HEATING WATER

FORTY PER CENT of an average dairy farm’s daily electricity is used for heating water – this is the biggest user of power at the shed. Keep the following principles in mind.

- Match the quantity of water heated to actual requirements – this is the best way to reduce costs, energy use and greenhouse gas emissions.
- Reduce the amount of hot water required by reviewing wash programs.
- Heat water to the temperature required for the job – every degree above requirements means higher costs.
- Deliver hot water quickly, when it’s needed – this minimises heat loss.
- Insulate, insulate, insulate to reduce heat loss – retaining heat saves money.
- Pre-heat water if you can – using water from the plate cooler or using a solar system to pre-heat water makes sense.
- Use the best quality water available – water high in minerals or organic matter reduces heating performance.

Hot water for milking machines

The table below is a guide to how much hot water is required to effectively wash and sanitise a milking machine with the most commonly used procedures in Australia – 3 cycles per wash (warm pre-rinse at 38°C, hot detergent wash, hot water sanitise).

As a general rule, allow 6-8 litres per unit. In the warm pre-rinse cycle around 25-35% of the volume is hot water.

<table>
<thead>
<tr>
<th>No. units</th>
<th>Hot water per wash (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>380</td>
</tr>
<tr>
<td>24</td>
<td>460</td>
</tr>
<tr>
<td>30</td>
<td>570</td>
</tr>
<tr>
<td>40</td>
<td>670</td>
</tr>
<tr>
<td>50</td>
<td>840</td>
</tr>
<tr>
<td>60</td>
<td>1000</td>
</tr>
</tbody>
</table>

Hot water for milk vats

Nearly all modern milk vats have semi or fully automated wash systems, but hot water use varies according to wash program selected and cleaning system design.

As a general guide, the amount of hot water required for effective cleaning is 1-3% of the milk vat’s storage capacity.

For older vats that require manual cleaning, the quantity of hot water required depends on individual cleaning practices.

<table>
<thead>
<tr>
<th>Milk vat capacity (litres)</th>
<th>Hot water per wash (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,000</td>
<td>60-180</td>
</tr>
<tr>
<td>10,000</td>
<td>100-300</td>
</tr>
<tr>
<td>16,000</td>
<td>160-480</td>
</tr>
<tr>
<td>20,000</td>
<td>200-600</td>
</tr>
<tr>
<td>24,000</td>
<td>240-720</td>
</tr>
<tr>
<td>30,000</td>
<td>300-900</td>
</tr>
</tbody>
</table>

Pre-heating is good for the environment

For every 1°C warmer that water enters the electric hot water service greenhouse emissions are reduced by 139 g per 100 litres of water heated.

Efficient hot water use in the dairy is all about delivering water at the right temperature with minimal heat loss.

Energy efficiencies also can be gained by capturing some of the heat available during milking – a by-product of milk harvesting.

Pre-heating water makes sense but alone it is unlikely to get it to the required temperature.

Below are some of the investment options currently available that make use of pre-heating.

Costs, energy usage and greenhouse gas emissions can all be reduced by proper matching of the quantity of water heated with what’s needed daily.
Other hot water requirements

Hot water is required for general washing up, diluting teat disinfectant (after the water has cooled), mixing calf milk and other general duties around the dairy. Allowing 100-200 litres per day should be sufficient for most situations.

Carefully review your wash program. Check you are not over-using hot water quantities.

- Check the temperature of the wash water in the drum as the wash cycle commences – it should not exceed 85°C.
- During recirculation (hot wash cycle) the drum should be around 20% full as the wash water returns. If it is more, then smaller wash quantities could be considered.
- Check out detergents that are effective at lower temperatures.
- Using a chemical sanitiser in the final wash cycle will also reduce the water heating demand.
- Capture the final rinse for use next time.

How much hot water do I need?

<table>
<thead>
<tr>
<th>Milking machine</th>
<th>______ litres/wash</th>
<th>x ______ washes/day</th>
<th>(a) Total = ______ litres/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>plus Vat</td>
<td>______ litres/wash</td>
<td>x ______ washes/day</td>
<td>(b) Total = ______ litres/day</td>
</tr>
<tr>
<td>plus Other uses</td>
<td>(c) ______ litres/day</td>
<td></td>
<td>Total hot water per day = (a) + (b) + (c) ______ litres</td>
</tr>
</tbody>
</table>

It sounds obvious, but if it is possible to use warmed water, go for it, as it saves energy and costs.

Pre-heating options include solar systems, heat pumps and heat recovery and recapture systems. Pre-heating systems can achieve temperatures of up to 70°C. In some situations even higher temperatures can be achieved.

<table>
<thead>
<tr>
<th>Which system is right for me?</th>
<th>Preheat</th>
<th>Dedicated insulated storage tank required</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pre-heated water</td>
<td>No</td>
<td>Traditional systems use the most energy to achieve the required usage temperature.</td>
<td></td>
</tr>
<tr>
<td>Solar hot water heater</td>
<td>Yes</td>
<td>An extremely effective way to reduce electricity consumption and greenhouse gas emissions. Performance is subject to location, positioning and climatic conditions.</td>
<td></td>
</tr>
<tr>
<td>Heat recovery systems</td>
<td>Yes</td>
<td>This system uses the heat generated by the refrigeration unit when cooling milk in the vat. Performance is related to the amount of running time of the refrigeration unit(s) – the longer they run the greater the heating. Well suited to herds with split/all year round calving patterns, as daily milk cooling volumes are more consistent. Water temperatures up to 70°C are possible.</td>
<td></td>
</tr>
<tr>
<td>Heat pump</td>
<td>Yes</td>
<td>This involves capturing the heat in the milk as it passes through the plate cooler. The amount of heat recapture is small but can be used for udder washing water, mixing calf milk powder and supplementing hand washing facilities. Water temperatures of around 30°C are possible. See InfoSheet B4: Cooling Milk (page 5) for details.</td>
<td></td>
</tr>
<tr>
<td>Heat pump</td>
<td>Yes</td>
<td>Heat pumps extract heat from the air, water or the ground and transfer it to the water. Performance is improved when a solar booster is used. Using renewable energy source to power a heat pump will reduce greenhouse gas production. Water temperatures of around 55-70°C are typically possible.</td>
<td></td>
</tr>
</tbody>
</table>
Instantaneous water heaters

By definition, instantaneous systems heat only the water required and do not use a storage tank.

They can operate on natural gas, LPG or electricity. Gas models are available with either electronic ignition or a pilot flame.

However, since instantaneous systems cannot deliver hot water at the required flow rates they would not suit milking machine or vat washing purposes.

Hot water flow rates of 18-26 litres/minute are possible. These rates can be achieved if the water temperature only has to rise by 25°C. Requirements of greater water temperature increases will result in lower flow rates.

Solar hot water heaters

These systems need:

- solar thermal collectors – there are three main types (see below);
- a fluid system to move the absorbed heat from the collector to its point of usage – these can be an open or closed circuit (see below); and
- a reservoir or tank for pre-heated water and subsequent use.

Formed plastic collectors

Large, flat array of ribbon plastic tubes, often dark in colour, through which water is circulated and heated.

Comments: These produce tepid water temperatures. Commonly installed to heat water used in swimming pools.

Flat collectors

These are flat, glass-fronted insulated panels that contain thin sheets of absorber materials. Fluid is circulated through copper pipes to remove the heat from the absorber and transported to an insulated water tank or heat exchanger.

Comments: Most commonly used for heating water. Also used in solar space heating systems. Can be either open circuit or closed circuit (see over page).

Evacuated tube collectors

Comprise rows of parallel mounted transparent glass tubes. Each tube contains an absorber tube. The sunlight passes through the outer glass tube heating the absorber tube which has been covered with a special light-modulating coating. The heated fluid can be used directly or heat water via a heat exchanger.

Comments: By design, these types of collectors capture heat more efficiently. They can achieve much higher temperatures than flat collectors. Tend to be more expensive.
Open circuit vs closed circuit

In an open circuit system, water flows directly through the solar collectors into the storage tank and is then available for use.

In a closed circuit system, a fluid other than water (such as glycol) flows through the collectors and transfers this heat to water in the storage tank through a heat exchanger.

Closed circuit systems are most commonly used for frost protection or when the water is corrosive.

Heat recovery: vats

This system utilises the heat generated by the milk vat’s refrigeration unit. It involves a storage tank – similar to a mains pressure hot water service – containing coils through which the heated refrigerant passes.

It can heat water to around 60-65°C and is generally used for cleaning the vat. It also can be used as a supplement to the main hot water system.

The quantity of hot water produced and the temperature achieved depends upon:

- The temperature of the milk entering the vat. The lower the temperature the less heat produced.
- The volume of milk to be cooled by the vat’s refrigeration system. The greater the volume of milk the more heat produced.
- The quantity and starting temperature of the water.

Heat recapture: plate cooler

The heat removed from the milk as it passes through the plate cooler can be transferred, via another plate cooler, to the water supplying the hot water storage system.

See InfoSheet B4: Cooling Milk (page 5) for details.

Heat pump water heaters

Heat pumps work like the vat’s refrigeration system but in reverse – they extract heat from the environment. Heat pumps have been widely used for many years.

There are several types of heat pump water heaters and each has various configurations:

- Air source heat pump systems (most common) extract the heat from the air. They can be found in domestic applications.
- Water source heat pump systems use a water loop or body of water to exchange heat. They are very efficient because of the temperature variability in the body of water is relatively smaller than that of the ambient air. These are used on larger commercial applications.
- Ground source (or geothermal) heat pump systems use coils buried deep in the ground where the temperature is stable throughout the year – also very efficient.
- Solar boosted heat pump systems utilise solar collectors as the evaporator, further improving performance.

Photovoltaics (system that converts the sun’s energy into electricity) can be employed to power the heat pump. This would make this system of heating water extremely energy efficient.

In the cool climates of southern Australia, greenhouse gas emissions from solar boosted heat pump systems can be similar to or less than those from a solar water heater with an electric booster.

However, in most other parts of Australia this would not be the case.

Source: Australian Greenhouse Office
The options for heating or boosting water to temperatures around 85°C for milking machine washing are limited. An electric heating element is as of January 2008 the simplest method. The trick is to maximise the pre-heating performance. This will ensure energy for electric heating will be minimised as will greenhouse gas emissions.

Which system is right for me?

<table>
<thead>
<tr>
<th>Heating/booster system</th>
<th>Dedicated insulated storage tank required</th>
<th>Suitable for applications that do not require water temperatures &gt;65°C</th>
<th>Suitable for applications that do require water temperatures &gt;65°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric heating element</td>
<td>Yes</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Instantaneous gas</td>
<td>No</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Gas storage</td>
<td>Yes</td>
<td>✓</td>
<td>×</td>
</tr>
</tbody>
</table>

Conventional electric storage hot water heaters

By far the most common way of heating water in the dairy. Heating of water normally occurs during off-peak electricity tariff conditions generally this is between 11pm and 7am each day.

Nearly all electric hot water heaters have an additional element that acts as booster. The booster is turned on via a manual switch.

In gravity-fed systems, the water drawn from the storage tank is only replenished during heating. This minimises the loss of water temperature inside the tank but necessitates a storage capacity to cater for the whole day’s requirements.

In vat wash systems, a dedicated mains-pressure hot water service is used. Since most vats require a lower wash temperature (~65-70°C) having a dedicated hot water system will reduce heating energy requirements. A heat recovery system would be worthwhile alternative.

Gas storage hot water heaters

Gas storage hot water heaters are commonly available for domestic applications. They can deliver water at temperatures of around 55-60°C and so have very limited application in the dairy.

Commercial gas storage hot water heaters can deliver water at temperatures of up to 85°C. But to achieve flow rates required for dairy use the capital expense makes this a prohibitive option.

Booster systems

Ensuring a reliable supply of hot water at temperatures required to wash the milking machine (above 80°C) will require an electric booster system and a dedicated, well-insulated storage tank.

For applications where the maximum required water temperature is less than 65°C other booster systems could be considered.

Electric booster: using a conventional electric hot water system. A separate holding tank would be required if the electric elements were to only operate during ‘off-peak’ times.

Gas booster: this relies on heating the water just prior to use. Often referred to as ‘continuous flow’ or ‘instantaneous’. Gas boosters cannot heat water quickly enough to meet the cleaning requirements in the dairy. Therefore, a separate holding tank would be required or the ‘heat boosted’ water could be recirculated in the storage tank. This tank would store enough hot water to cater for the next milking’s requirements.

Gas booster systems can be effectively incorporated into preheating systems, further reducing the reliance on electric element heating.

Solid fuel boosters heat water through a heat exchanger, commonly known as a ‘wet back’ system.

Solid fuel booster and gas booster systems produce less greenhouse gas emissions than electric boosted systems.
The options

ENERGY EFFICIENT WAYS OF HEATING WATER

Preheating

- Solar collector
- Heat pump

Well insulated hot water storage tank

Booster/heating

- Electric hot water storage heater with ‘rapid flow 2’ outlet
  - Operates on off-peak tariff rates
  - Electric heating and booster elements

- Gas hot water storage heater
  - ‘Mains pressure’

- Instantaneous gas hot water heater

Heating to 85°C

- All uses (<85°C) except automatic vat wash systems

Heating to 65°C

- Gas hot water storage heater
  - ‘Mains pressure’

- Instantaneous gas hot water heater

Miscellaneous uses (<65°C) with low flow rates, incl. some automatic vat wash systems

- During periods of high solar gain (e.g. summer) heating water with electric elements or gas may not be required

- Alternative gas heating options

- Select units designed for commercial applications

- May require multiple units to achieve desired flow rate

Alternative pre-heating options

- At best ~30°C

- If <60°C

- If >60°C
SCENARIO
Ken is looking to milk around 1,100 cows on a new farm north of Mt Gambier. The new 60-unit rotary dairy will be built on a green field site. Ken is keen to incorporate energy efficiency in as much of the new dairy as possible. Efficient use of water is another of Ken’s objectives. Ken has identified three areas where he thinks efficiency improvements will have the greatest impact. The first is in the way water is heated; the second is how his milk pre-cooling could be improved (refer to InfoSheet B4: Cooling Milk for details); and the third area is how water is used at the dairy and where savings could be made. Of course, energy efficient lighting and other power saving devices will be incorporated into the shed design.

Improving water heating
As there will be different staff working at the new dairy, Ken says “simplicity is very important”. A solar hot water system with evacuated tube collectors will be used to pre-heat the water. The pre-heated water will be stored in three highly insulated tanks from where it will be fed into the electric hot water services. The 40,000 litre vat will have a heat recovery system included. The calculated amount of hot water required each day at the new dairy will be as follows:

<table>
<thead>
<tr>
<th>Details</th>
<th>Period 300 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water from bore</td>
<td>18°C</td>
</tr>
<tr>
<td>90°C hot water (milking machine)</td>
<td>2,000 litres/d</td>
</tr>
<tr>
<td>90°C hot water (misc.)</td>
<td>200 litres/d</td>
</tr>
<tr>
<td>65°C tot water (vat)</td>
<td>600 litres/d</td>
</tr>
</tbody>
</table>

Without a pre-heating system

<table>
<thead>
<tr>
<th>Power to heat water to 90°C</th>
<th>211.8 kWh/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power to heat water to 65°C</td>
<td>37.7 kWh/d</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>260 kg CO₂e/d</td>
</tr>
<tr>
<td></td>
<td>78,000 kg CO₂e/yr</td>
</tr>
</tbody>
</table>

With a pre-heating system

Assumptions: water will be pre-heated to at least 40°C every day and 60°C every 2nd day

<table>
<thead>
<tr>
<th>Power to heat water to 90°C</th>
<th>117.67 kWh/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power to heat water to 65°C</td>
<td>12.03 kWh/d</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>135.15 kg CO₂e/d</td>
</tr>
<tr>
<td></td>
<td>40,456.70 kg CO₂e/yr</td>
</tr>
</tbody>
</table>

Savings

<table>
<thead>
<tr>
<th>Power to heat water to 90°C</th>
<th>119.81 kWh/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power to heat water to 65°C</td>
<td>124.84 kg CO₂e/d</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>37,453 kg CO₂e/yr</td>
</tr>
</tbody>
</table>

Rainwater will be captured and used for all equipment cleaning. A bore on the farm will be used to supplement the rain water tanks as required. The bore water has been tested and found to be less than 100 ppm in Total Hardness – suitable for equipment cleaning. The bore water temperature is around 18°C for most of the year.

These are conservative assumptions.

An estimated 48% reduction in greenhouse gas emissions – about 37.5 tonnes per year.
Heating water

Water quality

Water containing high levels of minerals can reduce heating performance and shorten equipment life. Organic matter in the water can also build up forming a sludge that further reduces heating performance. Sacrificial anodes placed inside hot water storage tanks offer some protection against corrosion but do not completely compensate for having a supply of good potable quality water.

For more information on water quality see InfoSheet C1: Water at the Dairy.

Is my existing system efficient?

Working out if your current system is efficient should be the first step – even if you are planning an upgrade or new dairy. The efficiency of electric storage hot water systems can be greatly improved by reducing thermal losses and minimising heating requirements. Things to check:

- Quantity of water heated matches quantity required.
- An efficient and effective wash program is used.
- The wash programs enable thrifty use of hot water – final hot rinse is recaptured.
- Storage tank is positioned away from drafts and breezeways.
- Additional insulation is wrapped around the storage tank (ensure relief valves and any vents are not obscured or restricted).
- Fast delivery mechanisms: 2” outlet valve and pipe.
- Thermostat is accurate. Only heat the water enough to achieve 85°C in the wash drum.
- All hot water pipes are well insulated. Insulating the wash supply line to the jetters is also advantageous.
- Good quality (potable) water supply is used.
- The warmest available (good quality) water is used to fill the storage tank.
- All leaks are rectified.
- Elements and anodes are well maintained (an inspection and service program is in place).
- The best (off-peak) tariff rate is used.

To calculate hot water requirements see page 2.

Further information

- InfoSheet A4: Renewable Energy Sources

Links


Rebates and assistance

Rebates are available from Federal, State and some local Governments. Some of the product manufacturers and utility supplies also offer assistance and incentives. Check with your local council for applicable rebates and eligibility criteria.

As at October 2007 there are SA rebates for commercial businesses, however, rebates are changing continually so please check the link on this page.