Reducing water use in **boiler houses**

Significant amounts of water are used in boiler houses to provide hot water and steam and steam-raising boilers require large quantities of make-up water to compensate for uncollected condensate or blowdown water.

Adding to the cost of this water is the cost of energy used in boiler houses to heat water, and in ancillary water-treatment processes to improve the quality of the boiler feedwater.

Any loss of water (or steam) will incur costs. These include the 'direct' costs (i.e. paying for the water itself) and the 'hidden' costs (i.e. for treatment and the energy used for heating). Quite often, it is the hidden costs that are the most significant.

HIDDEN COSTS

Reducing water use in a boiler house can save more than the direct cost of the water alone. Understanding the full cost of water is important, particularly for steam-raising boilers. Water is frequently pre-treated prior to use, may have conditioning chemicals added and is then heated in the boiler. Each of these steps contributes significantly to the overall cost of the water. Remember that additional costs will also be incurred for disposal of any wastewater to sewer, typically £0.54 – £2.67/m³.

TYPICAL COSTS FOR WATER

UK mains supply[1]	£0.59 - £1.75/m³
Softened water	£1.00 - £2.16/m³
Demineralised/deionised water	£2.53 - £3.70/m³
Reverse osmosis (RO) treatment[2]	£1.51 - £3.83/m³
Hot water (60°C) – gas heated[3]	£2.82 - £3.98/m³
Hot water (60°C) – electrically heated[3]	£6.48 - £7.64/m³
Boiler blowdown (100°C) – gas heated[3,4]	£5.09 - £6.25/m³
Condensate – gas heated[3,4]	£3.70 - £4.86/m³
Steam – gas heated[3]	£29.71 - £30.87/tonne

[1] UK mains supply based on standard 2010/11 tariffs

[2] Note this does not include capital and maintenance costs (e.g. membrane replacement) which can be significant for RO plant

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

[4] Excludes boiler-water conditioning chemical costs (e.g. oxygen scavenger/corrosion inhibitor/anti-foam)

Actions

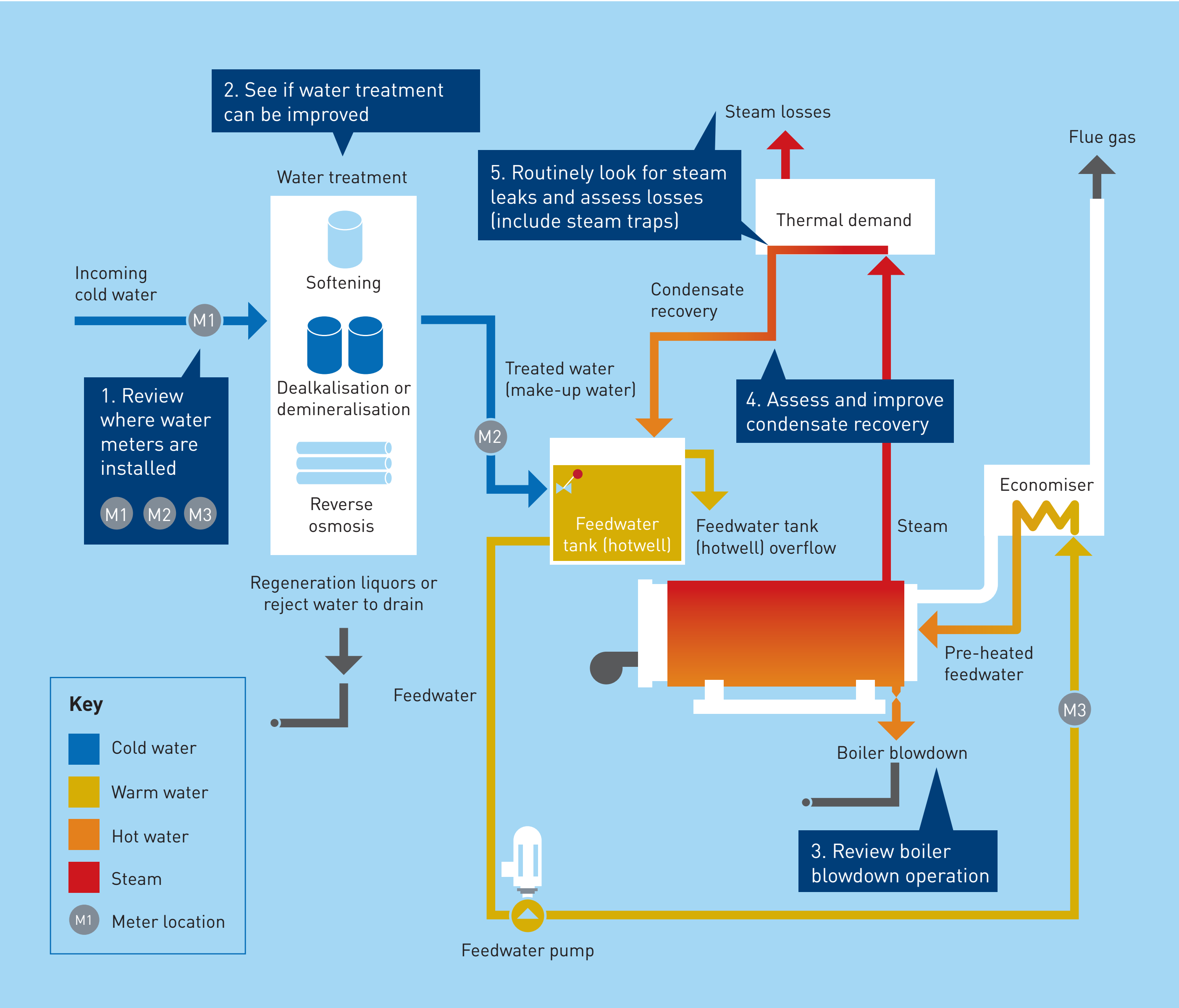
1. Determine the true cost of the water used in your boiler house by taking the cost of treatment and heating into consideration. Remember to account for steam and condensate.
2. Estimate any water and/or steam losses. Use the cost data on the front page to calculate the cost of these losses.

Understanding where water is used

Many businesses do not know how much water is used by their boiler(s), how much water is 'lost' at the water treatment plant or, in the case of steam boilers, how much condensate is collected and returned.

Monitoring the quantity of water used in each step of the process enables the water efficiency of the boiler house to be assessed. In multi-boiler installations, it can also allow the efficiencies of each boiler to be monitored. Suggested meter locations, together with potential water efficiency improvements in a typical steam boiler system, are shown in Figure 1. In this example, the installed meters would allow the following calculations:

Figure 1: Potential areas for water efficiency improvements in a typical steam-boiler installation

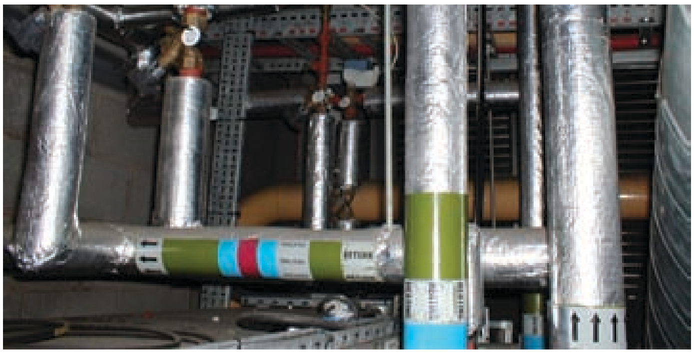


M1 – M2 = water used (loss[6]) at water treatment plant

M3 – M2 = condensate recovery return volume[7]

Installing meters is an easy and effective way to measure water usage at each step in the process. They are inexpensive to install - for example, a simple 30 mm water meter with a pulsed output costs around £75 to £95, excluding fitting. There are often many pipes in a boiler house and, unless they are easy to follow, it can be difficult to understand what flows where, which makes water management more difficult. Labelling pipework, ideally showing contents and direction of flow, can make this much easier and may be particularly useful in an emergency (see Figure 2).

Figure 2: Well-labelled pipework (courtesy of Lyreco)



Actions

1. Review where water meters are installed in your boiler house. If necessary, install more meters to monitor water usage effectively.
2. Label pipework to indicate its contents and direction of flow.

Treatment of boiler feedwater

In hard-water areas, many hot-water boilers have softeners installed on the water supply to help prevent scale building up.

The performance of most steam-raising boilers is improved if the feedwater has a low concentration of total dissolved solids (TDS). Lower TDS means the boiler will be less prone to foaming and less blowdown will be required. Most steam-raising boiler installations need some form of feedwater pre-treatment and common processes include:

- softening, to change the chemical composition of some of the dissolved salts and reduce scaling;
- partial removal of TDS and alkalinity (known as dealkalisation); and
- demineralisation or reverse osmosis (RO) to remove the majority of TDS.

These processes will use ion-exchange beds which will require periodic regeneration. Regeneration processes use water and chemical reagents, and generate effluent, all of which incur costs. Regenerating exchange beds daily, or on a similar time-dependent basis, irrespective of the amount of water that has been treated, can lead to more frequent regeneration than is necessary. Using automated systems based on the volume of water treated or a measured value (such as conductivity breakthrough) can be much more efficient and minimises the number of regenerations required.

If a membrane treatment process, such as RO, is used, a permeate stream and a concentrate (or 'reject' water) stream is produced. The permeate is essentially pure water and will be used to supply the boiler feed. The reject water can typically account for 30% of the incoming flow and, even though it will have high salt concentrations, it is still likely to be suitable for recovery and re-use elsewhere on site. An RO membrane treatment plant is shown in Figure 3.

Figure 3: RO membrane treatment plant (courtesy of G's Fresh Beetroot)

Actions

1. If softeners, dealkalisation or demineralisation plants are used on site, check whether the frequency of the regeneration cycles can be reduced.
2. If the site uses a reverse osmosis membrane treatment plant, assess the potential for re-use of the 'reject water' stream elsewhere on site.
3. Check whether you can improve treatment to reduce the TDS in the feedwater for a steam-raising boiler. This will reduce blowdown requirements (refer to page 4).

[6] Such as discharges to drain

[7] Excluding allowance for boiler blowdown

Boiler blowdown (steam boilers)

Periodic discharges of water from a steam boiler will be required to prevent the TDS from building up in the boiler water, even if pre-treated water is used.

Typically, values of TDS in boiler water should be no higher than about 2,500 – 3,500 mg/litre, although this will depend on specific operating conditions, such as pressure. Boiler blowdown can be controlled manually, by timer or automatically. Automatic methods are usually based on conductivity measurement, which is proportional to TDS concentration.

Using an automatically controlled system is recommended because a small volume of water is blowndown more frequently and, overall, this minimises the total amount of water discharged.

The amount of boiler blowdown required can be estimated using the TDS concentration of the feedwater and the maximum TDS concentration required in the boiler water. For example, in a boiler where the maximum TDS concentration required is 3,000 mg/litre and the treated (softened) feedwater has a TDS concentration of 250 mg/litre (assuming that the additional TDS burden from the returned condensate is small), the amount of boiler blowdown required, as a percentage of total boiler volume, can be estimated using the formula below.

Amount of blowdown required (%)

$$= \frac{\text{TDS of feedwater (mg/litre)}}{\text{Maximum increase in concentration of TDS (mg/litre)}} \times 100$$

$$= \frac{250}{3{,}000 - 250} \times 100$$

= **9.1%** of boiler feedwater

If water treatment can be improved to reduce the TDS of the feedwater, the amount of blowdown required to maintain the maximum TDS in the boiler water will be reduced. This can save significant quantities of water and energy.

Boiler blowdown water is very hot and is often under pressure. When boiler blowdown is discharged, 'flash steam' is usually emitted, which is generated as the boiler blowdown is depressurised. On larger installations, it may be worth recovering the water and heat from the flash steam for use in the boiler. This can be done by condensing the steam (using cold feedwater) and returning the flash steam condensate and warmed feedwater back to the feedwater tank (hotwell).

Any remaining blowdown will have to be disposed of but, under trade effluent consents, there are usually conditions for the temperature of the discharge. Typically, the upper limit is about 43°C. Instead of discharging hot blowdown water to drain, it is possible to use heat exchangers to recover the heat to pre-heat boiler feedwater.

Actions

1. Check if the boiler blowdown water volume, or the frequency of blowdown, can be reduced by improving water treatment.
2. Investigate whether boiler blowdown can be automated.
3. Check whether the flash steam from the boiler blowdown can be recovered.
4. Check how blowdown is being cooled to meet discharge requirements.

Condensate recovery and feedwater tanks (hotwells)

Wherever steam is used, condensate will form as the steam cools, either in the distribution system or at the point of use, resulting in the formation of hot condensate.

This condensate has a high value in terms of water and energy. Preventing condensation of steam by ensuring good insulation (lagging) of steam lines and vessels will reduce condensate production.

Well-maintained steam traps can remove condensate from the system without significant loss of steam. Provided the collected condensate is kept clean, it can be returned to the feedwater tank (hotwell) to help reduce water and energy use. Discharging condensate to drain is expensive and will also cause an increase in effluent temperature.

Because the feedwater tank (hotwell) needs to store the collected condensate, it is important to ensure it has sufficient working volume during its period of maximum generation (check the tank volume between the level at which the cold feedwater starts and the bottom of the overflow). Any overflow to drain from the feedwater tank is a waste of water and energy, and should be investigated.

Condensate recovery can reduce the:

- cost of water pre-treatment;
- use of oxygen scavenging chemicals (dissolved gas concentration decreases with an increase in water temperature); and
- frequency of blowdown (condensate typically has a low concentration of TDS).

Actions

1. Minimise the amount of condensate formed by lagging the distribution system.
2. Determine your condensate return rate and check if more condensate can be collected and re-used.

Unnecessary uses, losses and leaks

Any overuse of hot water will waste not just the water, but also the associated hidden costs.

Remember, hot water (60°C) can cost between £2.82 - £7.64/m^3. Common losses of hot water occur through dripping taps and automatic taps not turning off quickly enough. Hot water supplies are often misused (e.g. for vehicle washing).

Producing steam is an energy intensive process, with more than 80% of the energy used for the latent heat of vaporisation of water to steam. This means that steam contains about six times as much energy as water at 100°C, and is very expensive to produce at around £29.71 - £30.87/tonne. Hence, even a small steam leak has a significant cost attached.

Fortunately, steam leaks are visible and audible, so can be identified relatively easily. Most common leaks are from faulty valves (packed glands), and pipework flanges and joints (see Figure 4). Another way that steam leaks occur is through sticking steam traps, which can either result in a continuous escape of steam, or a blockage which will collect condensate. Steam traps, valves and pipework should be routinely checked and corrective action taken if found to be defective.

Figure 4: Steam leaks from faulty valves on unlagged steam lines

Actions

1. Check the hot water distribution system and ensure there are no leaks or unnecessary usage.
2. Carry out steam leakage surveys on a routine basis to identify and repair leaks.
3. Repair or replace faulty steam traps promptly.

Waste & Resources Action Programme

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