



# Water consumption in sustainable new homes





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# FOREWORD

Reducing unnecessary and excessive use of water is one of the key objectives of more sustainable housing. So one of the measures of sustainability included in the Code for Sustainable Homes and its predecessor, EcoHomes, is the quantity of water used by consumers living in new homes. Changes to Part G of the Building Regulations in England and Wales made last year also address the issue, aiming to bring down average water consumption from 150 to 125 litres per person per day. But what is the success of these design targets; what is the actual use of water in homes built to higher environmental standards?

To begin to answer these important questions the NHBC Foundation commissioned the research in this report. The evidence comes from measuring the actual consumption of water in seven homes designed and built in accordance with the Code/EcoHomes. Using multiple water meters in each home and state-of-the-art wireless telemetry, consumption was measured at each draw-off point over periods of between six and twelve months.

The principal finding of this important project is that average water use in these homes exceeded the design target by some significant margin. It also identifies clearly the split between the different uses of the water in the home and the quantity of hot water used, from which estimates of its carbon footprint can be derived.

The findings of this report add to the evidence already available from the *Energy and Carbon Implications of Rainwater Harvesting and Greywater Recycling* research published by the NHBC Foundation, the Environment Agency and the Energy Saving Trust in 2010. That research demonstrated the increase in CO<sub>2</sub> emissions that can arise through the adoption of water harvesting/recycling technologies in pursuit of the more demanding levels of water efficiency encouraged at the higher levels of the Code.

The objective findings of this present study and the earlier research into water harvesting/recycling provide sound evidence on water efficiency. I hope these will prove useful and help to inform the debate about future changes to the Code and Building Regulations in this area.

**Rt. Hon. Nick Raynsford MP**  
Chairman, NHBC Foundation

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The NHBC Foundation was established in 2006 by the NHBC in partnership with the BRE Trust. Its purpose is to deliver high-quality research and practical guidance to help the industry meet its considerable challenges.

Since its inception, the NHBC Foundation's work has focused primarily on the sustainability agenda and the challenges of the government's 2016 zero carbon homes target. Research has included a review of microgeneration and renewable energy techniques and the groundbreaking research on zero carbon and what it means to homeowners and house builders.

The NHBC Foundation is also involved in a programme of positive engagement with government, development agencies, academics and other key stakeholders, focusing on current and pressing issues relevant to the industry.

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## 1 Executive summary

The Code for Sustainable Homes ("the Code") is a national standard that aims to create homes that are more sustainable and reduce CO<sub>2</sub> emissions. The Code measures the sustainability of a home against nine categories including internal potable water consumption and external water use.

A pilot study has been carried out to monitor water consumption in dwellings built to Code specifications to compare it with values predicted by the Water Calculator in the Code, in order to assess whether the targets in the Code are practical and achievable.

Seven properties in which families lived normally were tested: five dwellings constructed to the standards of the Code and two to meet those of EcoHomes. Water meters were fitted and the actual water use was measured for a period of between 6 and 12 months.

The study has shown that actual water consumptions in the dwellings on average exceeded the designed maximum water consumption targets set in the Code. Although some improvements in water efficiency have been achieved, installing water efficient fittings and appliances as specified in the Code has only a limited effect on minimising water use. Consumer behaviour and attitude play a substantial role in reducing water consumption. Further research is needed to examine the impact of consumer behaviour and attitude on reducing water consumption through mitigation measures such as metering, awareness raising, and setting caps on water use. A linear correlation between CO<sub>2</sub> emissions and utility bills has been observed, which indicates that reduction in water consumption may help to reduce CO<sub>2</sub> emissions, as well as lowering energy and water utility costs (this may not be the case where very low targets dictate the use of grey water recycling and/or rain water harvesting). This study can also be used to assess the impact of Code water targets on reducing water consumption in new homes.

Key findings, albeit based on a small sample size, are as follows:

- The average water consumption measured in the seven properties (109.57 litres/person/day) was less than the current national average water consumption in existing UK homes (150 litres/person/day) and the target set in Building Regulations Part G

(125 litres/person/day). However, not all Code properties achieved the intended Code Level 4 target of 105 litres/person/day. Two of the five Code dwellings significantly exceeded this maximum target value.

- On average, hot water consumption accounted for 32% of the total water consumption.
- With the exception of Property 6 where the water consumption pattern showed irregularity, the measured water consumption in the Code properties exceeded the values predicted using the May 2009 version of the Water Calculator by between 5% and 63% with a mean value of 28.6%.
- The water consumption values predicted using the October 2008 Water Calculator were higher than those predicted using the May 2009 version for each test property.
- Typical water consumption values per person per day were derived for the following appliances and fittings: WC (20.75 litres), bath (24.26 litres), shower (27.82 litres), wash basin (3.44 litres), kitchen tap (11.69 litres), dishwasher (4.75 litres) and washing machine (17.89 litres). These figures highlight that the greatest potential water savings can be achieved by reducing the amount of water used in WCs, baths and showers.
- Water use behaviours in all households monitored had a significant influence on the amount of water consumed, and the associated CO<sub>2</sub> emissions, energy consumption and utility bills.
- In at least one case there was evidence of occupants exhibiting water-use behaviour associated with practical limitations of low-flow taps: ie the practice of filling kettles and other kitchen utensils from bath taps.
- CO<sub>2</sub> emissions and household utility bills associated with water use were found to be linearly correlated. Generally, for every pound the household paid for its water use (including water bill and energy bill for hot water), approximately 2 kg of CO<sub>2</sub> was emitted.
- On average, CO<sub>2</sub> emissions were about 0.9 kg/person/day and the total cost associated with water use was approximately 50 p/person/day when using an average metered energy tariff.

The results in this study consistently show disparity between calculated use for a given water fitting specification and the actual water consumption. This difference can be attributed to the impact of user behaviour which the calculator would not realistically be able to account for accurately in every case. Given that the specification of water efficient fittings can only go so far in reducing water consumption and may not on its own achieve the targets set out in the Code and Part G, this study recommends further research on how user behaviour can influence water consumption.



## 2 Introduction

The Code for Sustainable Homes<sup>[1]</sup> is the national standard for the sustainable design and construction of new homes, and was launched in 2006. It aims to create homes that are more sustainable and have lower CO<sub>2</sub> emissions than conventionally built homes. The Code is mandatory for social housing and homes built on ex-public land, and is required by a large proportion of planning authorities for new build homes in England; it is also mandatory for all developments of five or more units in Wales.

The Code measures the sustainability of a home against nine design categories. Water consumption is one of the categories and includes mandatory targets for internal water use. Three maximum water consumption target values for internal water use are specified for different Code Levels (Code Level 1 or 2: 120 litres/person/day; Code Level 3 or 4: 105 litres/person/day; and Code Level 5 or 6: 80 litres/person/day). The Code uses the Water Efficiency Calculator for New Dwellings (known as the Water Calculator)<sup>[2]</sup> to predict water use in a dwelling and credits are awarded to the water category accordingly. Water efficient fittings, such as reduced volume baths and low flow-rate taps (Figures 1 and 2), lead to predicted lower water consumption and hence a higher number of credits. The 2009 version Water Calculator is also used for Regulation 17.5K of Building Regulations Approved Document Part G<sup>[3]</sup> (known as Part G) which sets a water target of 125 litres/person/day.



**Figure 1** A reduced volume bath.



**Figure 2** Maximum flow-rate of low flow-rate taps.

The main aims of the study were to monitor actual water consumption in Code dwellings and to compare this with the values predicted by the Water Calculator, in order to assess whether the Water Calculator method is practical, and whether the water consumption targets set in the Code are realistic and achievable.

The following key tasks were carried out:

- Test properties were located and actual water consumptions in these new homes were monitored.
- Protocols for retrofitting water meters in occupied dwellings and wireless telemetry for logging and transferring data were developed.
- The monitored water consumptions in each test dwelling were compared with the design water consumptions determined using the recently published Water Calculators.<sup>[2,4]</sup> These results were also compared with the maximum water targets specified for the relevant Code Level to assess compliance within the Code.
- Energy use and CO<sub>2</sub> emissions associated with water consumption in the test homes were also determined.





## 3 Description of the study

### 3.1 Properties monitored

Seven properties (five Code dwellings and two EcoHomes) at four sites were selected for this study. The details of the properties are summarised in Table 1. Water consumption at the properties was successfully monitored for 6 to 12 months.

**Table 1**

**Details of the test properties**

Property	Property type	Location of property	Code Level	Metering level (number of meters)	Water company	Length of monitoring (months)	Number of occupants
1	Semi-detached house	Basingstoke, Hampshire	4	Fully metered (18)	South East Water	12	3
2	Ground floor flat	Crewkerne, Somerset	4	Mostly metered* (8)	Wessex Water	12	2 <sup>†</sup>
3	First floor flat			Mostly metered* (9)			2 <sup>†</sup>
4	Semi-detached house	Danbury, Essex	Eco-Homes: "Very Good" rating	Partially metered (3)	Essex & Suffolk Water	8	5
5	Semi-detached house						4
6	Second floor flat	Yeovil, Somerset	4	Mostly metered* (7)	Wessex Water	6	2
7	Ground floor flat						3

Notes:

\* It was not possible to fit water meters to the electric showers, so these properties are described as "mostly metered"

† The level of occupancy changed during the monitoring period. The nominal number of occupants in the table was used for calculating water consumption per person.

The specifications of each appliance and fitting were used to predict the water consumption for individual components and the total water usage in a home using the Water Calculators (October 2008 and May 2009 versions)<sup>[2,4]</sup> developed for the Code.

The occupants in Properties 2 and 3 were not content with the low flow-rates from the kitchen taps and the bathroom wash basin taps. Consequently, the tap flow-rates were increased midway through the monitoring period.

### 3.2 Monitoring protocol and equipment

State-of-the-art wireless telemetry equipment was modified to work within the UK telecommunications environment:

- Transponders (“data loggers”). Every water meter installed in the houses was wired to a transponder (Figure 3).
- Concentrator unit. This box contained a power supply, wireless data receiver and mobile phone modem (Figure 4). There was one concentrator unit at each monitoring site, which communicated with all the transponders at that site.
- Data logging program and data storage facilities.

Each transponder sent out a pulse for every cumulative litre of water that flowed through the water meter to which it was attached. Each concentrator unit collected data from the transponders at its site every 5 seconds, and recorded the time and volume of water used after an event had finished. The data logging program communicated, via a wireless telecommunication network, with all the concentrator units at the four sites and logged data every 15 minutes. At the end of each day, the data collected were sent to the server.



**Figure 3** Water meters and associated transponders.



**Figure 4** A concentrator unit.



## 4 Results and discussion

### 4.1 Data analysis

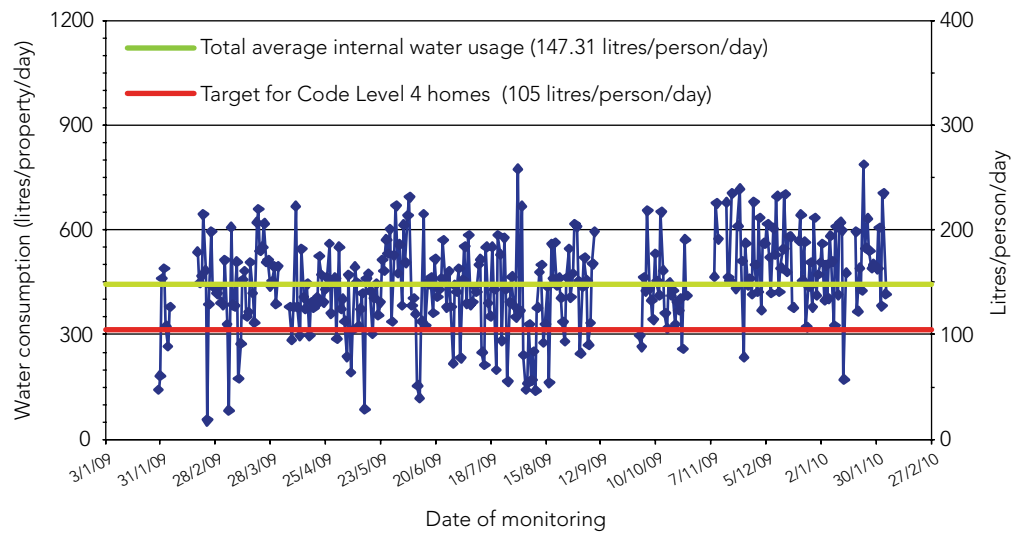
The raw monitoring data were downloaded from the BRE website and sorted by site location, test property, and then individual water meter. The daily water consumption for each appliance and fitting was determined by the cumulative volume of water used over a 24-hour period. The total daily water consumption in each property was calculated.

For each property, a set of water consumption values was derived. The daily consumption was averaged over the number of “valid days” throughout the monitoring period and divided by the number of the occupants. Valid days are defined as the days when the occupants were in residence and data transmission was regular. Holidays were not counted as valid days since the occupants were not in the property to consume water. Of the seven properties monitored, three families took holidays during the monitoring period (cumulatively: Property 4: 35 days; Property 6: 98 days; Property 7: 17 days). The occupants in Property 6 were not in residence for 52% of the time during the monitoring period. Consequently, the data from this dwelling may not be representative of a typical regular water consumption pattern.

### 4.2 Measurements of water consumption

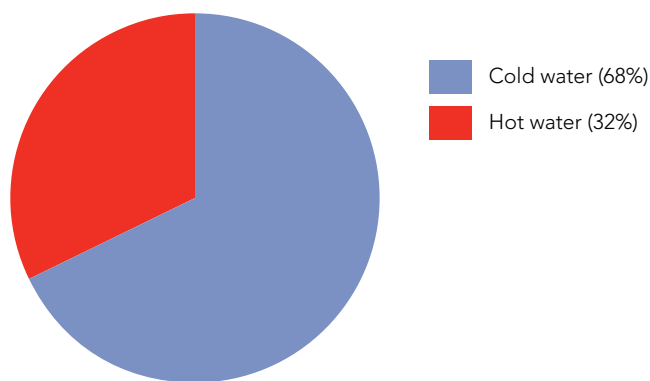
In general, the daily water consumption showed considerable variation mainly ranging from 50 to 250 litres/person/day. As an example, Figure 5 shows the total daily internal water consumption in Property 1 throughout the monitoring period. This varied between about 20 and 270 litres/person/day, giving an average of 147.31 litres/person/day which is around 40% higher than the 105 litres/person/day specified for Code Level 4 homes.

The measured water consumption values for each appliance and fitting in the seven properties are summarised in Table 2. In the absence of measured values, water consumptions were estimated from the difference between the revenue data supplied by the relevant water company and the measurements for other appliances in the same dwelling.

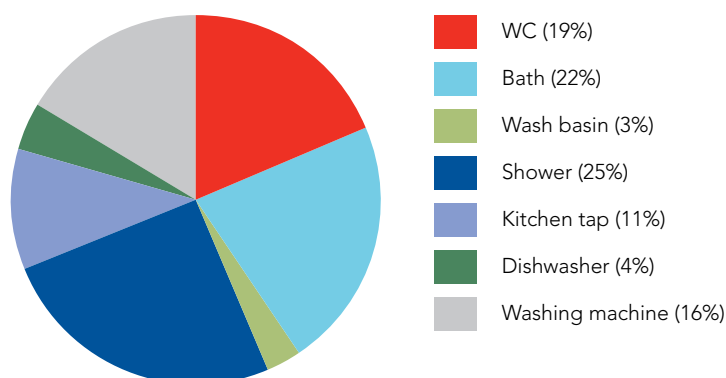


**Figure 5** Daily internal water consumption in Property 1 throughout the 12-month monitoring period.

Figure 6 shows the average percentage of hot and cold water consumption in the seven properties and Figure 7 shows the average water consumption for each activity in the five Code homes throughout the monitoring period.



**Figure 6** Average percentage of hot and cold water consumptions in the seven properties.



**Figure 7** Average percentage of water consumption for each activity in the five Code homes.



Table 2

## Summary of water consumption for each appliance and fitting in the test properties and prediction from Water Calculators

Appliance/ fitting	Measured or derived water consumption (litres/person/day) in property:							
	1	2	3	4	5	6	7	Average
Hot water consumption as a percentage of total water consumption	38%	22%	24%	49%	32%	30%	28%	32%
WC	26.24	18.59	17.64	Total hot water consumption: 31.79	Total hot water consumption: 51.11	22.07	19.20	20.75
Bath	28.06	23.10	21.63			24.26 <sup>‡</sup> (derived)	24.26 <sup>‡</sup> (derived)	24.26
Wash basin	4.95	4.70	3.20			2.43	1.94	3.44
Shower	51.97	41.59* (derived)	23.44* (derived)			11.55* (derived)	10.56* (derived)	27.82 <sup>¶</sup>
Kitchen tap	9.52	14.98	6.94			8.83	18.17	11.69
Dishwasher	5.31	4.75 <sup>†</sup> (derived)	4.20			NA	NA	4.75
Washing machine	21.26	24.93	7.49			10.08	25.43	17.84
<b>Total internal water consumption</b>	<b>147.31</b>	<b>132.65<sup>§</sup></b>	<b>84.55<sup>§</sup></b>	<b>65.36<sup>§</sup></b>	<b>158.24<sup>§</sup></b>	<b>79.27<sup>§</sup></b>	<b>99.59<sup>§</sup></b>	<b>109.57</b>
Maximum water target for Code dwellings	105	105	105	NA	NA	105	105	
Prediction by 2008 Water Calculator	115.10	102.86	102.86	192.24	192.24	106.72	107.40	
Prediction by 2009 Water Calculator	108.06	81.37	80.82	119.96	119.96	92.74	90.07	

## Notes:

- \* Water consumption for the electric shower in Properties 2, 3, 6 and 7 was derived from the difference between the revenue data for each respective property and the total water consumption by the other appliances and fittings in the same property.
- † Water consumption for the dishwasher in Property 2 was estimated from the measured water consumption by the dishwashers in Properties 1 and 3.
- ‡ Water consumption values for the baths in Properties 6 and 7 were estimated from the measured water consumption for the baths in Properties 1, 2 and 3.
- § Revenue meter data supplied by the Water Company for the monitoring period.
- ¶ There may be uncertainty in this value as it was calculated from one measured and four derived values.

### 4.3 Comparison of actual and predicted total water consumption

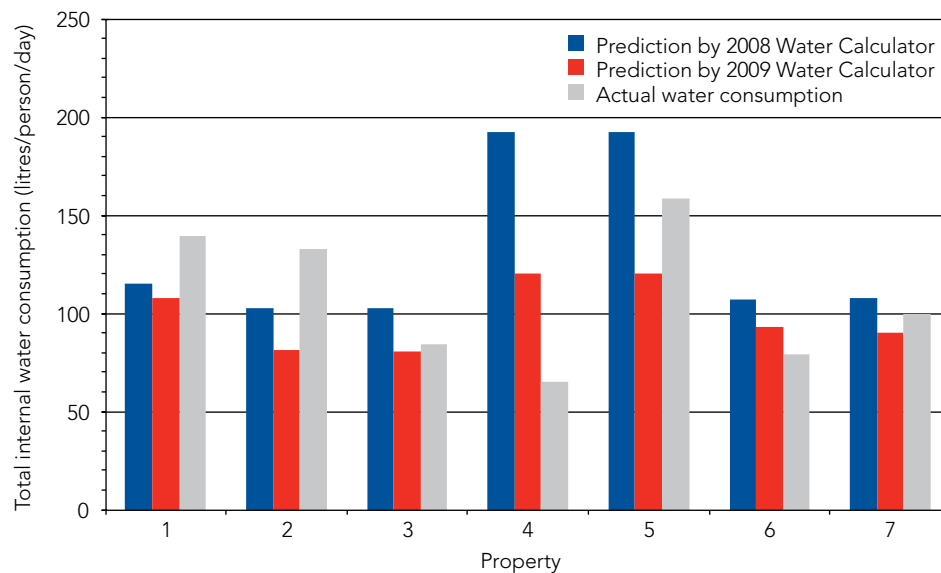
Table 2 summarises the total internal water consumption for each property, whether directly measured or derived from the relevant revenue data supplied by the respective water company. They are compared with the maximum water target set for Code Level 4 homes and the predicted values from the October 2008 and May 2009 Water Calculator. These data are also shown in Figure 8.

Predictions from the October 2008 Water Calculator were on average approximately 30% higher than those from the May 2009 Water Calculator.

Predictions using the Water Calculators for the EcoHomes dwellings were significantly higher than the Code dwellings. However, these dwellings were not specifically designed to meet the water efficiency requirements in the Code.

The average water consumption measured from the five Code homes was 108.67 litres/person/day, which is significantly lower than the current typical water consumption value of 150 litres/person/day in existing UK homes. However, not all the monitored CSH properties achieved the intended Code Level 4 target of 105 litres/person/day.

With the exception of Property 6, the actual water consumption values in the five Code Level 4 homes were higher than the predictions from the 2009 Water Calculator by 5 to 63%, with an average of 28% and a median of 23.5%.



**Figure 8** Comparison of the actual water consumption with predictions from Water Calculators.

#### 4.4 Comparison of actual and predicted water consumption for individual appliances and fittings

Table 3 gives both the measured and predicted water consumption from the October 2008 and May 2009 Water Calculators for individual appliances and fittings in each Code dwelling.

Figures 9 and 10 show the comparison between measured water consumptions and predicted values from the October 2008 and May 2009 Water Calculators, respectively, for individual appliances and fittings. Only measured data have been included. Points below the diagonal line show that the actual water consumption was higher than the values predicted using the Water Calculator (ie the measured values were higher than predicted). Points above the line indicate that the Water Calculator over-predicted the values (ie the measured values were lower than predicted).

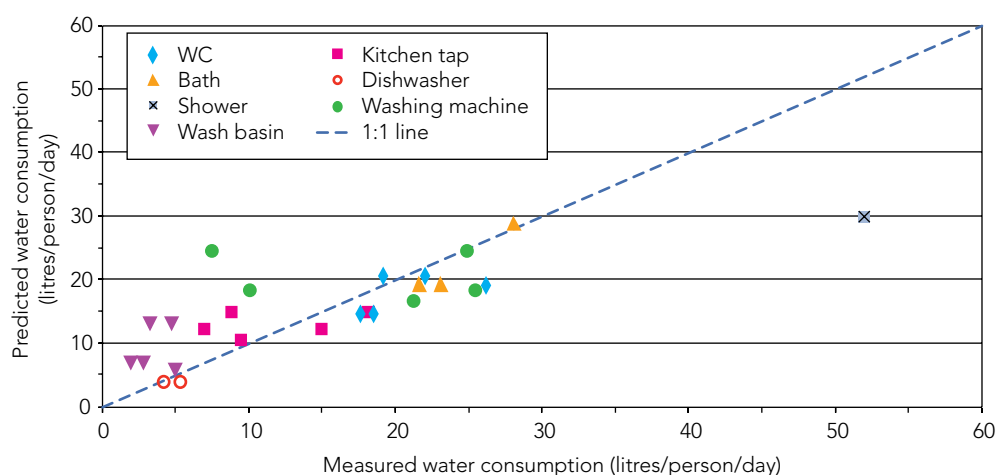
Figure 9 shows that the October 2008 version of the Water Calculator generally under-predicted water consumption for the WC by 12%, bath by 8%, shower by 42% and dishwasher by 17%. However, water use for the wash basin was over-predicted by 194%. Although the data points for the kitchen taps and washing machine are rather scattered, the 2008 Water Calculator over-predicted water consumption for these appliances by an average of 25% and 52%, respectively.

Table 3

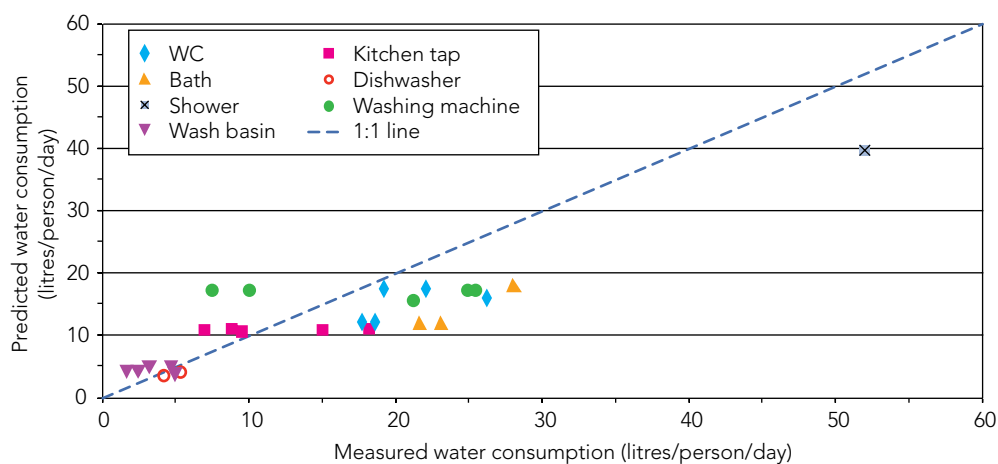
## Measured and predicted water consumption for appliances and fittings in Code dwellings

Property	Appliances and fittings	Water consumption (litres/person/day)		
		Measured	2008 Water Calculator	2009 Water Calculator
1	3 × WC	26.24	19.15	16.05
	Bath	28.06	28.80	18.02
	3 × Wash basins	4.95	6.00	3.88
	Shower	51.97	30.00	39.77
	Kitchen taps	9.52	10.59	10.63
	Dishwasher	5.31	3.90	4.10
	Washing machine	21.26	16.66	15.61
	Outside tap	1.07	NA	NA
2	WC	18.59	14.70	12.32
	Bath	23.10	19.20	12.01
	Wash basin taps	4.70	13.23	5.03
	Shower	41.59 (derived)	15.00	19.88
	Kitchen taps	14.98	12.35	10.83
	Dishwasher	4.75 (derived)	3.90	4.10
	Washing machine	24.93	24.48	17.20
3	WC	17.64	14.70	12.32
	Bath	21.63	19.20	12.01
	Wash basin taps	3.20	13.23	5.03
	Shower	23.44 (derived)	15.00	19.88
	Kitchen taps	6.94	12.35	10.83
	Dishwasher	4.20	3.90	3.55
	Washing machine	7.49	24.48	17.20
6	WC	22.07	20.78	17.42
	Bath	24.30 (derived)	28.80	18.02
	Wash basin	2.43	7.06	4.31
	Shower	11.55 (derived)	13.50	17.90
	Kitchen taps	8.83	15.00	11.13
	Dishwasher	NA	3.90	4.10
	Washing machine	10.08	18.36	17.20
7	WC	19.20	20.78	17.42
	Bath	24.30 (derived)	28.80	18.02
	Wash basin	1.94	7.06	4.31
	Shower	10.56 (derived)	13.50	17.90
	Kitchen taps	18.17	15.00	11.13
	Dishwasher	NA	3.90	4.10
	Washing machine	25.43	18.36	17.20

Figure 10 shows that the May 2009 version of the Water Calculator generally under-predicted water consumption for the WC by 27%, bath by 43%, shower by 23%, dishwasher by 19%; and over-predicted water usage for wash basin by 48%. Again, the data for kitchen tap and washing machine are scattered. Overall, the 2009 Water Calculator over-predicted water consumption for kitchen taps by 5% and washing machine by 22%. On the whole, the predicted water consumptions for the wash basin, shower, kitchen tap and washing machine are more accurate using the May 2009 Water Calculator compared with the October 2008 version, and less accurate for the WC and bath.



**Figure 9** Measured and predicted water consumption from 2008 Water Calculator for individual appliances and fittings in the five Code dwellings.



**Figure 10** Measured and predicted water consumption from 2009 Water Calculator for individual appliances and fittings in the five Code dwellings.



## 5 Energy use and CO<sub>2</sub> emissions

### 5.1 Results from Water Energy Model

Using the consumption data from this study and the Water Energy Model (WEMlite; a tool used by the Energy Saving Trust and the Environment Agency to develop water, energy and carbon saving information for UK water companies and retrofitting programmes),<sup>[5]</sup> the following outputs for each appliance and fitting were calculated:

- Energy consumption and costs for hot water use. These results took into account the heating device and its performance co-efficiency.
- Water costs for water (hot and cold) consumed. This is the amount that the households were charged by their water suppliers (ie water bill) if they were on a water meter and associated tariff. This bill includes tariffs for both water supply and sewage treatment.
- CO<sub>2</sub> emissions for heating hot water and embodied CO<sub>2</sub> emissions. The latter takes into account the total emissions resulting from water supply and wastewater treatment.

The results for the properties are summarised in Table 4.

### 5.2 CO<sub>2</sub> emissions and utility bills associated with water consumption

The total CO<sub>2</sub> emissions from a property associated with water use are determined by combining the CO<sub>2</sub> emissions from heating the water used with the embodied CO<sub>2</sub> emissions (those from other processes connected with water use). As shown in Table 4, the total CO<sub>2</sub> emissions varied considerably between properties from approximately 1.5 to 0.4 kg/person/day with a mean of about 0.9 kg/person/day. This is equivalent to the CO<sub>2</sub> emissions from a small car, such as a Vauxhall Corsa, travelling a distance of 9 km.

Table 4 also shows that the CO<sub>2</sub> emissions associated with water use are mainly due to heating water. Only 13% of the total CO<sub>2</sub> emissions were attributed to the processes for water supply. This is broadly in line with existing data.<sup>[6]</sup>

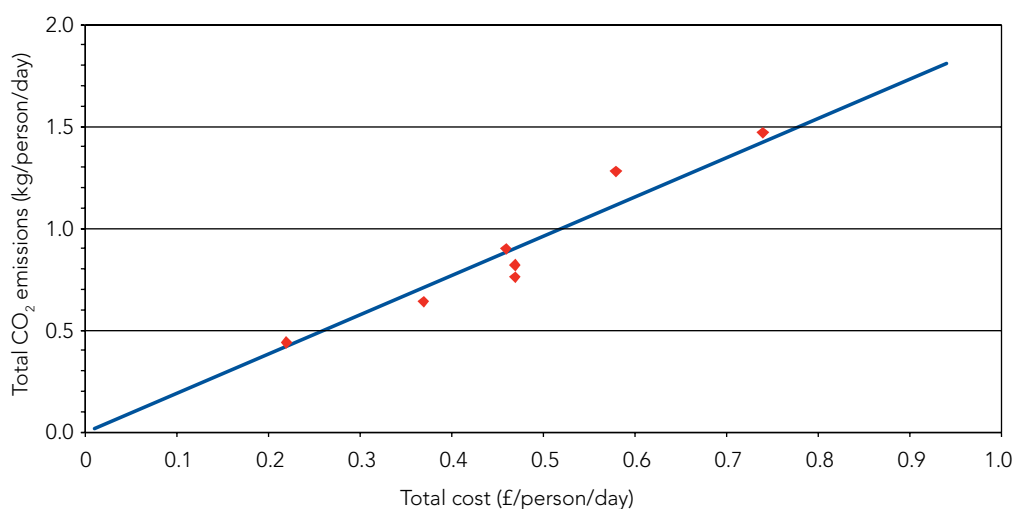
**Table 4****Energy use, CO<sub>2</sub> emissions, and utility bills associated with water use in the properties**

	Property						
	1	2	3	4	5	6	7
Energy consumption (kWh/person/day)	4.35	2.47	1.51	1.79	2.88	1.93	2.42
Energy cost for hot water (£/person/day)	0.22	0.31	0.19	0.07	0.11	0.11	0.15
Water cost (£/person/day)	0.36	0.43	0.27	0.15	0.36	0.26	0.32
CO <sub>2</sub> emissions for hot water (kg/person/day)	1.13	1.33	0.81	0.37	0.59	0.56	0.72
Embodied CO <sub>2</sub> emissions (kg/person/day)	0.15	0.14	0.09	0.07	0.17	0.08	0.10
Total CO <sub>2</sub> emissions (kg/person/day)	1.28	1.47	0.9	0.44	0.76	0.64	0.82
Total cost (£/person/day)	0.58	0.74	0.46	0.22	0.47	0.37	0.47

Energy consumption for heating hot water varied significantly between households. An occupant in Property 1 generally consumed almost three times as much energy as an occupant in Property 3.

The total household bills associated with water consumption were determined by combining the calculated water and energy costs associated with hot water use. On average, 34% of the total cost was due to energy consumption for heating water. Table 4 also shows that the total costs vary significantly between properties – from 74 p to 20 p/person/day with a mean value of about 50 p/person/day. These large variations are mainly caused by the different water-use practices and behaviours in different households, which highlight the significance of consumer behaviour on water use.

Figure 11 shows a linear correlation between total CO<sub>2</sub> emissions and combined household utility bills associated with water consumption in the properties. This means that, on average, for every pound the household paid for its water use (comprising water bill and energy bill for hot water), almost 2 kg of CO<sub>2</sub> was emitted. This demonstrates that improvements in water-use efficiency (ie reducing household water consumption), are likely to have a proportional benefit in lowering household bills and CO<sub>2</sub> emissions. Although based on a limited sample size, this finding is important in supporting water efficiency improvements, both for individuals and for large-scale housing policy and developments. However, this may not hold true in cases where grey water recycling and/or rain water harvesting are required.

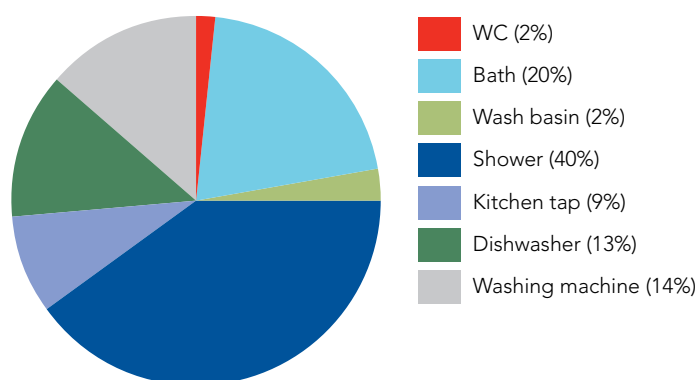
**Figure 11** Correlation between total CO<sub>2</sub> emissions and cost associated with water use.

### 5.3 CO<sub>2</sub> emissions and energy consumption in Code homes

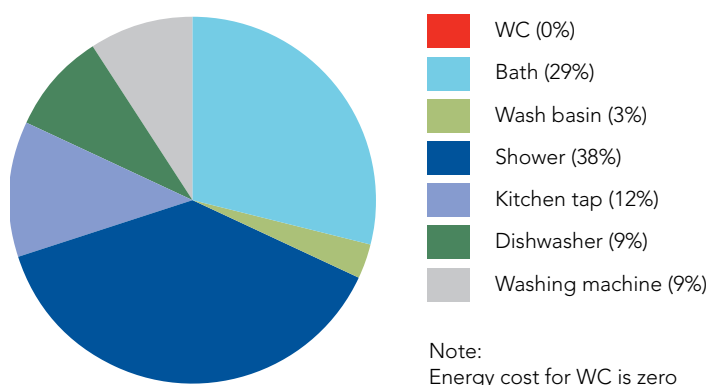
Based on the individual water-using appliances and fittings in the five Code Level 4 test properties, the average percentage of CO<sub>2</sub> emissions and the average energy consumption from hot water use for each appliance category are shown in Figures 12 and 13, respectively.

In general, the shower and bath are the greatest water users, and due to their large use of hot water, they also result in the largest proportion of water-based CO<sub>2</sub> emissions and energy consumption. Although similar appliances and fittings were installed in each Code Level 4 property, the total CO<sub>2</sub> emissions and water-related energy consumption from showering and bathing varied significantly. This was attributed to individual behaviour, which is outside the scope of the influence of the Code.

The information from this study is very useful for relating CO<sub>2</sub> emissions and costs to daily water-use activities. It demonstrates the potential to reduce CO<sub>2</sub> emissions, and energy consumption, as well as utility costs associated with water use through improvements in water-using appliances and fittings, and changes in water-use behaviours.



**Figure 12** Average percentage of CO<sub>2</sub> emissions for individual water-using appliances in Code homes.



**Figure 13** Average percentage of energy consumption for individual water-using appliances in Code homes.



## 6 Conclusion and recommendations

Water consumption, both hot and cold, for individual appliances and fittings was successfully monitored in seven properties (five Code Level 4 homes and two EcoHomes with a "Very Good" rating) for a period of between 6 and 12 months. The measured water consumptions were compared with values predicted using Water Calculators developed for the Code. CO<sub>2</sub> emissions, energy consumption and utility bills associated with water consumption in the monitored homes were assessed.

Key findings, albeit based on a small sample size, are as follows:

- The average water consumption measured in the seven properties (ie 109.57 litres/person/day) was less than the current typical water consumption in existing UK homes (ie 150 litres/person/day) and the target set in the Building Regulations Part G (ie 125 litres/person/day). However, not all Code properties achieved the intended Code Level 4 target of 105 litres/person/day. Two of the five Code dwellings significantly exceeded this maximum target value.
- On average, hot water consumption accounted for 32% of the total water consumption.
- With the exception of Property 6 where the water consumption pattern showed irregularity, the measured water consumption in the Code properties exceeded the values predicted using the May 2009 version of the Water Calculator<sup>[2]</sup> by between 5% and 63%, and with a mean value of 28.6%.
- The water consumption values predicted using the October 2008 Water Calculator<sup>[4]</sup> were higher than those predicted using the May 2009 version for each test property.
- Typical water consumption values per person per day were derived for the following appliances and fittings: WC (20.75 litres), bath (24.26 litres), shower (27.82 litres), wash basin (3.44 litres), kitchen tap (11.69 litres), dishwasher (4.75 litres) and washing machine (17.89 litres). These figures highlight that the greatest potential water savings can be achieved by reducing the amount of water used in WCs, baths and showers.



- Water-use behaviour in all households monitored had a significant influence on the amount of water consumed, and the associated CO<sub>2</sub> emissions, energy consumption and utility bills.
- In at least one case there was evidence of occupants exhibiting water-use behaviour associated with practical limitations of low-flow taps: ie the practice of filling kettles and other kitchen utensils from bath taps.
- CO<sub>2</sub> emissions and household utility bills associated with water use were found to be linearly correlated. Generally, for every pound the household paid for its water use (including water bill and energy bill for hot water), approximately 2 kg of CO<sub>2</sub> was emitted.
- On average, CO<sub>2</sub> emissions were about 0.9 kg/person/day and the total cost associated with water use was approximately 50 p/person/day when using an average metered energy tariff.

This study shows that some improvements in water efficiency have been achieved in the Code and EcoHomes test properties. However, installing water efficient fittings and appliances (eg low flow-rate taps, reduced volume baths and low flush volume WCs) in homes as specified in the Code can only go so far to help minimise water use. Consumer behaviour and attitude have been shown to play a substantial role in reducing water consumption.

This study has proved to be helpful in assessing water consumption in the test homes. This is a pilot study and the sample size is relatively small. The occupants' behaviour might have a large influence on the amount of water consumed in each property. In order to determine whether the water consumption targets set in the Code are realistic, practical and achievable, further monitoring of water use in Code dwellings along with the associated energy use and CO<sub>2</sub> emissions is still required. The methodology and monitoring protocols developed for this project can potentially be used for large-scale monitoring programmes in the future, both for new build and existing housing stock. It would be beneficial to investigate the water consumption while separating the influence of water efficient fittings in dwellings from the occupants' water-use behaviours.

It is hoped that studies of this nature will raise awareness of the importance of efficient water use in homes, and help to contribute towards reducing CO<sub>2</sub> emissions and making our homes more sustainable.

# REFERENCES

- 1 DCLG (2010). Code for Sustainable Homes: Technical Guide. November 2010. Available at [www.planningportal.gov.uk/uploads/code\\_for\\_sustainable\\_homes\\_techguide.pdf](http://www.planningportal.gov.uk/uploads/code_for_sustainable_homes_techguide.pdf).
- 2 DCLG (2009). The Water Efficiency Calculator for new dwellings. May 2009. Available at [www.planningportal.gov.uk/uploads/br/water\\_efficiency\\_calculator.pdf](http://www.planningportal.gov.uk/uploads/br/water_efficiency_calculator.pdf).
- 3 NBS (2010) The Building Regulations 2010 Approved Document G. Sanitation, hot water safety and water efficiency. NBS, London.
- 4 DCLG (2008). Code for Sustainable Homes: Technical Guide. October 2008. Category 2: Water, p.97. Available at [www.planningportal.gov.uk/uploads/code\\_for\\_sustainable\\_homes\\_techguide\\_oct08.pdf](http://www.planningportal.gov.uk/uploads/code_for_sustainable_homes_techguide_oct08.pdf).
- 5 Water Energy Model – WEMlite (2010). Available from the Energy Saving Trust.
- 6 Energy Saving Trust and Environment Agency (2009). Quantifying the energy and carbon effects of water saving – Summary and technical reports. Summary report available at [www.energysavingtrust.org.uk/Global-Data/Publications/Quantifying-the-energy-and-carbon-effects-of-saving-water-summary-report](http://www.energysavingtrust.org.uk/Global-Data/Publications/Quantifying-the-energy-and-carbon-effects-of-saving-water-summary-report). Full technical report available at [www.energysavingtrust.org.uk/Global-Data/Publications/Quantifying-the-energy-and-carbon-effects-of-saving-water-full-technical-report](http://www.energysavingtrust.org.uk/Global-Data/Publications/Quantifying-the-energy-and-carbon-effects-of-saving-water-full-technical-report).

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This guide explains in simple terms what is needed for new homes to comply with the revised Approved Document and allows easy comparison of the alternative approaches. **NF28** March 2011

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# Water consumption in sustainable new homes

A study was commissioned to monitor actual water consumption in Code for Sustainable Homes dwellings. This report covers the monitoring protocols used and the results of the study, including comparison of monitored water use with the water usage targets set out in the Code for Sustainable Homes.

Raising awareness of the importance of efficient water use in homes helps to contribute towards reducing CO<sub>2</sub> emissions and making our homes more sustainable.



The NHBC Foundation has been established by NHBC in partnership with the BRE Trust. It facilitates research and development, technology and knowledge sharing, and the capture of industry best practice. The NHBC Foundation promotes best practice to help builders, developers and the industry as it responds to the country's wider housing needs. The NHBC Foundation carries out practical, high quality research where it is needed most, particularly in areas such as building standards and processes. It also supports house builders in developing strong relationships with their customers.

