

Reducing water use – Hot water supply, distribution and use



All businesses use hot water in some way, whether for domestic use, in the manufacturing process or for ancillary activities. As there are considerable health and financial implications associated with the supply and use of hot water, it needs to be managed carefully. Good management should consider the following:

- Health and safety issues, such as legionella control. Legionella is generally controlled by storing hot water at temperatures above 60°C and distributing it at 50°C. Cold water should be kept below 20°C (source: Health and Safety Executive (HSE)).
- Energy issues. Boiler efficiency, temperature control, pipe insulation and using local hot-water generators can all influence the energy efficiency of a site.
- Water efficiency issues. Improving water efficiency not only reduces water supply and disposal costs but, for hot water, will also reduce the 'hidden' energy cost for heating.

HIDDEN COSTS

The cost of hot water includes the cost of the water and the cost of the energy to heat it. This needs to be taken into consideration when evaluating the cost of your water use.

Typical costs for hot water are given below:

UK mains supply ¹	£0.59 – £1.75/m ³
Hot water (60°C) – gas heated ²	£2.82 – £3.98/m ³
Hot water (60°C) – electrically heated ²	£6.48 – £7.64/m ³

Remember, additional costs will also be incurred for disposal of any wastewater to sewer, typically £0.54 – £2.67/m³.

¹ UK mains supply based on standard 2010/11 tariffs

² Energy costs at 3.6p/kWh for gas and 9.5p/kWh electricity, using a boiler with 90% efficiency

Heating costs are a large proportion of the overall cost of your hot water.

To calculate the cost of heating your water, you will need to know:

1. The amount of energy required to heat your water; and
2. The unit cost of your fuel.

The amount of energy needed to heat your water can be calculated as follows:

$$\text{Energy (kWh)} = \frac{V \times (T_2 - T_1)}{860}$$

Where V = volume of water heated (litres)
 T_1 = temperature of water to be heated (if unknown, assume 12°C)
 T_2 = required water temperature in the tank or boiler (°C)
 860 = conversion factor to convert kcal to kWh (860 kcal/kWh)

The cost of your heating fuel is often invoiced as pence per kWh (p/kWh). However, if oil use is given in p/litre or gas in p/m³, then a conversion factor, which may be given on the invoice, has to be used to calculate p/kWh.

To calculate the cost of heating your water, multiply the amount of energy required for water heating (from the formula above) by the cost per unit. To allow for boiler efficiency, a factor³ has to be applied to this figure to obtain the true cost of heating your water.

$$\text{Cost of heating water (pence)} = \frac{\text{Energy required (kWh)} \times \text{unit cost of fuel (p/kWh)}}{\text{Boiler efficiency}^3}$$

THE ROLE OF WATER IN CARBON MANAGEMENT

Carbon management is becoming increasingly important and you may be required to manage your carbon emissions to comply with Government legislation. When fossil fuels are burned, carbon dioxide (CO₂) and several other greenhouse gases (GHGs) are emitted. GHGs trap heat in the atmosphere, which leads to global warming.

Some GHGs have a greater warming effect than others. Therefore, CO₂ equivalent (CO₂e) is used to compare the global warming potential of GHGs on a like-for-like basis, relative to one unit of CO₂.

All products and services have GHG emissions associated with them. The embedded carbon in a product or service is known as its carbon footprint and includes the amount of GHGs (converted to CO₂e) that are emitted when fossil fuels are burned to produce the product or create and use the service. Hot water that is heated by burning fossil fuels almost always has higher embedded carbon than when it is supplied from the mains or other sources.

The embedded carbon for mains water is relatively low and is due to the energy used at the treatment works and for pumping the water through the distribution system. For 1,000,000 litres (1,000 m³) of mains water, the emissions to:

- supply the water are 0.34 tonnes CO₂e (0.34 kg CO₂e/m³);
- treat sewage are 0.7 tonnes CO₂e (0.7 kg CO₂e/m³).

Source: Water UK Sustainability Indicators 2009-10 report

However, the carbon footprint of the hot water must include the emissions associated with the energy used for heating. Table 1 shows the conversion factors that are used to calculate the CO₂e emissions associated with some common energy sources. A more comprehensive list of conversion factors is available from the Department for Environment, Food and Rural Affairs (Defra) website.

Table 1: Energy to CO₂e conversions

Energy source	Units	kg CO ₂ e per unit
Grid electricity ⁴	kWh	0.544
Natural gas	kWh	0.184
Gas oil	kWh	0.277
Gas oil	litres	3.029

Source: The Carbon Trust, 2009

However, boiler efficiency³ also has to be taken into consideration when calculating the embedded carbon in hot water.

An example showing how to calculate the embedded CO₂e in 1 m³ (1,000 litres) of water at 60°C is shown on the next page.

³ For standard boilers (efficiency 80%) use a factor of 0.8, for condensing boilers (efficiency 90%) use 0.9 and for electrical heating (e.g. immersion heater), which is nearly 100% efficient, use 1.

⁴ Not supplied under a green tariff. For a more comprehensive set of factors and full guidance, visit the Defra website (www.defra.gov.uk).

$$\begin{aligned}
 \text{Energy needed to heat the water (kWh)} &= \frac{V \times (T_2 - T_1)}{860} \\
 &= \frac{1,000 \times (60 - 12)}{860} \\
 &= 55.81 \text{ kWh}
 \end{aligned}$$

For water heated using electricity (assuming a boiler efficiency of 100%):

$$\begin{aligned}
 \text{Embedded CO}_2\text{e} &= \frac{55.81 \times 0.544}{1} \\
 &= 30.36 \text{ kg}
 \end{aligned}$$

For water heated using natural gas (assuming a boiler efficiency of 90%):

$$\begin{aligned}
 \text{Embedded CO}_2\text{e} &= \frac{55.81 \times 0.184}{0.9} \\
 &= 11.41 \text{ kg}
 \end{aligned}$$

Actions

1. Calculate how much 1 m³ of hot water costs.
2. Calculate the CO₂e of 1 m³ of your hot water.

Supply

Generally, hot water is either produced and stored for later use or produced as it is needed (on demand) without storage. It is important to know how your hot water is produced and stored to manage its use effectively.

Hot water storage systems include:

- calorifiers or hot water cylinders, where water is heated indirectly, often using high or medium pressure hot water which is generated centrally; and
- a combined heating and storage vessel where the water is heated directly (by gas, oil or electricity). An example of this type of vessel is shown in Figure 1.

Figure 1: Typical self-contained gas-fired storage water heaters (courtesy of Lyreco)



Non-storage or 'on-demand' systems include:

- combination boilers that supply hot water instantaneously;
- instant water heaters usually at, or near, the point of use (gas or electric); and
- heat exchangers, which are usually used where there is a large demand for hot water.

Heat exchangers can be either plate type (see Figure 2) or shell-and-tube type.

Figure 2: External plate heat exchangers (courtesy of Radisson)



Figure 3: Relief valve and tundish on hot water heater (courtesy of Lyreco)



Whichever type of hot water system you use, the following tips may help save water and energy:

- Ensure the temperature of the hot water you are generating is suitable for each point of use. For health and safety reasons, hot water should be stored above 60°C. However, if there is no requirement for hot water above this temperature on site, then make sure the thermostat is not set too high. This may also save water because cold water is often used to cool water that is being distributed at too high a temperature. Reducing the water temperature will also save energy.
- In hard water areas, limescale can build up on the water side of a boiler's heat exchanger. This creates an insulating layer that inhibits heat transfer to the water. A 1 mm layer of limescale will cause a 7% increase in energy input to the boiler to meet the same heat demand⁵. Limescale can be reduced by treating water prior to use (e.g. softening).
- When water is heated from 4°C to 100°C, it will expand in volume by about 4%. This means that an expansion facility in the storage system of around 4% of the volume of the hot water is needed⁶. This is particularly relevant on unvented hot water storage systems to avoid excessive pressures or overflows.
- Many hot water heaters and calorifiers are equipped with a pressure and/or temperature relief valve. The temperature is usually set between 90 and 95°C. The water from these valves should be discharged via a tundish so that if the valve leaks or is left open, this can be easily detected (see Figure 3).
- It may be more efficient to install local point-of-use heaters for some hot water applications depending on demand, site configuration and other energy demands. They may be beneficial for washroom sinks that are located some distance from the hot water supply. This is because the amount of water that is run to drain while waiting for hot water from the tap will be reduced and so will energy consumption. Installing local point-of-use heaters may also mean that the main boiler can be turned off, particularly during the summer months.

Actions

1. Identify how hot water is produced and stored on your site – remember there may be more than one source.
2. Identify all pressure/temperature relief valves and ensure discharge pipework has a tundish (or is easily visible) and that it is checked frequently.
3. Identify if any points of hot water use could be better supplied by point-of-use heaters.

⁵ Carbon Trust leaflet 'Low temperature hot water boilers technology overview – CTV008

⁶ Source: Water Regulations Guide. For more information, visit www.wras.co.uk/regulations-guide.htm

Distribution

Hot water generated and stored centrally will have to be distributed around a site. There are many opportunities for improving water efficiency in a typical hot water installation. These are shown in Figure 4.

The water distribution system itself can affect water efficiency. Ideally, hot water should be pumped around a well-insulated main distribution ring with very short lengths of take-off pipework to the point of use. Further considerations to improve efficiency are given below.

DIRECT (DEAD LEG) SUPPLY SYSTEMS

If points of hot water use are some distance from the storage tank, then long lengths of pipe, known as dead legs, will be required to serve them. It is likely that the water in the dead legs will cool when not in use. When hot water is required, this cooled water will have to be run to waste at the point of use until water of the desired temperature is obtained.

It is recommended that these dead legs be kept as short as possible and not more than those shown in Table 2.

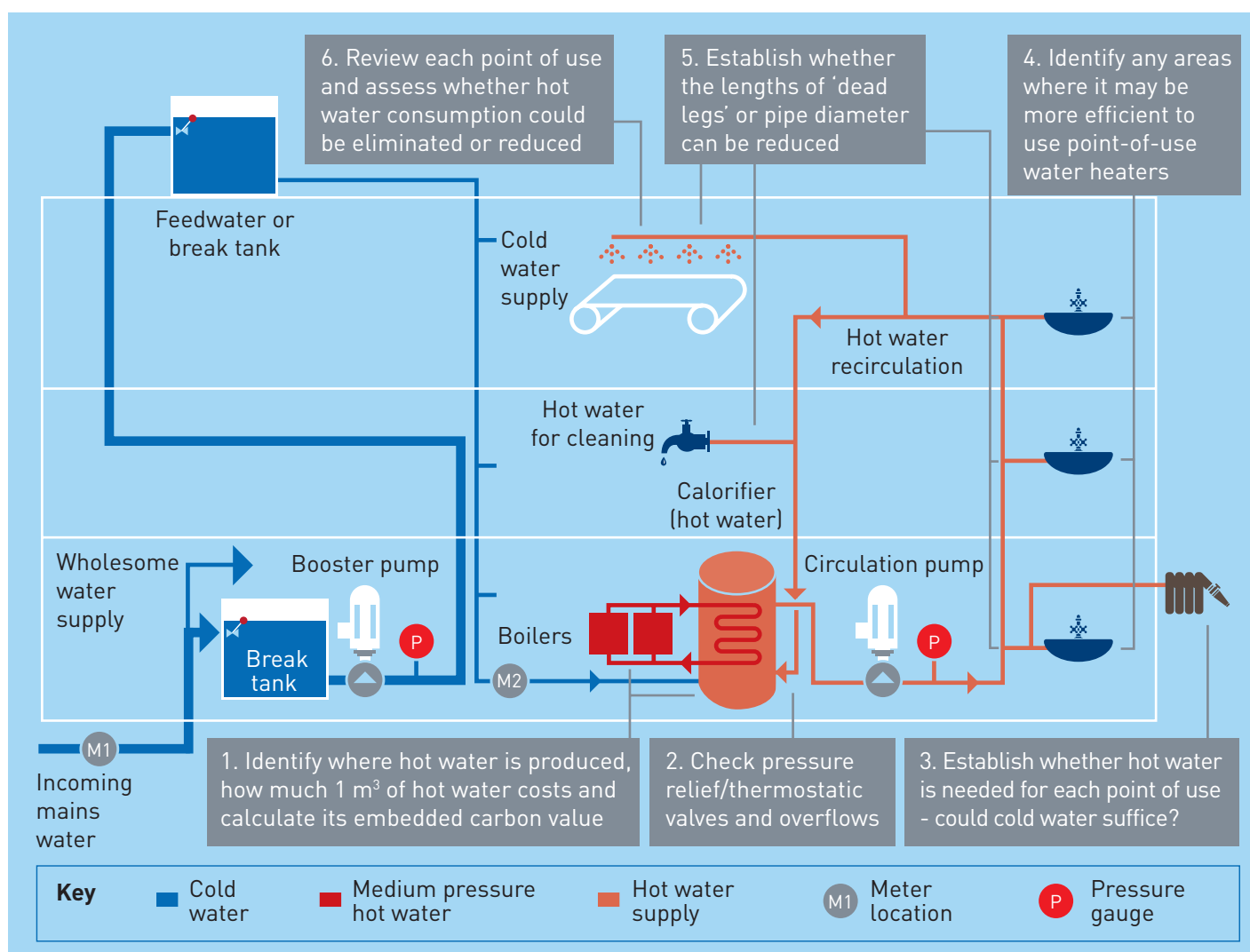
Table 2: Maximum recommended lengths of uninsulated hot water pipes⁷

Outside diameter of pipe (mm)	Maximum length (metres)
12	20
Over 12 and up to and including 22	12
Over 22 and up to and including 28	8
> 28	3

Source: Defra, Guidance on Water Supply (Water Fittings) Regulations 1999

If a 15 mm pipe is supplying a hot water tap and there is a 10 m dead leg, then 1.5 litres of water will have to be run to drain until water at the desired temperature is obtained. If the tap is used 20 times a day, 5 days a week and for 50 weeks of the year, this will waste 7,500 litres (7.5 m³) of water that has been heated and allowed to cool.

Figure 4: Potential areas for water efficiency improvements in a typical hot water installation



⁷ Pipes should be thermally insulated in accordance with BS 5422

This will cost between £21.15 and £29.85 if the water is heated by gas and between £48.60 and £57.30 if the water is heated by electricity.

Water in the dead leg will cool down, but heat loss can be minimised by ensuring the pipe is well insulated.

PIPE SIZE

Although the amount of water lost through dead legs can be minimised by reducing pipe lengths, there will always be a small amount remaining in the pipe. This can be minimised by reducing the pipe's diameter to the minimum acceptable (taking into account maximum velocities and pressure losses). The volume of water per metre of pipe of different diameters is shown in Table 3.

Table 3: Volume of water per metre of pipe of different diameters

Common outside diameters (mm)	15	22	28	35	42	54
Wall thickness (mm)	0.7	0.9	0.9	1.2	1.2	1.2
Volume per metre pipe length (litres)	0.15	0.32	0.54	0.83	1.23	2.09

Adapted from AECB Water Standards, Vol 2: The Water Standards Technical Background Report, Jan 2009

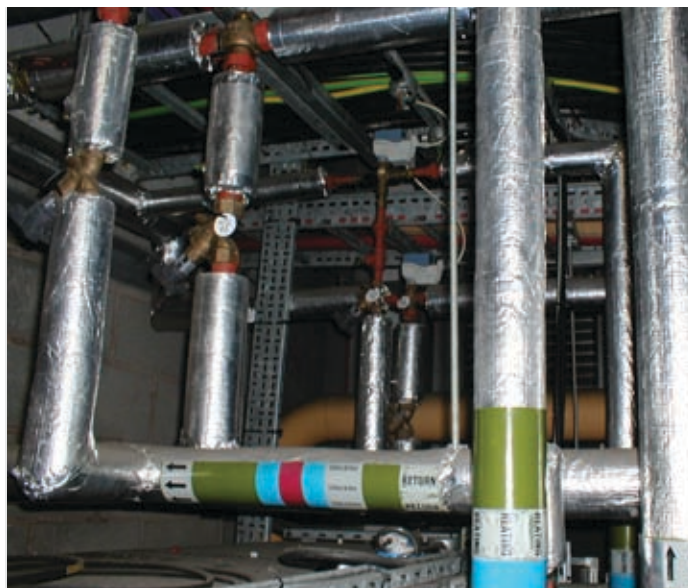
For example, if a 10 m length of 28 mm pipe was used to supply a tap, this would need 5.4 litres of water to run to waste before hot water is available, but only 1.5 litres would be wasted if a 15 mm pipe was used. In this example, using a smaller diameter pipe would result in a saving of 3.9 litres of water per use. If the tap was used 20 times a day, this would save 78 litres/day.

Assuming the tap is used for 5 days a week and for 50 weeks of the year, 19.5 m³ of water would be wasted. The cost saving would be between £54.99 and £77.61 if the water is heated by gas, and between £126.36 and £148.98 if the water is heated by electricity.

INSULATION

The primary objective of installing insulation is to save energy by minimising heat loss from hot water pipes or heat gain in cold pipes. Good insulation means that the water at the point of use is likely to be nearer to the correct temperature than without insulation and the amount of water that is run to waste is reduced or prevented. An example of well-insulated pipework is shown in Figure 5.

Figure 5: Well-labelled and well-insulated hot water distribution system (courtesy of Lyreco)



Actions

1. Review your hot water distribution system and identify any dead legs.
2. Establish whether dead-leg volumes can be minimised by reducing pipe length and/or diameter.
3. If refurbishing or installing a new hot water system, give careful consideration to a recirculating system.

Use

There are many areas around a site where hot water is used. However, sometimes, it is used where it is not really needed (e.g. for vehicle washing). Some simple tips on how the use of hot water may be reduced are given below.

GENERAL

- Make sure hot and cold water pipes/taps/valves are clearly marked 'hot' and 'cold'. This prevents the need to run water to waste to find out which is hot and which is cold.

TAPS AND HOSES

- Reduce the pressure at which water is supplied to the required level. The volume of water flowing through a tap, hose or spray head is directly proportional to the pressure. Therefore, reducing the pressure will reduce water flow.
- Reduce the diameter of hoses and pipes - the smaller the pipe, the lower the volume of water in the pipe.
- Fit trigger nozzles on hoses so that water flow stops when the trigger is released.
- Fit aerators on taps to reduce flow.

BATHS AND SHOWERS

In some sectors, such as hospitality and healthcare, the major use of water may be for domestic purposes. To reduce water use, consider the following:

- Select baths with the lowest volume. Remember, the shape of a bath greatly influences the volume of water it can hold.
- Use low-flow shower heads rather than high-flow, high-pressure power showers. This can reduce the flow from about 12 litres/minute (for a 'typical' power shower) to around 6 litres/minute or less.

FILLING TANKS

- Do not overfill tanks and only use water when necessary.
- If overflows are present on tanks, make sure these are routinely checked. A small overflow, such as a 3 mm stream of water, will waste 300 m³ of water per year.

RINSING

- If continual flushing is required, use mist or spray rinsing rather than continuously running water from a hose or tap.
- If possible, use batch tank rinsing instead of using running water. This is particularly beneficial in domestic situations, such as washing dishes (see Figure 6).

Figure 6: Using a full sink of water rather than rinsing under a running tap (courtesy of Lyreco).



Actions

1. Review each point of hot water use and assess whether hot water is actually required.
2. Where hot water is required, assess whether any actions can be taken to eliminate or reduce its use.