ON AVERAGE, cooling milk from around 35°C to 4°C uses around 30% of a dairy’s daily energy use, so aiming to be more efficient is well worth the effort. Keep the following principles in mind:

- Pre-cooling milk before it enters the vat is the key to an efficient system – don’t make the vat do most of the work.
- Check the performance of the plate cooler through regular monitoring.
- Use the coldest water you can – every degree drop in temperature of the milk entering the vat reduces energy use and greenhouse gas emissions.
- Use good quality water through the plate cooler – it helps maintain efficient performance.
- Investigate cooling tower options – even if you have access to relatively cool bore or spring water, cooling towers can offer further opportunities for reducing water temperatures.
- Heat is a by-product of cooling – use it where you can.
- Optimise performance of the refrigeration system – regular maintenance can reduce cooling times and energy costs.

For every 1°C drop in temperature of the milk entering the vat using a plate cooler you can reduce greenhouse gas emissions by 375 g per 1,000 litres of milk.

### Plate cooler efficiency checks

By maximising plate cooler performance two things happen:

- energy required to cool milk in the vat is reduced; and
- more heat is removed from the milk and can be used for other applications.

Use the following checks to determine if your plate cooler is efficient.

#### Table: Plate cooler efficiency checks

<table>
<thead>
<tr>
<th>Check</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature of milk entering vat</td>
<td>The temperature of milk exiting an efficient plate cooler should be within 2°C for an industrial plate cooler and 3°C for a standard ('M' or 'P' series) of the incoming water.</td>
</tr>
<tr>
<td>Water flow rate</td>
<td>The ratio of flow rates between the water and milk is critical. A ratio of between 2:1 and 3:1 of water to milk is required. The specific design and size of the plate cooler will determine the best ratio, so refer to manufacturer’s recommendations.</td>
</tr>
<tr>
<td>Correct sizing</td>
<td>The size (number of plates) of the plate cooler should be matched to the maximum flow rate of the milk pump(s).</td>
</tr>
<tr>
<td>Plate cleanliness</td>
<td>Contaminants from either the water or milk that adhere to the plates will affect their heat exchange capacity and reduce their performance.</td>
</tr>
<tr>
<td>Correct spacing between plates</td>
<td>If the gap between the end-plates is too small flow through the plate cooler will be impeded and performance can be compromised. Allow 2-3 mm/plate (refer to manufacturer’s specifications for further details).</td>
</tr>
<tr>
<td>Maintaining the cooling tower</td>
<td>Regular cleaning and general maintenance is required to ensure performance is not compromised. Regularly monitor the temperature of the cooled water.</td>
</tr>
</tbody>
</table>
**How plate coolers work**

Nearly all pre-cooling systems use plate heat exchangers – ‘plate coolers’ – to cool the milk before it enters the vat.

- The warm milk transfers its heat to the water (or glycol) via the plate.
- The liquids must flow in opposite directions if the heat transfer is to be maximised.
- The better the pre-cooling system the greater the savings in electricity consumption and refrigeration operating costs.
- Some newer brands of plates, by design, have a greater surface area, thereby improving their heat exchange capacity.
- Don’t forget the better the pre-cooling system the greater the savings in electricity consumption and refrigeration operating costs.

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**Cooling towers**

Cooling towers offer a way to recycle water from the plate cooler without compromising plate cooler effectiveness – but their key advantage is reducing water temperature.

- They are relatively cheap so can be used by dairy farmers making improvements to existing systems.
- Check the temperature of the water currently going into the plate cooler – this is what you’re aiming to improve on.
- Remember, bore (and sometimes spring) water will have a relatively stable temperature all year round but, depending on how it is stored, the temperature of other water (i.e. surface water) may rise considerably in hot weather.
- Positioning, burying, screening or planting shade around tanks are options to help insulate against the warming effects of direct sunlight. See InfoSheet A2: Thermal Efficient Design for more information.

The lowest water temperatures achievable from a cooling tower ranges from the wet bulb temperature of the ambient air to about 5°C above it. So, if the wet bulb temperature is say, 8°C you can expect cooling tower water temperature to be in the range of 8°C – 13°C (see table on page 3).

**Average wet bulb temperature (°C)**

<table>
<thead>
<tr>
<th>Region</th>
<th>January</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9am</td>
<td>3pm</td>
</tr>
<tr>
<td>Clare</td>
<td>15.0</td>
<td>17.6</td>
</tr>
<tr>
<td>Mount Gambier</td>
<td>14.1</td>
<td>15.8</td>
</tr>
<tr>
<td>Murray Bridge</td>
<td>15.4</td>
<td>17.8</td>
</tr>
<tr>
<td>Victor Harbour</td>
<td>16.0</td>
<td>17.4</td>
</tr>
</tbody>
</table>

Source: Bureau of Meteorology

Remember, wet bulb temperature is likely to be lower overnight or very early morning. Use the table to estimate the range of temperature reductions you might expect.

- Cooling tower performance can be poor on days of high relative humidity and high wet bulb temperatures. It may not be possible to lower the water temperature under these conditions.
- If you have a very efficient cooling tower you could expect to get close to the wet bulb temperature.
- If you have sufficient water storage to cater for the needs of both the morning and evening milkings, the cooling tower should be operated during the night.

Each 1°C drop in temperature you can achieve using a cooling tower has cost and greenhouse gas emission benefits.
Water re-use and recycling with a cooling tower

Water circulation through the cooling tower during off-peak and/or lowest wet bulb temperature.

Solar collected feed
Hot water storage feed

Storage tank, above or in ground

Cooling towers can also use power during off-peak tariff rates, when it is cheapest.

Operation during the early morning can achieve lower water temperatures.

Cooling milk in the vat is influenced by:
- Vat design
- Type of refrigeration unit
- Volume of milk to be cooled
- Schedule of pick-ups
- Prevailing environmental conditions.
Consider each when you are making decisions about your refrigeration system.

**Key facts for decision making**

### Cooling milk in the vat

<table>
<thead>
<tr>
<th>Refrigeration system</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct expansion</td>
<td>This is the most common system.</td>
</tr>
<tr>
<td></td>
<td>Energy efficient - best choice if access to power and reliability of supply is not a problem.</td>
</tr>
<tr>
<td></td>
<td>Plate coolers are essential to reduce size and operating costs of refrigeration units.</td>
</tr>
<tr>
<td>Scroll compressor refrigeration units</td>
<td>Scroll compressors are 10-15% more energy efficient when compared with traditional 'open drive' units.</td>
</tr>
<tr>
<td></td>
<td>Units are now available for large capacity vats (&gt; 30,000 litres).</td>
</tr>
<tr>
<td>Open drive compressor refrigeration units</td>
<td>Traditional design, known for their reliability. Less energy efficient that comparable scroll compressors.</td>
</tr>
</tbody>
</table>

### Cooling milk before it enters the vat

<table>
<thead>
<tr>
<th>Refrigeration system</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal storage systems</td>
<td>Less energy efficient than direct expansion but may be the only option if grid power is limited.</td>
</tr>
<tr>
<td></td>
<td>Initial capital costs are higher than direct expansion systems.</td>
</tr>
<tr>
<td></td>
<td>Economics become more favourable for larger herds producing more than 15,000 l/day (individual circumstances greatly influence the economics).</td>
</tr>
<tr>
<td>On demand thermal storage systems (chiller units)</td>
<td>Smaller quantity of cooling medium (usually glycol) is required, but chiller unit needs to be larger to cope with the demand.</td>
</tr>
<tr>
<td></td>
<td>More costly to run than other systems – operate during milking (often at peak tariff rates).</td>
</tr>
</tbody>
</table>
Energy can be wasted and costs increased by poor maintenance.

**Keep the condenser clean**
- carefully brush the fins of the condenser unit to prevent build-up of dust and grime which reduces performance. Make this part of your (monthly) maintenance routine.

**Service the unit** – annual servicing by a refrigeration mechanic.

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**Heat recovery from refrigeration**

A heat recovery system designed to capture the heat removed from the milk by the refrigeration unit is an ideal energy efficient way of heating water.

*See InfoSheet B3: Heating Water.*

Some systems are not suited to applications where the water is hard. In South Australian situations where water quality is adversely affected by chloride the types of heat reclaim systems is limited.

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**Heat capture from plate cooler**

The heat removed from the milk via the plate cooler can be transferred to water feeding the hot water storage system. This can be achieved by directly filling a well-insulated storage tank or by heating the water contained within a well-insulated storage tank via a plate cooler (see below).

By using method 1, the amount of heat captured from the plate cooler will result in water temperatures within a few degrees of the milk.

In method 2 the temperature difference between the water filling the storage tank and the milk will be much greater. It will be governed by the relative flow rates between the milk and the water.

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**Capturing heat from milk to pre-heat water: Heating via plate cooler**

*Example: If the temperature of the milk entering plate cooler 1 is 30°C then the temperature of water in the storage tank could reach ~30°C.*

**Capturing heat from milk to pre-heat water: Direct fill**

*A milk pump controlled solenoid valve installed on the water line should be used in Method 2 to improve heat capture.*
Ken is looking to milk around 1,100 cows on a new farm north of Mt Gambier. The new 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.

The new dairy will be a rotary – 60 units, although an 80 unit rotary may be considered. “We will be milking many more cows and so want to make sure our operation is very efficient” says Ken. “We want to improve on the way we currently do things in our existing 50 unit rotary.”

Ken has identified three areas where he thinks efficiency improvements will have the greatest impact. The first is in the way water is heated (refer to InfoSheet B3: Heating Water for details); the second is how his milk pre-cooling could be improved; 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 pre-cooling and re-using water

Ken’s existing dairy uses water directly from the bore to run through the plate cooler. The water is then used to fill the flood wash tank. Any overflow runs onto the holding yards and then into the effluent pond.

In the new dairy Ken will re-use the water that passes through the plate cooler by recycling it into a 20,000 gallon concrete tank that will be buried in the ground. A cooling tower will operate overnight to bring the average water temperature down to about 12°C. The water temperature is expected to reach ~8°C during the colder months of the year, resulting in even greater energy savings.

### Details

<table>
<thead>
<tr>
<th>Period</th>
<th>300 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water from bore</td>
<td>18°C</td>
</tr>
<tr>
<td>Av herd size</td>
<td>1,100 cows</td>
</tr>
<tr>
<td>Av daily prod.</td>
<td>28 litres/cow</td>
</tr>
<tr>
<td>Av daily prod.</td>
<td>30,800 litres/day</td>
</tr>
<tr>
<td>Milk storage</td>
<td>4°C</td>
</tr>
</tbody>
</table>

**Without a cooling tower**

- Milk enters vat: 20°C
- Energy required: 532.91 kWh/day
- Electricity consumed: 167 kWh/day
- CO₂e/day: 174 kg CO₂e/day
- CO₂e/year: 52,058 kg CO₂e/year

**With a cooling tower**

- Water from cooling tower: 12°C
- Milk enters vat: 14°C
- Energy required: 333.07 kWh/day
- Electricity consumed: 104 kWh/day
- CO₂e/day: 108 kg CO₂e/day
- CO₂e/year: 32,536 kg CO₂e/year

**Savings**

- 62.5 kWh/day
- 65.1 kg CO₂e/day
- 19,522 kg CO₂e/year

This temperature of 18°C will remain fairly constant throughout the year.

This temperature of 12°C is an average. In winter can expect ~8°C and ~15°C in summer.

An estimated 37.5% reduction in greenhouse gas emissions – about 19.5 tonnes per year.
In the future

- The use of photovoltaics (See InfoSheet A4: Renewable Energy Sources) to power thermal storage systems may be worth considering if grid power is limited or limits the use of a direct expansion system.
- New gases for use in direct expansion systems are becoming more available. They claim to be more “environmentally friendly” than the R22 gas used in current direct expansion systems. Their operational performance is similar to that of R22.

Further Information


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