Quantifying the energy and carbon effects of water saving **summary report**

Environment Agency

energy saving trust®

Domestic water use in the UK is around 150 litres per person per day. Taking water from the environment, treating it, distributing it to households, using it in the home, collecting it when it has become sewage and then treating it before discharging it back into the environment are all processes requiring energy, and therefore result in CO_2 emissions.

The full technical version of this report is available at **www.energysavingtrust.org.uk/corporate** in the library section

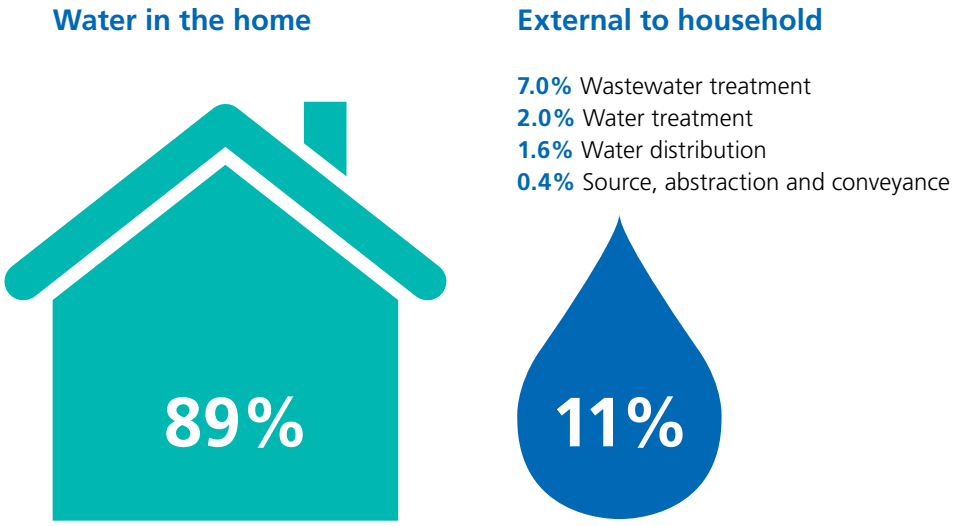


Figure A
The CO_2 emissions associated with water abstraction, treatment, conveyance, use and disposal are mostly due to water use in the home. (Figure from Environment Agency).

Total carbon emissions of 6.2 tCO_2e per Ml water for water in the home. This equates to 2.2kg CO_2e daily per household.

In order to best focus policy on how to minimise carbon dioxide (CO_2) emissions from this train of events, we need to understand which parts of this process are the most energy intensive. A recent study by the Environment Agency[1] quantified the CO_2 emissions associated with these processes and demonstrated that 89 per cent of the CO_2 emissions were due to the use of water in the home.

Existing homes

The CO_2 emissions from water use in households come mostly from heating water. While per capita water use in households has remained fairly constant in the last 10 years, the way in which we use water has been changing. Improvements have been made in the energy and water efficiency of washing machines and dishwashers, and in the water efficiency of toilets, but there is a trend towards increased frequency of showers, and towards showers with higher flow rates. The trend towards smaller households also leads to increasing water use, since water use per person is higher if occupancy is low. If left unchecked, these factors will in turn lead to an increase in CO_2 emissions from domestic hot water use.

New homes

As energy efficiency standards of new houses improve due to the impact of Building Regulations and the Code for Sustainable Homes, requirements for home heating will decrease. Consequently there will come a point when the CO_2 emissions from domestic hot water use will exceed those from home heating unless steps are taken to address it.

CO_2 from water use

The major CO_2 emissions from heating water in homes are related to the volume of hot water used (and can therefore be combated by using less water), but there are also significant CO_2 emissions resulting from the water heating system that are known as 'fixed losses'. These include heat losses from the hot water storage cylinder, and heat losses from hot water pipes. It is important to understand how much these fixed losses contribute to the total CO_2 emissions under a range of conditions, since they cannot be combated by using less water, but can be reduced by energy efficiency measures such as improved pipe or cylinder insulation, or improved plumbing system design. For all of these reasons it is necessary to better understand the effects of water use on domestic CO_2 emissions.

1. Greenhouse gas emissions of water supply and demand management options. Environment Agency Science Report SC070010

Methods used in the project

The current study explores the issues discussed above in the following ways:

Collating evidence on domestic water use by different appliances and identifying data gaps.

Devising models which calculate the energy and water use, and CO_2 emissions from domestic water use, including allowances for heat gains and losses from the water heating system and consideration of how this affects home heating.

Calculating the effect on CO_2 emissions of various interventions including behaviour change, water metering and water efficiency retrofits in existing houses.

Investigating the way in which different patterns of water use in new houses affect the CO_2 emissions, including assessing the impact on water requirements of the Code of Sustainable Homes (CSH).

Investigating thermally efficient buildings such as those at higher CSH levels and Passivhaus standards, to identify the point at which CO_2 emissions from domestic hot water use exceed those due to home heating.

Recommending policy actions based on these findings and further research needed to address gaps in knowledge.

Project outputs

A detailed report on the findings and recommendations can be found in the full technical report 'Quantifying the energy and carbon effects of water saving'.

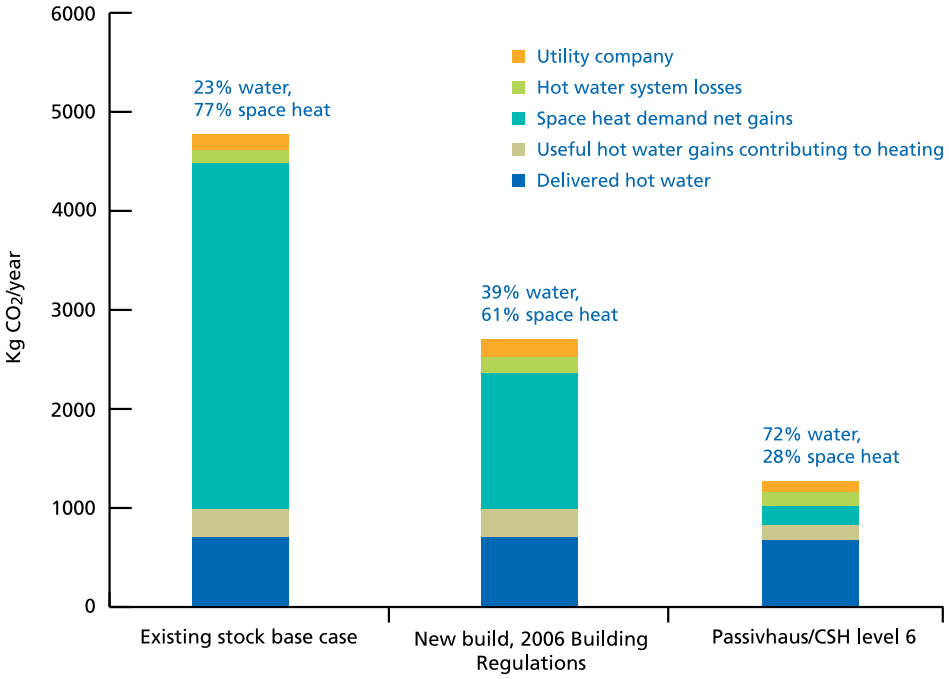
A simple model (WEMlite) that allows the CO_2, water and financial impacts of behavioural interventions or appliance change to be investigated on a household scale.

A Water Energy model (WEM) that incorporates broader considerations of how domestic water use interacts with space heating within the home.

A Marginal Abatement Cost Curve (MACC) spreadsheet (using the Carbon Trust's methodology) that can be used to assess the cost effectiveness of carbon abatement measures.

Figure B

CO_2 emissions from domestic water use in a home with gas heating.



Key Points

- The left hand stacked bar shows existing housing stock.
- The largest part of CO_2 emissions here are from home heating (turquoise part).
- Water heating requirements are small by comparison (dark blue part).
- The central stacked bar shows a new house complying with Building Regulations; as building energy efficiency standards improve, the CO_2 emissions due to home heating decrease.
- The right hand bar shows that at exemplary building standards (Passivhaus is roughly equivalent to CSH level 6 in this context) the CO_2 emissions from water heating are far higher than those from home heating.

Detailed explanation of terms and calculation methods are given in accompanying report.

Headline results for existing households

The heating of water in the home is responsible for around 90% of water-related CO_2 emissions

The energy efficiency of typical UK housing stock is poor, so currently the CO_2 emissions from home heating far exceed the CO_2 emissions from domestic hot water use (77% home heating, 23% water heating) as shown in Figure B.

A range of heating fuels are used in UK households, including electricity, gas, oil and wood. Because these fuels have different efficiencies, they result in different CO_2 emissions for each unit of usable energy supplied. This means that houses with the same water use but different heating fuels will have very different CO_2 emissions from their water use.

In most households the way in which water is heated will differ between appliances (for example within one house, a dishwasher or washing machine will heat water using electricity, whilst water for the bath, shower and taps might be heated using a gas boiler). Because gas is more carbon efficient than electricity, the CO_2 emissions from washing machines and dishwashers are disproportionately high, despite the fact that they have low water use.

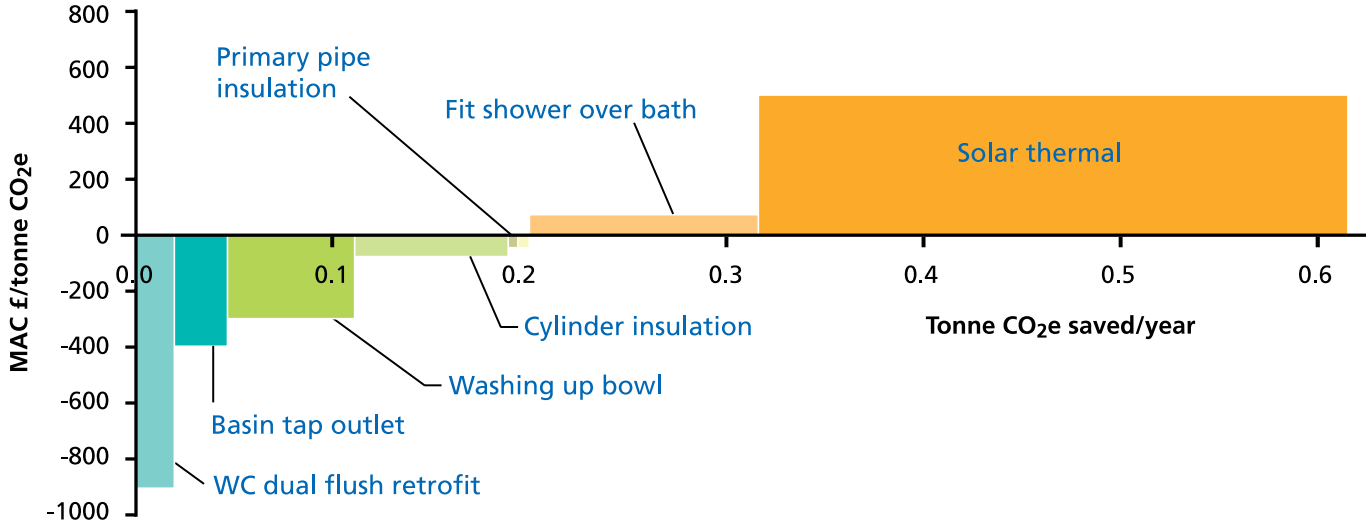
Water metering results in lower CO_2 emissions as well as lower water use.

The way in which different households use water varies enormously. The potential for CO_2 savings from behavioural change is significant (e.g. 200kg CO_2 per person per year from a single measure such as reduced shower duration) but requires us to understand much more about how people interact with water using appliances and why people behave in the ways that they do.

Water efficient retrofit devices that save hot water (e.g. tap aerators, low flow shower heads) can save more CO_2 than cold water retrofits (such as dual flush WC retrofits), but all result in water and financial savings in addition to reduced CO_2 emissions. This is illustrated in Figure C.

Figure C - Existing stock retrofit

Marginal abatement cost (MAC) for common retrofit measures relating to water use.



Measures below the x axis save money as well as CO_2. The width of the bar along the x axis represents the total CO_2 saved by the measure, so allows us to consider the relative importance of measures (some may save very small amounts of CO_2 but be financially attractive to householders while other measures may not save money but have high carbon saving potential)

Headline results for new build dwellings

Hot water use in new houses is higher in volume than in the existing housing stock, largely because of increased ownership of showers, higher flow rates and more frequent use. This means that, despite increases in boiler efficiency and decreases in water use for flushing toilets in new homes, their CO_2 emissions from water use are not significantly lower than in existing houses.

The current framework for reducing water use in new homes (principally the Code for Sustainable Homes) considers hot and cold water uses to be equivalent, and incorporates loopholes that can lead to higher CO_2 emissions from domestic water use. The most common example is the installation of water recycling systems to provide water for toilet flushing in order that a higher flow rate shower may be fitted. This leads to conflicting requirements between different sets of regulations and frameworks.

There are a number of ways in which plumbing system design in new homes can be significantly improved in order to decrease CO_2 emissions without requiring any change in the behaviour of the householder.

If attempts to increase the energy efficiency of new buildings are successful but aren't accompanied by equivalent increases in water efficiency, the CO_2 emissions from hot water use will exceed those from home heating (Figure B, right-hand bar showing 72% water heating, 28% home heating). This level of building efficiency has already been reached by houses complying with exemplary building standards (such as the Passivhaus standard, and Code for Sustainable Homes level 6).

The proportion of CO_2 emissions attributable to the utility company compared to domestic emissions is very close to the 11% calculated in the Environment Agency study (compare Figure A with Figure E).

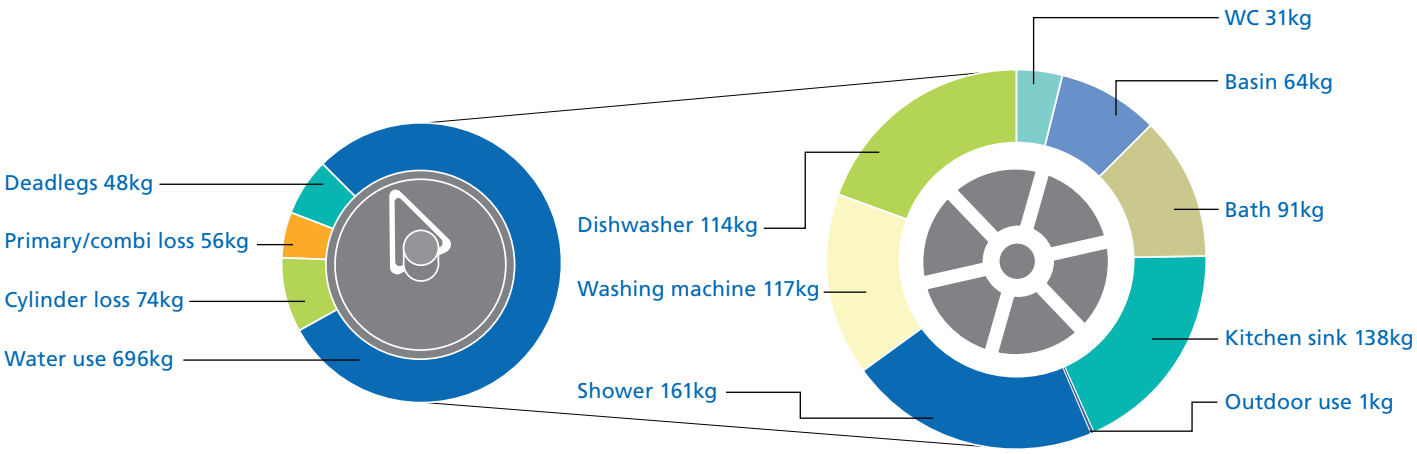
The CO_2 emissions from water use in new houses[2] are not significantly lower than in existing houses, despite increases in boiler efficiency and decreases in water use for flushing toilets.

2. "New house" means a house whose heating demands are based on Building Regulations 2006

Using less hot water will save money and CO_2 as well as saving water.

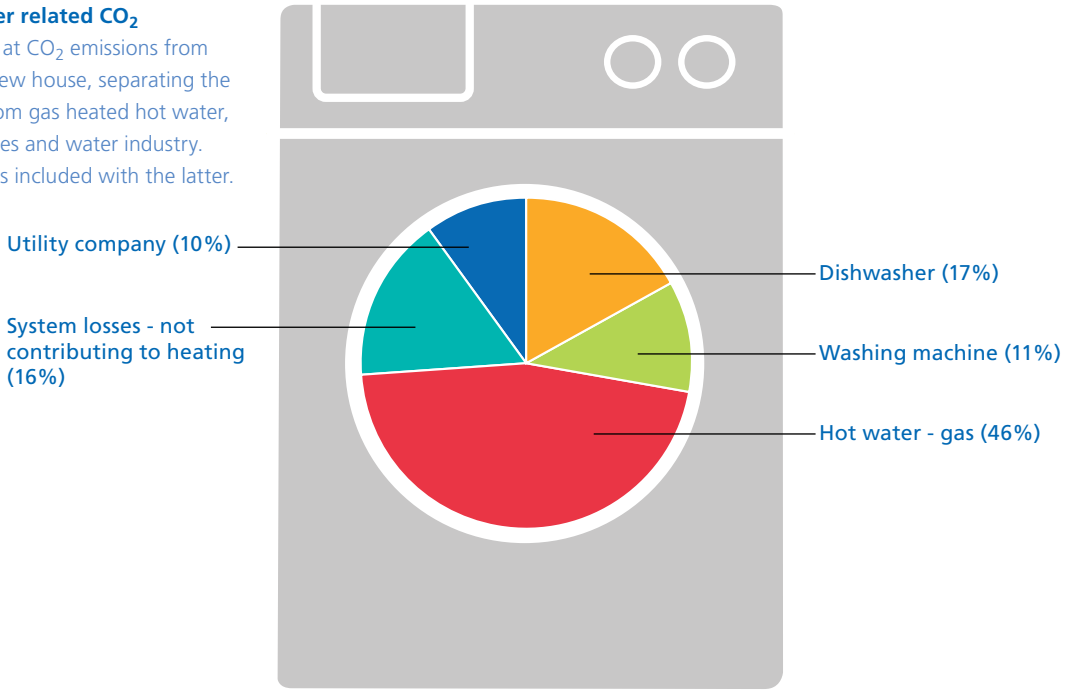
Washing up in a bowl rather than under a running tap can have more impact than installing water saving technology.

Figure D
Water related CO_2 emissions in new homes.



Above pie chart indicates the annual CO_2 emissions due to 'fixed' losses (which are not related to the volume of water used, but are a function of the type of water heating and plumbing configuration) and those relating to water use (696kg). The right hand pie chart breaks this down into individual water using appliances. Based on an average occupancy of 2.4.

Figure E - Water related CO_2
A different look at CO_2 emissions from water use in a new house, separating the contributions from gas heated hot water, electric appliances and water industry. Cold water use is included with the latter.



Whilst the water used by dishwashers and washing machines is low, the fact that this water is heated electrically rather than by gas means that CO_2 emissions from these appliances are disproportionately high. A condensing gas boiler is assumed for all other hot water.

Headline results for consumer communications

Using hot water has associated energy costs and CO_2 emissions, so using less hot water will save money and CO_2 as well as saving water.

Simple behavioural changes have the most potential: spending less time in the shower and washing up in a bowl rather than under a running tap can have more impact than installing water saving technology. Without addressing behaviour, technology alone may not deliver the expected savings.

Dishwashers use less water than washing up by hand, but result in higher CO_2 emissions due to energy use.

Electric showers generally use less water than baths or other types of showers, but, because water is heated by electricity, may have higher carbon emissions.

Further research needed

There are many gaps in our understanding of how much water is used by different appliances. Existing data on this should be re-analysed before undertaking new studies. Detailed recommendations are provided in the technical report that accompanies this summary.

The largest CO_2 emissions from domestic water use in the future are likely to come from showering. Further research is needed to define shower performance and to develop standards that guarantee a satisfactory performance of water efficient showers. Consideration should also be given to labelling and/or regulation of shower flow rates and energy use.

Water storage temperatures are often considerably below that which is recommended to prevent bacterial (Legionella) growth, although there are no reported increases in health risks. Increasing hot water storage temperatures to the recommended amount would increase CO_2 emissions from hot water by around 5-10%. Whilst avoiding risks to human health should clearly be a priority when setting regulations, it should be noted that being overcautious would have undesirable effects in terms of CO_2. So further study into the risks should be carried out.

Research into boiler design is needed as there appears to be considerable scope for measures that lead to both CO_2 savings and better performance as perceived by the householder.

Key recommendations

Energy efficiency retrofit programmes for existing housing stock should incorporate water efficiency measures, since these have the potential to save water, CO_2 and money. For example, a 6 litre per minute shower head to replace a 16 litre per minute existing shower, together with a 4.5 litre toilet to replace an old 9 litre one, could result in annual savings of 67m^3 water, 371kg CO_2 and £225 for a household with a standard occupancy of 2.4[3].

There is a risk that the current regulatory and voluntary frameworks for water use and plumbing systems in new buildings may not lead to lower CO_2 emissions from water use, despite the advances in energy efficiency of boilers. The regulatory framework for hot water system design should be overhauled to incorporate a similar level of detail to that currently afforded to building design and ventilation.

There is considerable potential for synergy in communicating water efficiency and energy efficiency messages. However, there are also potential conflict points between water and energy efficiency messages and this needs to be understood by policy makers and regulators. The main conflict points relate to the use of washing machines, dishwashers, electric showers and the offsetting of higher flow showers with water recycling under the Code for Sustainable Homes.

The lack of knowledge regarding water use behaviour and what influences it is a major barrier to effective marketing of water efficient behaviour. The monetary savings from even the most cost effective measures are quite modest so consideration needs to be given to how messages are framed for maximum impact. For some groups, explicit mention of financial savings or references to environmental benefit may not be effective ways of changing behaviour.

3. See table 4 of main report. WC saves 24m^3, £58 and 26kg CO_2/year. Shower saves 43m^3, £167 and 345kg CO_2 per year.

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