters the default figure for washing machines or dishwasher is used unless stated to the contrary.[6]

is only a notional "Zero Carbon Home", so the 80 litres per capita consumption (pcc) per day in a CSH Level 5 or 6 house is also only a notional figure, and behavioural use will have a large effect on actual daily consumption. There are hundreds of different combinations of appliances that can be specified to meet different levels of the CSH. To simplify matters all calculations in this article are selected from a core set of flow rates and capacities as detailed in Box 2 (above).

Appliance	Flow rate or capacity	Total litres
WC	4/2.6 litre dual flush	14.72
Basin	1.7 litres/min	5.98
Shower	8 litres/min	24.00
Bath	160 litres	25.60
Sink	4 litres/min	14.13
Washing machine	None specified - default used	16.66
Dishwasher	None specified - default used	3.90
Total		104.99

Table 1. Targeting a dwelling at Levels 3 and 4 with 160 litre capacity bath: PASS

Appliance	Flow rate or capacity	Total litres
WC	4/2.6 litre dual flush	14.72
Basin	1.7 litres/min	5.98
Shower	13 litres/min	39.00
Bath	97 litres	15.52
Sink	4 litres/min	14.13
Washing machine	None specified - default used	16.66
Dishwasher	None specified - default used	3.90
Total		109.91

Table 2. Targeting a dwelling at Levels 3 and 4 with a small bath and 13 litre/minute shower FAIL

Meeting the CSH

Levels 3 and 4 (Maximum daily use 105 litres pcc)

As the dwelling example in Table 1 shows, a developer can reach the required level of 105 litres with an 8 litres/minute shower as long as they also accept a flow rate of 4 litres/minute at the kitchen sink. This is using the default figure for a washing machine and dishwasher. If developers are willing to specify a smaller bath than 160 litres, WC flush volumes can be increased to 6/4 litres dual flush or 4.5 litres single flush, or slightly higher flow rates can be provided at the kitchen sink, (but not both). If no bath is specified (smaller flats with a wet room only), the flow rate at the kitchen sink can be increased to 6 litres/minute and a 6/4 litres dual flush WC can be installed. Once a shower with a high flow rate is specified (as Table 2 shows), even with a small bath, the required 105 litres cannot be achieved unless spray taps are fitted at the kitchen sink. Alternatively, a greywater recycling or rainwater harvesting system needs to be installed at extra cost.[7]

As the dwelling in Table 1 gives a satisfactory performance at all appliances, it is far more likely to be specified than the dwelling specification in Table 2. At this level, the CSH can be seen to work well in rewarding water efficiency over using alternative water supplies. Specifying an 8 litres/minute shower over a 13 litres/minute shower results in a saving (for a 5 minute shower) of 25 litres of water per day, over 9000 litres per person per year.

Appliance	Flow rate or capacity	Total litres
WC	4/2.6 litre dual flush	14.72
Basin	1.7 litres/min	5.98
Shower	5 litres/min	25.00
Bath	No bath	0.00
Sink	4 litres/min	14.13
Washing machine	None specified - default used	16.66
Dishwasher	None specified - default used	3.90
Total		80.39

Table 3. Targeting a dwelling at Levels 5 and 6 with no bath and 5 litres/min shower JUST FAILS

Appliance	Flow rate or capacity	Total litres
WC	4/2.6 litre dual flush	14.72
Basin	1.7 litres/min	5.98
Shower	5 litres/min	15.00
Bath	116 litres [8]	18.56
Sink	4 litres/min	14.13
Washing machine	None specified - default used	16.66
Dishwasher	None specified - default used	3.90
Total		88.95

Table 4. Targeting a dwelling at Levels 5 and 6 with small bath and 5 litres/min shower FAILS

Appliance	Flow rate or capacity	Total litres
WC	4/2.6 litre dual flush	14.72
Basin	1.7 litres/min	5.98
Shower	5 litres/min	15.00
Bath	116 litres	18.56
Sink	1.7 litres/min	5.98
Washing machine	None specified - default used	16.66
Dishwasher	Dishwasher specified - 10 litres per cycle	3.0
Total		79.90

Table 5. Targeting a dwelling at Levels 5 and 6 with small bath and 5 litres/min shower and spray taps at kitchen sink and a supplied efficient dishwasher PASSES

Levels 5 and 6 (Maximum daily use 80 litres pcc)

Unfortunately, at levels 5 and 6, the CSH starts to become less water-literate and begins to reward higher flow rates and the specification of water that has a high carbon load. It is very difficult to reach the required figure of 80 litres using water efficiency measures alone, especially if the developer wants to install a bath, and therefore greywater recycling or rainwater harvesting becomes almost the norm.

As Table 3 shows, with no bath specified, using low flow rates at showers and taps, and the most water efficient WC, the calculator gives a figure of 80.39. By fitting spray taps at the kitchen sink, or providing an efficient washing machine or dishwasher, the dwelling can reach the required 80 litres figure. In the case of a one-bed or two-bed flat, it is possibly acceptable to provide a wet room only. But for a larger dwelling where a bath is deemed vital for the property to sell, the addition of a small bath means that water use is calculated at 88.95 litres a day (Table 4) and both spray taps at the kitchen sink and an efficient dishwasher or washing machine will need to be supplied. This solution (Table 5) now has a small bath, a very low flow rate of 5 litres/minute at the shower, and a frustratingly low flow rate through the spray taps at the kitchen sink. It is unlikely that such a specification will appeal to prospective buyers, so the developer will choose to install either a rainwater harvesting system or a greywater recycling system. These systems are expensive so once a developer has invested in the technology it is not surprising they take advantage of the opportunities it gives them to increase water use elsewhere.

The dwellings in Tables 6 and 7 both have a 13 litres/minute shower and greywater recycling using the Pontos Aquacycle, which can supply water at a high enough quality for use in a washing machine as well as to flush the WC. Bath capacity must reduce to 97 litres but this offset by the powerful shower and a decent flow rate from the kitchen taps. As the amount of available greywater, is greater than required the WC specification can also be changed to a 6 litre single flush to offset some of the developer's costs for the greywater recycling system. (Dwelling 7). It is possible to specify the Ecoplay for WC flush and rainwater harvesting for washing machine use to get the same effect of being able to specify a 13 litres/minute shower if there is no space for the AquaCycle.[9]

Once greywater recycling or rainwater harvesting is specified, the developer can begin to be quite water-profligate. The specification for the shower has been increased from 5 litres/minute to 13 litres/minute, a performance increase (and therefore water use increase) of 260%! A 13 litres/minute shower provides so much greywater there is no need to specify a water efficient washing machine! Internal water consumption has risen to 110 litres in Dwelling 6 and 124 litres in Dwelling 7. The residents in Dwelling 7 are now using over 44 litres more per day than the residents in Dwelling 5, and water consumption for a 5-minute shower has increased from 25 litres to 65 litres.

Knock on effects

So what are the knock-on effects of specifying greywater recycling and/or rainwater harvesting to permit higher

Appliance	Flow rate or capacity	Total litres
WC	4/2.6 litre dual flush	14.72
Basin	1.7 litres/min	5.98
Shower	13 litres/min	39.00
Bath	97 litres	15.52
Sink	4 litres/min	14.13
Washing machine	None specified - default used	16.66
Dishwasher	None specified - default used	3.90
Total before any offset		109.91
Greywater recycling	Potential from bath, shower and basin	60.50
Greywater recycling	Used for WC flush and washing machine	-31.38
Rainwater harvesting	No	0.00
Total		78.53

Table 6. Targeting a dwelling at Levels 5 and 6 with very small bath and 13 litres/min shower and greywater recycling PASSES!

flow rates at showers? Even the simple water knock-on effects are significant. The CSH calculates water use per day for WC flushing to have increased from 14.72 litres to 28.80 litres, an increase of 14.08 litres per day and 5,139 litres per person per year. A change of specification from an 5 litres/minute shower to a 13 litres/minute shower, assuming just a 5 minute shower per day increases water consumption at showers by 40 litres per day and 14,600 litres per year.[10] It has been argued that such figures do not matter as the dwellings are, in effect, making the water on site. It is true that Dwellings 6 and 7 pull no more water from the main than Dwellings 3, 4 or 5 as far as the CSH calculator is concerned. But if the CO_2 loading of the recycled greywater is greater than 0.7 kg CO_2.it is not a carbon-literate choice. Even the smallest Pontos AquaCycle can supply enough greywater for WC flush and washing machine use for 14 occupants per day and should therefore be specified in blocks of flats, to serve several dwellings, not one-off houses where the carbon load per m^3 of water supplied is far in excess of using water from the mains. The Ecoplay has a far lower power consumption but can only be used to offset WC flush, and the pumps in rainwater harvesting systems are rarely more carbon efficient than a mains supply when supplying WC cisterns and washing machine points in a single dwelling.

However of far more concern is the increased amount of hot water required for the 13 litres/minute shower. Assuming that a temperature rise of 30 degrees C is required for the shower, then every 1000 litres of water requires 34.89 kWh of energy to heat it. Using an A-rated gas condensing boiler 8 kgCO_2 are produced; using an electric immersion heater, 18 kgCO_2 are produced. An occupant having a 5 minute shower will produce 117 kgCO2 extra per year if the water is heated by gas, 263 kgCO_2 if it is heated by electricity.

The carbon load of the extra hot water required increases as shower times increase, and this is not picked up by the CSH. Any underestimation of shower use will have a large knock-on effect on both water use and carbon emissions as clearly shown in Table 1. Whilst for many adults a 5 minute shower is perfectly adequate, for many others it is not, and we all know the predilection adolescents have for long showers! A dwelling with 4 people living in it whose average use in the shower is 10 minutes long would require a solar thermal system that offset over 934 kg CO_2 a year, a system that is about twice the size of those currently specified. And this is merely to negate the extra carbon load of specifying a 13 litre minute shower, yet alone offset the CO_2 from other water use in the dwelling. Now, the shortcomings of the CSH at levels 5 and 6 become apparent.

We need a more intelligent CSH

The CSH should reward intelligent carbon choices at all levels. Water efficiency should be prioritised over alternative sources of water, and far more consideration should be given to using both rainwater and greywater outside the building for garden watering. Just 30 minutes of hose pipe use will use 280 litres of water. It is clear that more than a couple of water butts are needed, if mains water use is not to be required during dry summer periods. At present the CSH for Sustainable Homes awards 1.5 points for installing water butts in recognition of the advantages of removing rainfall from the stormwater stream and offsetting mains water use, but the developer is not rewarded for putting in extra storage unless the water is used back in the building. As developers are unlikely to incorporate systems that result in extra expense if no points can be gained, the chance to use rainwater or greywater in the garden is lost, even though, in the east and south east of England

Appliance	Flow rate or capacity	Total litres
WC	6 litre single flush	28.8
Basin	1.7 litres/min	5.98
Shower	13 litres/min	39.00
Bath	97 litres	15.52
Sink	4 litres/min	14.13
Washing machine	None specified - default used	16.66
Dishwasher	None specified - default used	3.90
Total before any offset		123.99
Greywater recycling	Potential from bath, shower and basin	60.50
Greywater recycling	Used for WC flush and washing machine	-45.46
Rainwater harvesting	No	0.00
Total		78.53

Table 7. Targeting a dwelling at Levels 5 and 6 with small bath and 13 litres/min shower and 6 litre single flush WC and greywater recycling PASSES!

The Watermatic system diverts greywater directly to drain during the winter months; in the summer, when the greywater is required, it is filtered and pumped immediately to the garden so there is no chance of anaerobic decomposition.

Carbon emissions per person per year from shower use						
Duration of shower	Water use @ 5 litres/min	Water use @ 8 litres/min	Water use @ 13 litres/min	Difference in water use per year between 5 and 13 litres/min shower *	Carbon difference/year between 5 and 13 litres/min (using an A rated gas condensing boiler) **	Carbon difference/year between 5 and 13 litres/min (using an electric immersion heater) ***
				(Litres)	$kgCO_2$	$kgCO_2$
2 mins	10	16	26	5,840	46.72	105.12
5 mins	25	40	65	14,600	116.80	262.80
10 mins	50	80	130	29,200	233.60	525.60
15 mins	75	120	195	43,800	350.40	788.40
30 mins	150	240	390	87,600	700.80	1,576.80

Table 8. The carbon load of specifying high flow rate showers

Notes: *. Calculated at one shower per day at stated duration

**. Calculated at a required 30 degree C temperature lift, 90% efficiency of the boiler and a CO_2 load of 0.21$kgCO_2$/kWh (DEFRA figures)

***. Calculated at a required 30 degree C temperature lift, and a CO_2 load of 0.527$kgCO_2$/kWh (DEFRA figures)

that would be the best use of these alternative sources, as they will be used when the strain on the mains is at its greatest. Indeed it could be argued that collecting and storing winter rainfall for garden use in the summer, should be compulsory for new houses in the south and east of the UK. If the dwelling has a garden then rainwater or greywater for outside use should be rewarded just as much as if it was used back in the building. Both can be used on the garden without any requirement to treat the water further (although greywater needs to be delivered in sub-surface pipework.) There are plenty of solutions already available on the UK market for existing homes. Most rainwater harvesting suppliers provide a system for garden use with rainwater accessed from underground tanks either by small electric pumps or even hand pumps. The Watermatic system diverts greywater directly to drain during the winter months; in the summer, when the greywater is required, it is filtered and pumped immediately to the garden so there is no chance of anaerobic decomposition. Both these options have a low carbon load compared to reuse back in the dwelling.

Conclusions

The CSH as it currently stands needs a major rethink with regard to water use at levels 5 and 6. There is still time to make it an intelligent tool as the vast majority of dwellings being designed or on site now are meeting level 3 or 4 of the CSH, where water efficient solutions are properly rewarded. The CSH should recognise reducing demand for water per se as the best option and recognise the use of rainwater or greywater in the garden as at least equal to use in the building.

Water efficient appliances on their own should be sufficient to reach the required pcc consumption at levels 5 and 6, even if this requires an increase in required usage to, say, 90 litres per day. Finally, behavioural changes as well as technical innovations are needed to overcome the problems of water shortages. Whilst it is clear that the CSH cannot change behaviour, a minimum prescriptive requirement of water efficiency at higher levels of the CSH is necessary. At levels 5 and 6, showers rated at 8 litres/minute should be the maximum allowed, regardless of alternative water sources used.

Cath Hassell

With thanks to Jean-Pierre Wack and Elliot Carter at Eight Associates for preliminary discussions about this article, and Judith Thornton (Water Works) and Eric Hassell for subsequent comments.

References

1. 2016 is now the target date for all new homes to be Zero Carbon Homes in England. The date for Wales is 2011.

2. To reduce the strain on stormwater drains, the minimum standard for surface water management is that peak run-off rates and annual volumes of run-off will be no greater than previous site conditions.

3. Future Water. The Government's water strategy for England. February 2008.

4. Bathroom Manufacturers' Association.

5. Although there is confusion at present about whether bath capacities are German ratings and would be rated differently if for the UK market only, at present they are being specified (indeed the demonstration CSH houses at BRE use this method of measuring the bath volume) and accepted as valid in CSH assessments.

6. At present developers rarely fit a washing machine or dishwasher into homes for sale to the private market.

7. If the 13 litres/min shower is specified without a bath, the daily usage is calculated at 120.39. If it is specified with a standard bath, the daily usage is calculated at 119.99.

8. Even with a 97 litre capacity bath we cannot reach the required 80 litres level.

9. It is very difficult to collect enough rainwater in most parts of the UK from most new dwellings to have enough rainwater for both WC flush and washing machine use and therefore rainwater by itself has not been used as an option.

10. The CSH itself does not calculate the extra use as high as this as it assumes only 60% use of the shower as a bath is fitted. For the purposes of these calculations, we will assume shower use only and one per day rather than complicating things by including bath use.