Efficient Water Heating

EarthCheck

Many larger tourism operators use boilers to provide their site with hot water and in some cases to also provide space heating via a heat exchanger (such as a radiator) that transfers the heat in the hot water or steam to the air. Smaller tourism operations will typically use storage water heaters which hold smaller amounts of water that are heated using electricity, natural gas, liquid petroleum gas (LPG) or renewable energy sources such as solar. Operations with restricted space and access may use instantaneous systems that heat water to one or several taps where it is used. They typically operate on natural gas or LPG but in some cases 3 phase electricity.

Both boilers and hot water systems can waste a lot of water and energy if they are not operated efficiently. This fact sheet provides a list of opportunities to help ensure your site's system is operating as efficiently as possible.

Before investigating efficient water heating options, consider opportunities to reduce energy consumption from water heating by reducing the quantity of hot water consumed. See *Factsheet 6: Reducing water consumption* / which focuses on reducing water consumption, water efficient equipment and installing flow restrictors and low flow shower heads.

Improving boiler efficiency

Boilers waste water, energy and chemicals in a number of ways, namely:

1. **Blowdown** - When a portion of water is expended from the boiler to prevent the build-up of contaminants in the circulating water which can cause biological growth, corrosion and scale. '**Blowdown**' means more fresh '**make-up**' water is consumed to replace the water lost from the boiler.
2. **Poor combustion efficiency** - Boilers can consume excessive amounts of energy if they do not convert their fuel into heat efficiently. This not only wastes energy (fuel) but also increases combustion gas emissions and unburnt fuel deposits (soot) on the inside surface of the boiler tubes which act as an insulator, reducing heat transfer efficiency and allowing heat to escape.
3. **Distribution losses** - Some losses of steam or hot water will occur during the distribution of steam through leaks, lack of insulation and incorrectly sized pipes.

Reduce blowdown

Install an **automatic blowdown** system instead of undertaking manual blowdowns at set time intervals. This may require the installation of a conductivity probe that can measure the salt level within the water and only blowdown when the level exceeds a set value. Conductivity probes can **reduce energy consumption by 2-5% and typically have a payback period of 1-3 years**[1].

Reuse boiler blowdown water for other activities such as cleaning if the water quality is appropriate to the application (i.e. salt and chemical concentrations must be compatible with the intended use).

Install a **blowdown heat recovery** system to recover heat from the blowdown to preheat make-up water. Blowdown heat recovery systems consist of a heat exchanger and flash tank that drop the pressure of the blowdown, converting some of the blowdown into low-pressure steam which is sent back to the boiler while the remainder is sent to the heat exchanger. Heat recovery systems also limit the discharge of hot liquids to sewer systems which is a concern for some local authorities.

Reduce the amount of mains water required to replace blowdown by identifying suitable **alternative water sources** such as rainwater, condensate, recycled water or bore water. When assessing suitability of alternative water supplies consider:

- Water quality
- Availability & variability of supply/ quality
- Infrastructure requirements (pumps, pipes etc.)

Scale and soot deposits prevent the efficient exchange of heat between combustion gases and water.

Scale refers to the build-up of solidified contaminants on the water side of the boiler.

Soot refers to the build-up of solidified combustion gases on the fuel side of the boiler.

Case Study:

Melia Bali, Indonesia

Melia Bali has reduced their energy consumption of fuel oil boilers by:

1. Installing a dual gas/oil burner on their boiler to improve efficiency and allow for flexibility in fuel use. **The dual burner cost US$41,000 and is estimated to save US$101,234 with a payback period of 4.5 months**
2. Increasing the frequency of fire tube cleaning from 6 to 3 monthly
3. Installing a water softener to reduce scale build up and improve heat transfer efficiency.

Improve combustion and heat transfer efficiency

Regularly monitor flue temperatures (chimney/exhaust). Many boilers lose 15-20% of their fuel energy input up the stack[2]. An increase in temperature usually means soot and scale are having an insulating effect and reducing the boilers efficiency. As a 5°C rise in flue temperature indicates a 1% efficiency loss[3], find out the optimum temperature, by reading the flue temperature immediately after the boiler has been serviced and cleaned. If your boiler uses inline temperature sensors, make sure they are regularly calibrated and not fouled.

Monitor boiler flue gases for excess air to help reduce unnecessarily high fuel consumption. Flue gas analysers are usually integrated into the boiler. If not, consider purchasing an analyser. Installing an oxygen trim system can help by adjusting the ratio of air to fuel to optimize fuel combustion. Also undertake regular checks for air leaks to reduce excess air in the system.

Tip

Soot has an insulating value five times greater than asbestos. Regularly clean and inspect boilers to prevent the build-up of scale and soot. Scale that is 1.6mm can cause a fuel loss of 4%[4]. Heat transfer can be improved by cleaning the boiler:

- Scale on the water side often needs mechanical or acid cleaning. As this is often very expensive and difficult, prevention through effective water treatment and water analysis is often a better alternative.
- Soot from combustion gases are usually removed with brushes and vacuums but can be prevented through more efficient combustion and use of cleaner fuels.

Reduce distribution losses

Heat losses in the distribution system can be reduced by removing redundant pipework. Ensure pipework is correctly sloped for maximum drainage and not over-sized as larger surface areas lose heat, while undersized pipes result in greater pressure which increases the probability of leaks.

Regularly check the system for leaks including the tank and pipework. Ensure all steam traps are regularly maintained to ensure they are opening and closing effectively. Traps that remain closed become water logged which will increase heat loss, while traps that don't close effectively lose water, heat and chemicals.

Insulating boilers and steam lines can greatly reduce heat loss. Insulation can typically reduce heat loss by up to 90%[5].

For steam at 700 kPa, a 1 m2 of uninsulated surface (approximately 2.5 m long, 125mm pipe) will lose approximately 0.225 GJ through a 24-hour period, equating to approximately 81 GJ per year of natural gas or 2 tonnes of fuel oil[6]. With a fuel cost of $12/GJ, insulation could save up to $350 in fuel costs per metre of pipe.

Install condensate return lines to capture condensate to be returned to the boiler reducing water and energy consumption and the amount of treatment chemicals required.

Reduce pipework by ensuring the pipes between the tank and points of end use are as short as possible to reduce heat loss when the water is being distributed.

Operation and maintenance actions to improve efficiency

Make sure boilers are operated at their optimum working pressure and temperature. Operating boilers at lower pressure will reduce their efficiency. If lower pressures are required, instead of reducing the boiler operating pressure, consider installing pressure reducing valves at the end point of use rather than operating the boiler at lower pressure. Ensure thermostats are not set too high causing the water to be heated unnecessarily, wasting energy and costing money. Make sure however that it is not set so low that there is a risk of harmful bacteria growing in the tank.

Only operate boilers as needed and start up boilers as late as possible and shut them down as early as possible. If the boiler is operating at times of low demand consider if a smaller boiler or hot water storage system could operate during these hours.

Retrofitting and replacing hot water systems

Assess the efficiency of your current hot water system to determine whether retrofitting or replacing the system would be economically more efficient. New, more efficient systems may be able to achieve significant annual savings in fuel or electricity.

Annual Fuel Utilisation Efficiency (AFUE) is the measure of how efficiently a boiler converts input energy into heat energy. When deciding whether to replace a boiler, consider the payback period (i.e. the balance between the cost of replacing the boiler and the estimated annual fuel savings).

For example, replacing a boiler with an estimated AFUE of 50% with an 80% AFUE boiler would provide approximately $37.50 in savings for every $100 in fuel costs for the same heat output[7]. If the current annual fuel costs are $10,000 per year, this equates to approximately $3,750 in fuel savings. For a new boiler costing $15,000, the system will pay for itself within 4 years.

If demand for hot water or steam at your site is variable, consider installing an accumulator which is an additional vessel filled with heated water. When there is a sudden peak in demand the pressure is reduced causing some of the water to immediately become flash steam, thus protecting the boiler from instantaneous loads. Alternatively, consider replacing boilers with multiple de-centralised boilers for part-load systems.

Other retrofit/replacement options to improve efficiency and reduce fuel costs include:

- Retrofitting gas pilot lights with automatic electronic ignition systems.
- Replacing the system with an alternative such as solar assisted or biomass fired boilers, heat pumps or cogeneration systems. Combined heat and power systems are another alternative that use a single source of fuel to produce both electrical and thermal energy.

Alternatives to electric storage water heaters

Energy intensive electric storage water heaters tend to generate more greenhouse gases than other types of water heaters as Table 1 highlights.

Table 1 – A comparison of greenhouse gas emissions from different types of hot water systems[8]:

Type of system	GHG emissions over 15 years (tonnes of CO2 equivalents)
250 litre electric hot water system*	60
Electric heat pump	26
Gas storage (LPG)	17
Gas storage (Natural gas)	15
Gas instantaneous (LPG)	13
Gas instantaneous (Natural gas)	11
Solar electric boosted	8
Solar gas boosted	3

*Assuming electricity sourced from mains power derived predominantly from coal fired power stations.

CASE STUDY:

The Taj Residency Bangalore

The Taj Residency Hotel in Bangalore, India installed a heat exchanger to recover heat from the site's air conditioning system. The hot refrigerant is used to preheat water used to feed its boiler. By mixing this water with water preheated using energy captured by 100 solar panels, the hotel is able to increase the boiler's feed water from 44oC to 70oC. This equates to an energy saving of around 2.22 MJ per hour or 52 L of fuel.

ACTIONS TAKEN:

Other initiatives undertaken by the hotel to reduce energy consumption include:

- Closely monitoring the consumption of fuel in the boiler and compare readings with the manufacturer's recommendations. When fuel consumption starts increasing, de-scaling of the water tube boiler is undertaken. Scale acts as insulation and reduces the boilers ability to transfer heat from the burning fuel to the water.
- Automatic monitoring of fuel to air ratios to ensure efficient fuel combustion.
- Recovering steam condensate from the steam boiler for use in the boiler feed water saving not only energy but also water and chemicals.
- Using ultra diesel for the boiler which has a lower sulphur content to reduce carbon monoxide emissions and increase the boiler efficiency

Gas

Alternatives include gas heaters that produce around one third the greenhouse gas emissions which may be an alternative for sites with limited space (they are usually smaller than electric systems) and access to piped natural gas. If town gas is not available, bottled LPG can be used but operating costs will usually be higher.

Heat pumps

Heat pumps absorb heat from the outside air using a refrigerant liquid which is kept at a temperature lower than the outside air temperature. The heated refrigerant is then compressed into a hot vapour which can be used to heat water via a heat exchanger. A compressor is required to compressor the refrigerant and subsequently these types of systems do make a noise similar to an air-conditioning unit. While they still consume electricity, this can be up to 40% less than conventional electric hot water heating[9].

If your operation is located near another source of heat such as hot groundwater, bedrock, or even waste heat from nearby processes or businesses, heat pumps can also utilise this heat. Unlike solar systems these pumps do not require sunlight so they can be located anywhere, including sitting on top of existing hot water systems inside buildings.

Solar

The viability of solar systems depends largely on the climate and the site's level and type of hot water usage. Smaller operations may be able to meet all their hot water needs while operations using large amounts of hot water may find solar pre-heaters that feed water heated by the sun into a conventional heater more suitable.

Solar systems typically have an insulated tank either located on the roof so they can use gravity rather than a pump to circulate water or on the ground where they require a pump but are less visually intrusive and accessible for maintenance. There are two common types of solar collectors:

- **Flat plate collectors** consisting of copper tubes attached to a dark-coloured metal plate facing the sun; or
- **Evacuated tube collectors** consisting of copper tubes encased in two layers of glass that contains a liquid that absorbs heat from the sun and then transfers this heat to the water. The liquid is then pumped back up to the roof. Because of their cylindrical nature they are exposed to the sun throughout the day making them good for areas with cold sunny days.

Most systems have an electric or gas booster for periods of insufficient sunshine. Huge advances in the materials used to make solar heaters and technological advances using lenses, mirrors or dye coated glass to focus sunlight into a small beam to achieve higher efficiency should make solar a much more efficient and costs effective alternative for water heating in the near future.

References

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