

**Opportunities for Reducing the Intensity of Water
Consumption in the Australian Dairy Processing
Sector**

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Acknowledgments

Thanks to the following key contributors to study:

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Abbreviations

CAPEX	Capital Expenditure
CIP	Clean in Place
FP7	European Union's 7 th Framework Programme of Research and Innovation
HPP	High Pressure Pasteurisation
OPEX	Operational Expenditure
MF	Microfiltration
NF	Nanofiltration
NWC	National Water Commission
NWI	National Water Initiative
RO	Reverse Osmosis
TDS	Total dissolved solids
UF	Ultrafiltration
UHT	Ultra High Temperature

Executive Summary

Australian dairy processors are striving towards improved sustainability and corporate responsibility through reduced water intensity in their production processes. As part of this, they have voluntarily committed to reduction targets with respect to a number of environmental indicators through their participation in the Australian Dairy Industry's Sustainability Framework. This study is intended to assist dairy processors in the task of achieving these targets by providing information about emerging technologies that have potential to assist dairy processors in their pursuit of reducing the economic and environmental cost of water use.

A large range of technologies and techniques were considered for their potential to reduce water intensity, covering a wide range of areas involved in the dairy process. These were then filtered to produce a list of forty-six potentially promising technologies. Fourteen technologies were then short-listed based on a set of selection criteria and examined further through discussions with Dairy Australia to identify and prioritise eight key technologies of interest. These are detailed within this report.

The technologies are split into three main categories based on the water conservation hierarchy: reduce, reuse and recycle. The greatest opportunities, and least risk, for reducing water intensity come from stopping water use where possible, optimising systems, and changing processes completely. There is increased risk and complexity to the opportunities when reuse and especially recycling options are considered. The technologies investigated are commercially available, though many are based outside of Australia.

Each of the eight technologies prioritised have been profiled in detail in the report and evaluated in terms of cost effectiveness versus water reduction potential. The remaining shortlisted technologies are profiled in the Appendices.

Reduce

Water reduction is the first area that should be considered when embarking on the journey to reduce water intensity. It should be seen as standard practice throughout the process and all employees at dairy processors need to be involved. The individual water savings may not seem great, but it is more the combined savings of multiple activities that provide the significant reduction in water use. In particular, increased metering and water management provides insight into lost water, leakage as well as process issues which may lead to preventing product loss. A water quality monitor, such as **Liquum** which measures the chemical fingerprint, can provide insight into where the water/product interface is and assist in optimising cleaning systems and prevent product loss.

The greatest individual water saving can be achieved through innovations in CIP. A way to do this is by rethinking the process, such as with the **Babcock Vortex system**. By using air instead of water, product recovery is increased, water is saved and there are no issues with pipework or constrictions. There is also minimal alteration to the pipework and due to a low energy requirement, the process can have a payback in as low as a year.

Reuse and Recycle

Water reuse and recycle is a much more complicated area to approach, with greater risk, to achieve water intensity reduction. Many dairy processors are already reusing the cleanest streams from production such as the condensate. The next area that should be reviewed is cooling towers to assess whether the recirculation could be improved and whether the water from the system can be reused. There are a number of options for chemical free cooling water treatment that are simple, low energy systems that can be installed on a side stream and both **Pathema** and **UET** do this well.

The last consideration to reduce water intensity will be the possibility of fully recycling water from the wastewater. Despite the low cost of water and the high cost of fully treating water to potable quality, dairy processors should consider scoping this option for the future to protect against the potential of a drought.

Alternative dairy processing options

Several alternative dairy processing technologies were also evaluated as part of this project but were not covered in detail due the significant production changes required to the dairy process and therefore water reduction is seen as a secondary benefit.

These technologies focus mainly on the pasteurisation and heating processes as these consume a huge amount of water through the CIP required to clean the system, and to a smaller extent the boiler water required. The two technologies highlighted in the report are **High Pressure Processing (HPP)** and **Microwave heating**. HPP is a method of preserving and sterilising food, where the product is processed under very high pressure, leading to the inactivation of certain microorganisms and enzymes in the food. The advantages from a water conservation view is that no boiler or CIP is required. Similarly, microwave heating of liquids results in minimal fouling in pipes, therefore longer processing times can be achieved, and due to shorter pipe lengths required compared to heat exchangers, CIP is shorter and simpler and uses less water.

Future water management planning

In general, water use is not a key focus for dairy producers in Australia as there is little current external pressure in most dairying regions (i.e. legislation or drought) to reduce or reuse. Water resource management and water security should not be ignored though as there are numerous other pressures on water supply, with urban growth competing with agriculture and industrial needs. Therefore, dairy processors should consider scenario planning various options for the future and have a water management plan in place to increase resilience against any future water scarcity.

Background

The Australian dairy processing sector uses significant amounts of water at its processing sites as a result of ongoing operations. Water is used for processing and cleaning, for the operation of utilities such as cooling water and steam production, and for ancillary purposes such as amenities and gardens. Figure 1 shows an example of water use in a dairy processing factory that produces market milk.

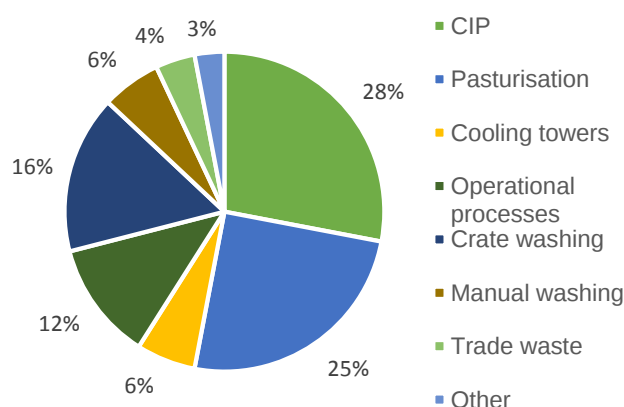


Figure 1 Breakdown of water use by a market milk processor (Prasad et al, Eco-efficiency for the Dairy Processing Industry, 2004)

Many dairy processors track the overall consumption of water by monitoring the ratio of water to raw milk intake. Water consumption varies based on the types of products produced at a given factory as well as the other economic, social or environmental drivers that encourage reduced usage rates. In Europe, water consumption at dairy processing sites has been reported to range from 0.2 to 11 L/L milk (Daufin et al. 2001) with effluent volumes per raw milk intake in the same range. Ratios for Australian processors producing any combination of white milk, cheese, powders or yoghurts range from 0.07 to 2.90 L/L milk, with the average being around 1.5 L/L milk (UNEP 2004).

Table 1 shows the range of ratios for factories producing white or flavoured milks, cheese and whey products, and powdered products. For factories that produce powdered products, there is the potential for the majority of water (>95%) to be supplied from treated condensate, also known as 'cow water'. However, the potential for recovering condensate depends on the scale of a particular powder plant and the ratio of supply to demand on a given day. For example, if the production rate is reduced during the off-peak season there will consequently be less condensate available for recovery. The range in water to milk intake ratios indicates there is potential for some dairy processing plants to decrease water consumption significantly.

Table 1 Water to milk intake ratios (L/L) (Prasad et al, Eco-efficiency for the Dairy Processing Industry, 2004)

Selection criteria	Min	Max	Average	No. of plants providing data
White and Flavoured only ¹	1.05	2.21	1.44	7
Cheese and whey products	0.64	2.90	1.64	3
Powdered products	0.07	2.7	1.52	10

¹Excludes UHT Milk

The source and quality of water is an issue for some processors, depending on their location. Generally, companies use town water, but other sources include river water, irrigation channel water, bore water and reclaimed condensate. Water shortages in both regional and urban areas at times are leading processors to review the effectiveness of their onsite water use, both of their own accord and in response to pressure from local authorities. There is also mounting pressure from investment firms who are analysing the environmental, social and governance (ESG) credentials of companies/organisations to detail, and where possible minimize, their exposure to baseline water stressed regions.

Despite the aforementioned pressures placed on water usage, the cost of water purchase at dairy processing sites remains quite low and this is often cited as a reason for the industry being slower to improve its water efficiency than other environmental metrics. As pointed out in the 2004 industry publication "Eco-efficiency for the Dairy Processing Industry", however, the true cost of water consumption by dairy processors does not just include the water purchase price but should also consider costs associated with;

- treatment of incoming water;
- heating or cooling costs;
- treatment of wastewater;
- treatment of evaporator condensate for reuse;
- disposal of wastewater;
- pumping costs;
- maintenance costs (e.g. pumps and replacement of corroded pipework and equipment);
- capital depreciation costs.

The sum of these costs is often poorly understood.

Apart from the potential commercial drivers for reducing the cost of water consumption, a number of the largest Australian processors have also recognised that demonstrating the principles of sustainability and corporate social responsibility are key to maintaining a social licence to operate and is increasingly influencing

consumer behaviour. As such, these companies have also voluntarily committed to reduction targets with respect to a number of environmental indicators as a result of their participation in the Australian Dairy Industry Council's Sustainability Framework. Specifically, these reduction targets include;

- **Target 9:** Reduce the consumptive water intensity of dairy manufacturers by 20%
 - Based on a 2010/11 baseline of 1.75 litres of water per litre of milk processed
- **Target 10:** Reduce greenhouse gas emissions intensity by 30%
 - Based on a 2010/11 baseline of 178.7 tonnes of CO₂-e per ML milk processed
 - Includes Scope 1 and 2 emissions
- **Target 11:** Reduce waste to landfill by 40%
 - Based on a 2010/11 baseline of 2.69 tonnes of waste per ML of milk processed

The dairy processors who have made commitments to these targets report on progress each year and substantial in-roads have been made towards achievement of the goals set. Further work needs to be done, however, and the industry continues to monitor and act upon evolving risks and opportunities which might hinder or support progress.

One vehicle for supporting processor's progress towards meeting the manufacturing-based Framework targets is the Dairy Manufacturer's Sustainability Council (DMSC). The DMSC is a membership based community of practice which includes eight core dairy processor members. These members include; Devondale Murray Goulburn, Lion Dairy and Drinks, Parmalat Australia, Warrnambool Cheese & Butter, Bega Cheese, Bulla Dairy Foods, Norco Foods, and Fonterra Australia. Most of these DMSC members contribute data to the Framework and all of them have an interest in improving the environmental performance of their businesses as well as the overall sustainability of the industry. In bringing together the environmental, sustainability and energy managers from the member companies to discuss progress, evaluate technologies and share knowledge/experiences with respect to environmental compliance or performance, the DMSC acts as a technical working group for the manufacturing related aspects of the Sustainability Framework. Dairy Australia supports and manages the DMSC on behalf of its members.

In order to support the DMSC and the Australian dairy processing sector in achieving its reduction targets 9 through to 11, Dairy Australia is commissioning an annual series of study reports which provide a summary brief to DMSC members on the global risks and opportunities that are arising which might hinder or support progress. These reports will look to cover three main areas of influence on these targets; emerging

technology, policy developments, and funding availability.

The objective of this study and report is to provide a brief overview of the current state of the Australian dairy processing industry, provide a short list of potential technologies that can provide a reduction in the intensity of water consumption. Also, it provides funding avenues and a summary of current/upcoming national and international policy developments which provide opportunities for reducing intensity of water consumption in the Australian dairy processing sector.

Technology selection

Technology Selection Criteria

The study conducted a global scan to identify emerging technologies with potential to reduce water intensity for dairy processors. 'Emerging' was defined as commercially available but with no or low level of take-up by the Australian dairy sector.

Technologies were selected to meet the following criteria, within the Australian context:

- Judged as being beyond current typical good practice in Australia
- Assessed as being potentially cost-effective now or in the near term
- Commercially available
- Demonstrated as applicable to Australian dairy milk processors
- Will result in materially-significant savings to water consumption and processing costs
- Practical to implement

Identified Technologies (and Techniques)

The approach taken to identifying emerging technologies involved consultation with a body of dairy industry technology developers and equipment suppliers. Data was collected from:

- Dairy Australia;
- Isle Utilities' technology database;
- Industry analysts;
- Technology suppliers to the industry;
- Research institutions;
- International research projects;
- Overseas technology suppliers;
- Technical literature; and
- Publicly available literature.

Over 46 technologies and techniques with potential to reduce water intensity within a dairy processing facility were identified and considered for a more detailed analysis. These technologies were split into three main categories based on the water conservation hierarchy shown in Figure 2 :

- Reduce;
- Reuse;
- Recycle.

The hierarchy was developed to illustrate where the priority should lay when it comes to water conservation. The first aim should be to eliminate all

unnecessary waste of water, and to reduce where possible, as this has the lowest inherent risk to the production process. Secondly, low risk sources of water should be considered as an alternative, starting with rain water and then process streams that require minimal treatment. The final option is the full recycling of water that has gone to waste, as this will require the most complex array of processes to treat and therefore creates the greatest risk to the production process.

Consequently, there are a wider range of options to reduce water consumption compared to recycling water and this is reflected in the technologies found for this project.

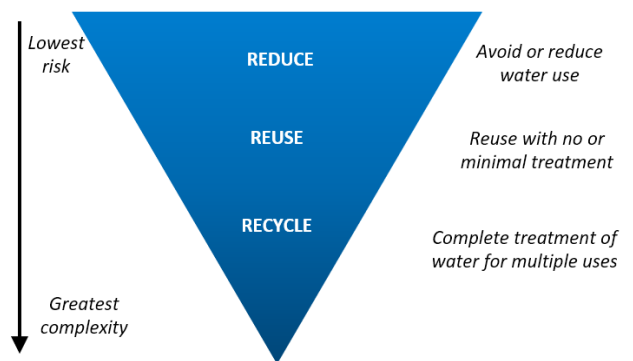


Figure 2 The Water Conservation Hierarchy

A breakdown of how these technologies are spread across the three areas is shown in Figure 3 below.

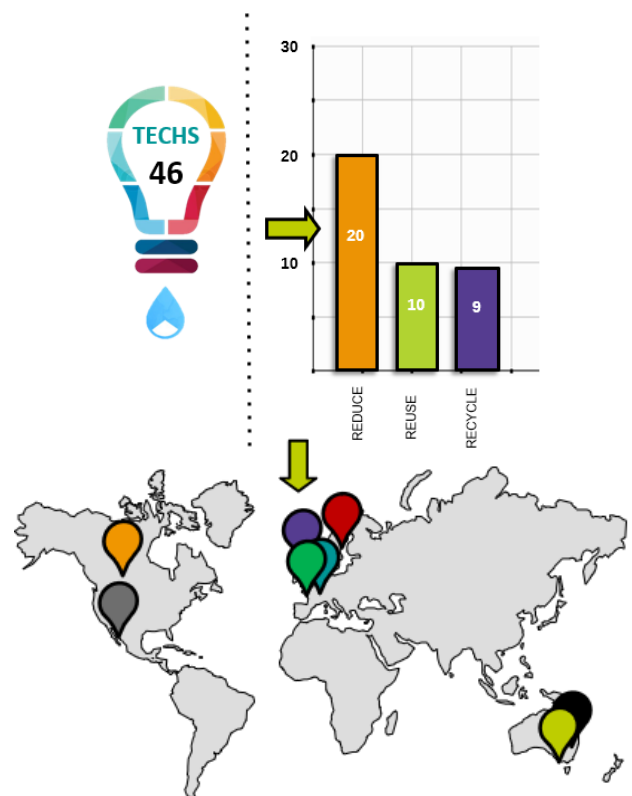


Figure 3 Technology selection at a glance

The technologies were narrowed down to approximately five technologies per category and the selection criteria used is shown in Table 2 below.

Table 2 Criteria for technology selection

Selection criteria	Description
Applicability	Technologies that are applicable to the food and beverage industry with a focus on dairy processing
Technology development	Technologies that are well developed and available to the market for water reduction and treatment (though they may not be already used in dairy processing)
Uniqueness	Technologies that are not widely used in the dairy industry but provide a potential improvement in water management and use
Relevance and Case Studies	Technologies that have case studies in the food and beverage industry that are relevant to dairy processing

Typical water consumption in dairy processing

Milk processing is very water consuming, but this will depend on the product being produced and the process. The actual water use per litre or kilogram of product is hard to obtain as data is not always available. However, if direct water use is considered then the water use per litre milk and flavoured milk processed is between 1.05 and 2.21 L/L (Table 1) in Australia. Similarly, milk processing plants on average use 0.8-1.7 in the UK L/L (WRAP, 2013), 0.98-2.80 L/L in Sweden and 1.20-2.9 L/L in Finland (Wojdalski et. al., 2013). The product that consumes the greatest volume of water is ice cream production, this typically uses 4-6.5 L/kg produced (WRAP 2013), but it can be up to 8 L/kg.

The main water usage areas can be broadly categorised as: process water i.e. CIP; cooling water i.e. to remove heat from the process; boiler feed water for steam production; and miscellaneous water use such as crate washing. As shown in Figure 1 the greatest areas of water use in dairy processing are reported to be in CIP and pasteurisation (thought to mainly be the CIP of this process), which encompasses over 50% of water use and Figure 4 confirms these numbers. Therefore, based on the figure below, this study has focused on technologies to reduce the water intensity required for the CIP and cooling tower processes

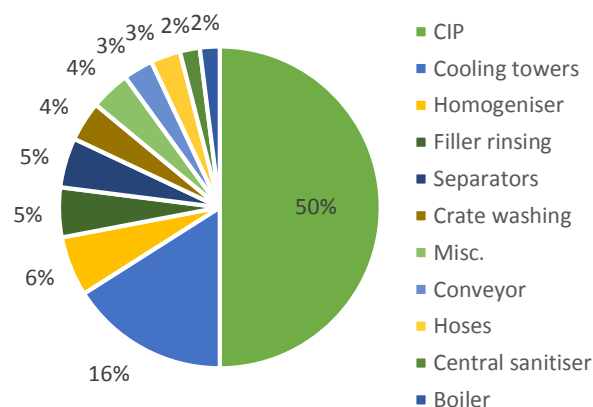


Figure 4 Water Consumption in Dairies - Presented at FPSA Annual Conference (2015)

A high-level process overview was compiled as shown in Figure 5 to get an overview of where water could be potentially reused and recycled. This shows that water for non-product surfaces (with no or minimal treatment) could be reused in the wash water processes and the cooling water systems.

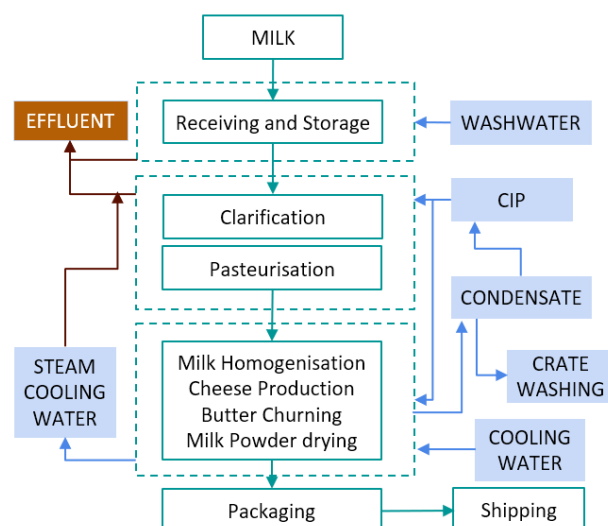


Figure 5 Overview of liquid flows in dairy processing

Business case for reducing water intensity

The typical purchase cost of water in Australia in 2013-14 is an average of \$3.08 per kL. Most dairy processors may be drawing water from a variety of sources such as surface water, boreholes or from the municipal system, therefore the actual cost will vary with the quality and can range from \$1.5-2.9 per kL.

This incoming cost of water should not be used when considering the cost benefit of implementing a technology to reduce water intensity. The business case for saving water only becomes apparent when the full cost of water is taken into account including: the purchase of potable water; treatment of water; heating or cooling of water; treating wastewater;

disposal of wastewater to the sewers; pumping and maintenance; and capital depreciation of related infrastructure. Previous calculations by Prasad et al., 2004, looking at the true cost of water use in dairy factories, and which incorporated some of these elements, demonstrated that the cost of heated water could be as high as \$5.23/kL. This figure was developed using examples of water, trade waste and energy tariffs in 2004, however, all of which have increased substantially in the last 13 years.

DMSC Members discussions

A few of the DMSC kindly gave up their time to provide information on their water consumption, cleaning practices and current water reuse and recycling. These members were:

- Murray Goulburn
- Norco
- Warrnambool Cheese and Butter

A summary of the members' experiences is included under each technology category section.

Other Industry experts consulted

As part of the project, a number of industry experts and end users across the world were consulted on their experiences of reducing water intensity in the dairy industry. They were:

- CSIRO
- Dairy Crest (UK)
- Large multinational product company
- MicroMilk (EU FP7 project)
- DairyWater Project (Ireland)

Their experiences and comments are included under each technology category section where relevant.

Water Reduction

DMSC members experiences

The discussions with DMSC members covered:

- Processes that consume the largest proportion of water;
- Water management including site metering and sub metering;
- Leak monitoring;
- Alternative water use;
- Water saving initiatives.

In general, the members seemed to have a clear grasp of the processes in their plant that were consuming the most water. This was typically through partial sub metering of sites or tank level monitoring, but in most cases, they required manual management. This monitoring has allowed them to review water usage on site and trend it over time, as well as identify systems with unaccounted water losses. All members consulted stated that the CIP processes were the largest consumer of water on their sites and in particular the CIP required for the pasteurisation system. Therefore, they have all had a focus on optimising the CIP process where possible and some members are using conductivity monitoring to assist this aim.

Interestingly, reduction of water use by using an alternative source such as captured rainwater was not particularly considered by the members. There was a feeling that the water would represent a contamination risk. The wider discussion with other industry experts regarding this subject found a similar reluctance due to contamination, with the additional comment that the water recovered might not be a significant amount to offset the costs. Some manufacturing companies however were capturing rainwater on their sites to offset water used for non-product purposes such as irrigation and toilet flushing, which minimises the risk.

In general, water use is not a key focus for the members due to the low-cost drivers, but most are considering or have already implemented some form of water saving initiatives, from staff based water saving KPIs to dedicated water saving teams.

Figure 6 is an overview of the perceived barriers to innovation and potential opportunities

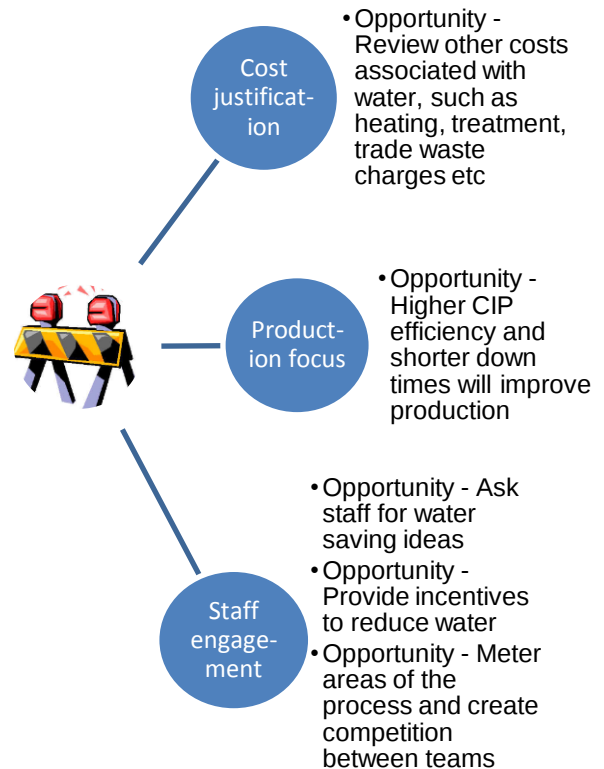


Figure 6 Perceived barriers to innovation in water reduction

Key water saving strategies

The following strategies are already in use at many dairy processors but they are only effective if they are continuously reviewed and reconsidered, especially as processes and operations change over time. These strategies should be considered and employed before or in conjunction with the technologies proposed in this report. The key water saving strategies are:

- Detect and repair leaks;
- Use of efficient spray nozzles;
- Optimise flow pressures;
- Improve process control;
- Reduce water losses from boilers;
- Review processing methods;
- Low water use cleaning methods.

Reducing water use

Based on the discussions with Dairy Australia, the DMSC and other industry experts, a number of water reduction technology areas became the focus of water reduction:

- CIP;
- Rainwater collection;

- Metering;
- Monitoring;
- Washing;
- Leakage.

Potential technologies in these areas were investigated and were shortlisted to seven using the criteria described in Table 2 “Criteria for technology selection”.

Figure 7 below shows the areas that water reduction could be achieved and an overlay of the technologies shortlisted.

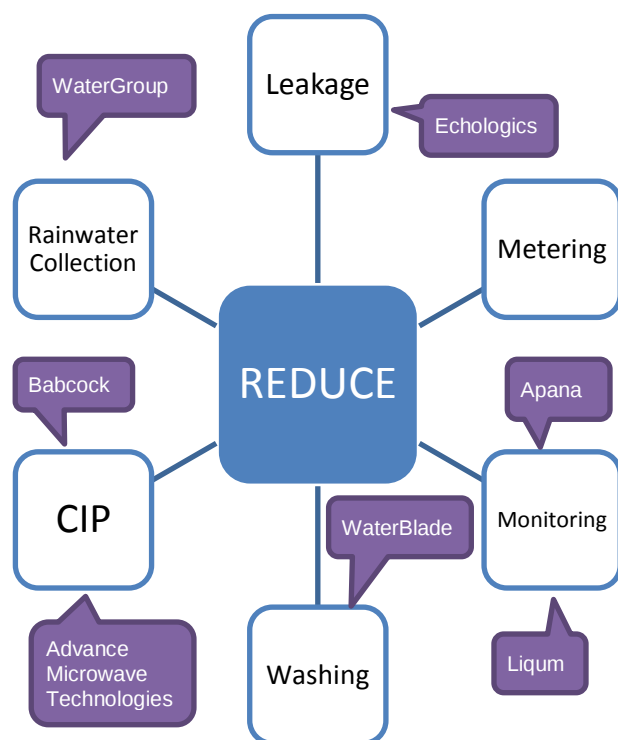


Figure 7 Water reduction areas and technology opportunities

The technologies selected are described in more detail in Table 3 below.

Table 3 Shortlist of water reduction technologies

Company name	Description
Waterblade	Water saving device for taps
Echologics	Non-invasive acoustic detection and location of leaks
Apana	Water management software
Liquim	Multiple electrode probe for water quality fingerprinting

WaterGroup	A rainwater and stormwater harvesting design model
Advanced Microwave Technologies (AMT)	Microwave Volumetric Heating (MVH) of a flowing liquid
Babcock	CIP using air vortex for the effective recovery and removal of any liquefied product

Cost and water reduction technology mapping

The technologies were mapped in Figure 8 to provide an indication of cost effectiveness and is based only on indicative cost information because in many cases cost is site dependent. The technology that stood out from this assessment was the Vector from Babcock because of the very high water reduction possible in CIP processes. It is currently at the demonstration stage and has huge potential to replace existing water based CIP systems.

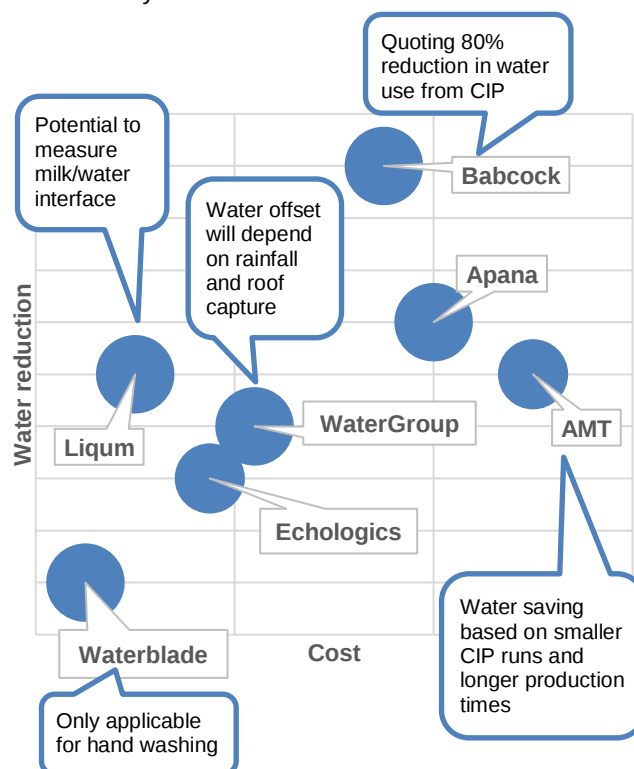


Figure 8 Mapping of water reduction technologies

Technologies prioritised

Following detailed discussions with Dairy Australia, the most applicable technologies, with the greatest potential cost benefit were prioritised and these were:

- **WaterBlade** – This water saving device can easily be installed onto taps and though the overall water savings are small, it is cost effective and has the potential to be adapted for other applications such as spray nozzles;
- **WaterGroup** – Rainwater and stormwater collection systems are straight forward to implement but this

modelling service can provide detailed understanding of the volume of water that might be collected over time and how this relates to the process requirements, optimising the size of collection systems;

- Liqueur – The probe records a chemical fingerprint of the liquid medium it is in and then it is able to indicate variations in quality from this fingerprint, which could be used to optimise CIP;
- Apana – Their water management system consists of multiple water monitoring points throughout a process providing real time data which is analysed by the program. This identifies events and provides guidance on solutions;
- Babcock – This alternative CIP system uses a highly controlled air vortex technology to achieve the product removal in a two-phase process.

On the next pages are summary descriptions of each of the prioritised technologies including information on:

- Applicability;
- Effectiveness of the technology;
- Case Studies;
- Indicative costs;
- Contact details of the supplier.

Information on the technologies that were not prioritised can be found in Appendix A.

Alternative and future technology opportunities

As highlighted in Figure 1, pasteurisation consumes a large amount of water, and this is most likely due to the CIP required to clean the system, and to a smaller extent could also be due to the boiler water required. Either way it is clear that removing or reducing water use from the process would be significant. Below are emerging processing technologies that offer numerous advantages as well as being able to reduce consumptive water requirements.

High Pressure Pasteurisation (HPP)

This is a method of preserving and sterilising food, in which a product is processed under very high pressure, leading to the inactivation of certain microorganisms and enzymes in the food. It involves sealing food products in their final packaging and placing them into a steel compartment containing a liquid, often water. Pumps are then used to create the pressure.

Operational advantages of this technology are the complete elimination of the heat exchanger processes required for traditional pasteurisation through the application of heat. Without this process there is no requirement for the boiler and associated energy and water needed, as well as no need for CIP. There is also no need to cool the product again after heating.

There are other advantages such as: the process extends the shelf life, does not change the texture of the product and enhances digestibility. Despite these advantages, the process is relatively expensive to purchase and requires considerable pressure to be applied, which means a high energy consumption. All the water needed can be collected and reused.

There are two main companies supplying equipment for this process:

- Hiperbaric
- Avure

Microwave heating and pasteurisation

Another alternative process to heat exchangers for pasteurisation and heating products in general is to use microwave systems. By applying microwaves to liquids there is minimal fouling on the surface of pipe, therefore longer processing times are available, the pipe lengths through the system can be considerably shorter than heat exchangers and as metal pipe cannot be used, typically Teflon coated plastic pipes are employed. This all results in a shorter and simpler CIP requirement reducing water and chemical use, not to mention eliminates energy and water requirements of boilers. Due to the energy requirement of the system and maintaining the heat required for pasteurisation, this process may be more suitable to UHT processes.

There are a number of technologies being developed in this area and AMT (mentioned above) have experience processing a variety of food products through their technology. There is also a European FP7 project underway called MicroMilk which is currently at the demonstration stage of their microwave technology. CSIRO have also developed a microwave processing technology that is available to trial.

Dry Cooling

Cooling is required at all dairy processors and is typically achieved through plate heat exchangers and consequently the water carrying away the heat will be put through a cooling system. There are a number of methods for cooling this water: once through, closed loop, dry cooling and hybrid systems. Once through and closed loop cooling systems consume the greatest amount of water and are the most common. Whereas dry cooling systems use air rather than water. However, they are more expensive and not as efficient. The hybrid system is more efficient because a section of the cooling coil surface is wet with water recirculated from a sump at times of high ambient temperature, but at other times the cooler acts as a normal dry cooling system.

Conclusions

Water reduction is the first area that should be considered when embarking on the journey to reduce water intensity. It should be seen as standard practice throughout the process and all employees at dairy processors need to be involved. The individual water

savings may not appear substantial, but it is more the combined savings of multiple activities that provide the significant reduction in water use. In particular, increased metering and water management provides insight into lost water, leakage as well as process issues which may lead to preventing product loss. The greatest individual water saving can be achieved through innovations in CIP.

Water management

There are many ways to monitor and manage water through dairy processes. This would they require an increase in sub metering around a process, to increase data granulation, and allow greater potential to identify unaccounted water use such as leaks, as well as alerting to processes operating incorrectly. This can be done manually or utilising water management systems such as Apana.

CIP

As CIP is the process with the greatest water use, there should be more opportunities to save water. Currently, water reduction is mainly through refining the process timings and recovering the last rinse as the first wash. The addition of conductivity monitoring can also provide security and refinement to CIP operations, but other emerging monitoring methods such as the Liqum probe can assist in identifying the milk/water interface allowing greater clarity on when cleaning is complete.

The major water saving in CIP comes from rethinking the process, such as with the Babcock Vortex system. By using air instead of water, product recovery is increased, water is saved and there are no issues with pipework or constrictions. There is also minimal alteration to the pipework and due to a low energy requirement, the process can have a payback in as low as a year.

Alternative processes for heating and pasteurisation

A more radical approach could be achieved by to changing some operations completely by replacing the traditional heating and pasteurisation processes. The use of either HPP or microwave technologies have several advantages, not just on water reduction, but longer production runs, energy saving and potential improving product quality and shelf life.

WaterBlade

Water saving device for taps

Technology highlights:

- Easy and quick installation
- Low cost
- Simple to keep clean
- Potential to adapt for spray nozzles



Description: Waterblade enables hand washing with half the water consumption of standard taps. Suitable for use in cloakrooms and bathroom basins, it is easier to install, more energy efficient and more hygienic than tap aerators. Waterblade works by taking a trickle of water and spreading it into a paper-thin fan-shaped flow. The user draws their hands through the flow, washing them in an effective and efficient manner. Waterblade is the most efficient handwashing solution available. The alternatives, aerators and spray heads, do not perform as well, additionally, aerators have been shown to harbour and distribute pathogens and are no longer acceptable in food and beverage environments. Waterblade creates a laminar flow, which is more hygienic.

Applicability:

- Waterblade can be fitted to 95% of European mixer taps (any tap with a detachable M22/M24 nozzle, including retrofit)
- Requires only a low flow rate of 2.5 L/m compared with other aerators which operate at 6 L/m, standard taps at 10 L/m

Effectiveness of the Technology

- A typical home tap, used 20 times per day for 15 seconds, would save 4.5 – 13.7 m³ of water per year

Case Studies

- Royal Bank of Scotland carried out a monitored trial on a total of 30 wash basins. Preliminary results show a 66% reduction in water consumption.
- A large UK corporation has, following a trial, determined that annual savings of \$59,000 can be achieved by installing Waterblade throughout a 40-floor office building.
- Sony DADC and a UK water utility are proceeding with roll outs following successful trials. The Waterblade is easily cleaned by wiping with a cloth. It is possible that the Waterblade may accumulate limescale externally on its tip, however none has accumulated after a year in use in a high lime area.

Indicative costs

- ROI depends on usage and utility costs. In an office trial a saving of \$75 per tap per year was calculated (\$50 water and \$25 energy). The Waterblade retails at \$12.50, which corresponds to a payback period of just 2 months.
- In a trial with the Royal Bank of Scotland a saving of \$44.50 per tap per year was measured (\$16.80 water and \$21.80 energy), corresponding to a payback of less than 3.5 months. Ease of installation has been confirmed in all cases by facilities staff. The Waterblade is made from ABS Plastic which is durable and can reasonably be expected to last the lifetime of the tap it is fitted to.

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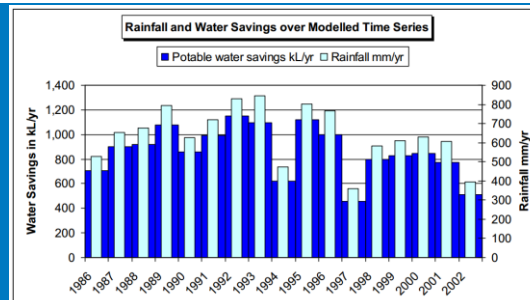
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WaterGroup

RainHarD and StormHarD, rain and storm water harvesting design models

Technology highlights:

- Considers other recycle water streams
- Assesses different options from small to medium to very large
- Capital and operational costs can be estimated



Description: RainHarD and StormHarD were specifically developed to address the need to have a rainwater and stormwater harvesting design model suited for commercial applications. The model allows a reliable prediction of the amount of: runoff available based on runoff coefficient as well as initial loss (taking into account preceding wet days), the amount of water actually saved, i.e. the total runoff minus the overflow amount balanced against a detailed demand model, and the optimum tank sizing through a sensitivity tool. It does this through the daily calculation of water supply using daily rainfall data from the nearest representative weather station coupled with the appropriate daily demand profile. It can consist of up to five different pre-set or custom-made profiles including sophisticated weather based irrigation schedules and the resulting daily storage volume in the tank.

Applicability:

- Modelling the balance between catchment area, tank size and reuse demand allowing for the best possible fit for maximum water savings or economic return (payback). Many rainwater tanks are sized too large.
- Allows for input of other recycled water streams, e.g. fire water testing, or recycled wastewater
- Provides a rough capital cost guide

Effectiveness of the Technology

- Model output parameters are:
 - Optimum tank size,
 - Total runoff,
 - Percentage of total rainwater / stormwater utilised
 - Water saved
 - Percentage potable water reduction
 - Budget cost of the system

Case Studies

- WaterGroup have completed a number of projects with Woolworths:
 - Woolworths Wyong RDC – The water consumption patterns at each site were assessed to determine the best way to save water and money. The site has a collection area of 22,000m² the rainwater system designed saves close to 90% of the potable water consumed in the cooling towers, that's 13,000kL p.a. which equates to almost \$39,000 p.a. There is also reduced scaling due to the softer rainwater
 - Woolworths Minchinbury SRDC – This site has a collection area of 21,000m², and rainwater system modelled and designed saves close to 90% of the potable water consumed in the cooling towers, that's 11,000kL p.a. which equates to almost \$39,000 p.a.

Indicative costs

- An example site in Melbourne, with 16,800m² of collection area and a water cost of \$1.93/kL, could use the rainwater water for cooling towers (consumption 7,000kL/y) and save \$10,835 in potable water.
- Operating costs can be estimated with the model and are approximately 0.5 kWh/kL for larger schemes.
- The service would involve an onsite consultation and modelling of the rainwater system and this would come to an approximate cost of \$1500

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Liqum

Continuous monitoring of change through electrochemical profile in real-time

Technology highlights:

- Real time monitoring of changes in quality
- Battery operated
- Wireless communication



Description: Wireless, on-line probe (Liqum Early Warning LEW-100) for real-time water quality change monitoring, with emphasis on providing an early warning of contamination or natural deteriorations in quality. The system consists of a battery-powered probe which takes a measurement once every minute, 24/7, and transmits the data wirelessly to an Internet hub, which forwards the data to the Liqum Global Service Centre. The signals are converted by means of a bespoke neural network to a Quality Index, or “quality fingerprint”, which appears instantly on the operator’s screen via a secure Internet connection. The sensor is sensitive to a wide variety of parameters whose presence and interaction affect the electrochemical profile of the liquid.

Applicability

- The system can be used for 24/7 monitoring of CIP and other process discharges
- In combination with additional sensors connected upstream, the device can be used for detection and prevention of liquid leakage (milk, cream etc) and hence reduce costs as well as waste
- The Liqum solution typically shows quality changes before they are detected as changes in pH. Many phenomena that the Liqum solution detects, would simply not manifest themselves as changes in pH or conductivity.

Effectiveness of the Technology

- The probe has numerous electrodes and they measure various redox reactions
- There is no focus on specific parameters. The overall quality profile of the water is monitored for deviations from a pre-defined good quality fingerprint.

Case Studies

- A water utility in Finland supplying drinking water to food and beverage companies used the LEW-100 to monitor water entering the distribution pipeline. The system triggered a contamination alarm, and it was found that there was a substantial amount of heavy metals in the water which had not been detected by other means. It was discovered that rain and melting snow, in causing the streams to rise and overflow, led to water draining from the fields into the wells and boreholes.

Indicative costs

- The CAPEX is \$12,000 for a single sensor, plus \$450 per sensor per month ongoing charge for data management
- It is a low-maintenance system, therefore typically only the sensor's battery needs changing approximately once a year

Contact details of supplier:

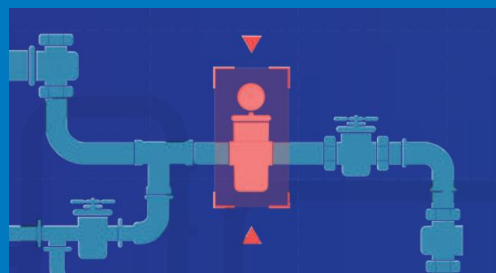
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APANA

Water monitoring and management

Technology highlights:

- Real time visibility and alerts
- Actionable guidance provided
- Holistic approach



Description: APANA ScanNet technology is a system which can delivery actionable alerts. Smart water metering sensors placed in select areas of a facility monitor the water infrastructure around the clock capturing high resolution data down to the second. These sensors send data to a secure, cloud-hosted analytics engine that continuously looks for patterns and discrepancies to isolate water loss events across 1000's of failure points. When water loss is detected, mechanical failures and operational breakdowns are identified at the source. Staff are instantly notified with actionable guidance. Alerts contain automated step-by-step instructions telling operators that there is a problem, where it is, and how to resolve it. Customised reporting and mobile accessible dashboards provide business intelligence, making financial impacts obvious.

Applicability

- Mechanical failure - Malfunctions occur routinely and cooling towers, purification and filtration systems, and CIP are common sources of water waste
- Operational waste - Avoidable water use practices exist in all operations. Sinks and hoses get left running. Production shifts use water differently, even when tasks are the same
- Water volume alerts can also prevent trade waste compliance failure

Effectiveness of the Technology

- Real time alerts are provided to the correct team members who can resolve
- Alerts contain step-by-step instruction on how to resolve the problem, increasing speed and efficiency of water loss prevention
- Customised reporting allows long term planning of water usage

Case Studies

- The warehouse giant Costco started testing a system of sensors and algorithms to cut water use at a handful of its buildings in Mexico. Costco has now expanded the water conservation technology to over 50 sites and has cut water use by 22% on average. The projected water consumption for one location was between 22.7 and 30.3 kL a day, but typical consumption was above 45.4 kL a day. The high-resolution data identified a series of operational and mechanical issues that dropped water use by close to half.

Indicative costs

- Apana can provide a complete service and support, including installation of inline impeller meters and ultrasonic meters where required to provide high resolution data
- Investment in the meters and software system ranges from sub \$13K to \$23K for a typical installation such as a production manufacturing plants, but this can range by two to three times depending on the complexity.

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Babcock - Vector

Low water use CIP

Technology highlights:

- CIP rinse water reduction up to 80%
- Increased product recovery
- First bottle within specification after product changeover
- Reduction in water and chemicals to waste



Description: Vector is a patented smart recovery system for the effective removal of any liquefied product within a distribution system. In its simplest sense it is a replacement for what is known as “pigging” and will remove practically all of the product remnants from a processors distribution system. The Vector utilises highly controlled air vortex technology to achieve the product removal in a two-phase process. The second phase can also introduce atomised rinse water into the air flow (where CIP water flushing is necessary) and this will reduce the dairy producers waste water usage by a minimum of 80%. The benefits of the system are that no launch-and-retrieval system is necessary (unlike pigging) and the process is not restricted by valves, pumps, filters, heat exchangers, bends or internal pipe intrusions. It recovers product at the end of a cycle that would be otherwise lost and it minimises waste and wastewater.

Applicability

- Suitable to be adapted to existing CIP systems with minimal modifications
- The technology is currently being demonstrated at food producers looking to increase product recovery or reduce water use
- Their R&D team are currently working on extending this solution to include pasteurisers and plate pack heat exchangers

Effectiveness of the Technology

- Designed to reduce waste ‘at source’ by removing 99% the liquefied contents from the system at the outset
- Reduces CIP rinse requirements by 80% plus

Case Studies

- Princes foods (UK) installed a duplex system at their soft drinks manufacturing centre. The objectives of this installation were to improve yield, reduce water usage and waste production, to come as close as possible to a zero-loss manufacturing facility. The initial aim was to save 49kg per batch, which would result in recovering 1400 tonnes/year of syrup. The project was expanded though and an additional 201 – 276kg of syrup was saved per batch. Within the original scope the process saved 10,600m³ of water and 12,000m³ of wastewater per annum. The savings so far have been estimated at \$1M per annum which equates to a payback of less than one year. The results of full trial on the site to achieve complete removal of rinse water will be available in November 2017.

Indicative costs

- The CAPEX cost of unit is circa \$250K to \$340K
- Costs for OPEX are site dependent, i.e. power cost and duration of purge, typically \$0.50 to \$0.60 per clearance.

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Water Reuse and Recycle

DMSC members experiences

The discussions with the DMSC covered:

- Boiler water use for pasteurisation;
- CIP systems and water circulation;
- Condensate recovery systems and use;
- Cooling systems.

While there are clear and simple actions that can be taken to reduce water, when considering water reuse and recycle there are a number of additional factors that become key. Any water reused or recycled back into the process has a potential risk to food safety, the additional treatment has an additional cost, as well as energy demand. These are all themes raised by members during discussions, but there are still a clear number of opportunities in these areas. There is opportunity to use the water for cleaning surfaces that do not come into direct contact with food, therefore reducing treatment requirements.

In general, all members were ensuring a closed loop in the boiler systems and re-circulating the final CIP rinse as the first pre-rinse of the next cycle. Where condensate recovery was available, then this water source was reused for a variety of applications such as feed water for boilers (to recover heat as well as the water), in powder plants as rinse water and as well as general wash water. Treatment of the condensate mentioned involved dosing chlorine dioxide to stop bacterial growth. Although this is an effective treatment, it does require a chemical make-up system and alternative options such as ozone dosing could be considered. When recovering condensate, the temperature should also be considered and the heat recovered where possible.

Another point raised by members and the additional experts consulted was in relation to an excess amount of condensate available from the evaporators during certain times of the year when producing powders. Therefore, it is worth considering all options for storage and reuse around the site, as well as opportunities to sell the excess water to other local businesses etc.

For dairy processors without powder production, there is a reduced amount of high quality water for reuse and therefore the next step would be to consider increasing recycling around cooling towers and recycling wastewater from the site. In general, the members were not considering this as option due to the lack of drivers caused by the low cost of potable water. Despite the general trend, one member was concerned about the possibility of future drought and water restrictions. As a result, a trial was recently launched on membrane wastewater treatment with the aim to add filtration before using it back on the site. Almost full reuse and recycle is also being done by Dairy Crest in the UK at a site where the drivers are limits on

abstraction, an unreliable potable water source and a desire to expand production. They now treat the majority of the wastewater with MBR, then UF and RO before disinfection, and use this for food surface contact processes such as CIP. To ensure that they are using the water that costs the lowest to produce, recycled water, potable water, abstracted water and condensate water are all kept in separate tanks and drawn on as required.

The final area of water use discussed with the members were cooling towers. There was a clear feeling that this area of the process had yet to be seriously considered for water reuse and recycling.

Figure 9 is an overview of the perceived barriers to innovation and potential opportunities.

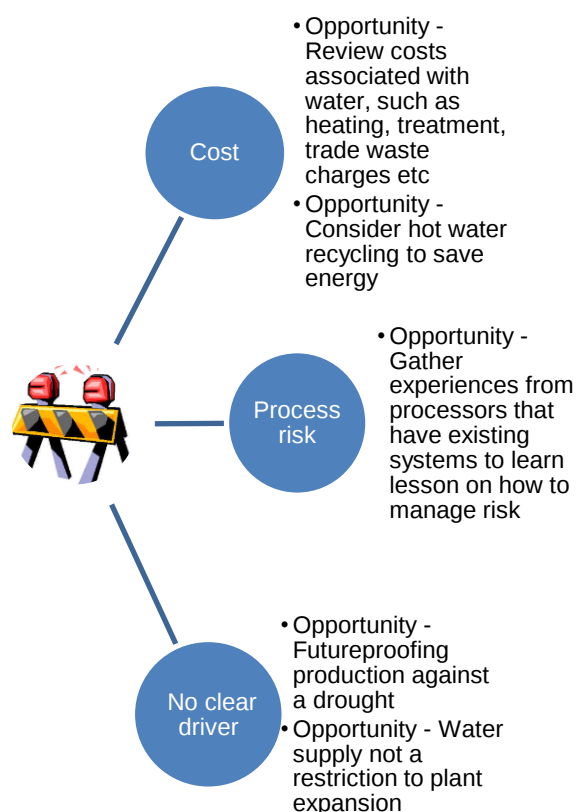


Figure 9 Perceived barriers to innovation in water reuse and recycling

Treatment technologies

To achieve full water recycling, as discussed above, the wastewater treatment will typically require biological treatment to remove the organics and reduce the solids loading before some form of membrane filtration. Membrane filtration uses semi-permeable polymeric or ceramic membranes. Polymeric membranes can have small enough pore sizes for RO, but ceramic membranes typically can only go as small as 2nm (nanofiltration range) but they have the advantage in being much more robust and can resist high temperature or extreme pH. Figure 10 provides a

rough guide to what filtration level is required for various waste streams (depending on what the reuse purpose) by showing what product is removed by which type of membrane. The cost benefit consideration however needs to take into account the increasing energy required to drive the liquid through the membrane as the pore size gets smaller.

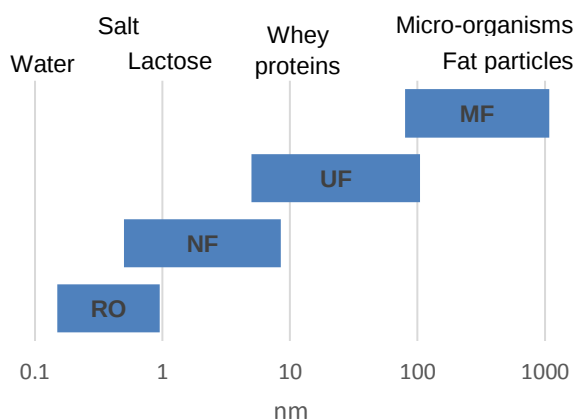


Figure 10 Pore size and type of product removed with various types of membrane

Water reuse and recycle

Based on the discussion with Dairy Australia, the DMSC and the analyses above, three process flows stood out where water reuse and recycling can be utilised:

- Wastewater;
- Condensate;
- Cooling Water.

Technologies that could assist or perform the reuse and recycle responsibilities were investigated and seven were shortlisted using the criteria described in the Table 2 “Criteria for technology selection”.

Figure 11 below shows key process flows where the water could potentially be reused or recycled and an overlay of shortlisted technologies that could be applied.

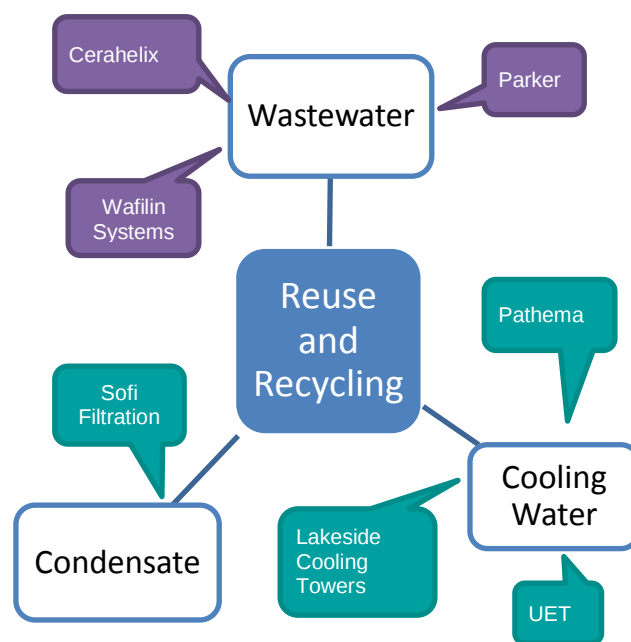


Figure 11 Key process flows where there are technology opportunities to reuse or recycle water

The technologies selected for potential water reuse and recycle are described in more detail in Table 4 and Table 5, respectively below.

Table 4 Shortlist of reuse technologies

Company name	Description
Pathema	Low-energy Vortex Process Technology (VPT) coupled with filtration and UV disinfection for cooling water treatment
UET	Cooling tower water treatment which solves scale, corrosion and biological contamination problems electrochemically, without the use of chemical additives
Lakeside Cooling Towers	Antimicrobial coating in their cooling tower fibreglass components allowing use of recycled wastewater
Sofi Filtration	A self-cleaning microfilter, using Integrated ultrasonic and back-pulsing functions, operating at the range of 0.1-20 micron

Table 5 Shortlist of recycle technologies

Company name	Description
Cerahelix	Electro-PicoFiltration - electrocoagulation (EC) and filtration using ceramic picofiltration (PF) membranes
Parker	Momentum from Parker is a fouling-resistant vibrating membrane system
Wafilin Systems	Specialists in designing membrane filtration systems in the food, beverage and dairy industries

Cost and water reuse and recycle technology mapping

The technologies were mapped to provide an indication of cost effectiveness. This is based only on indicative cost information because in many cases cost is site dependent. The technology area that stood out from this assessment was the possibility of recycling water in cooling systems and both technologies identified in this assessment aim to provide chemical free cleaning that will extend the number of times the water can be recirculated. This both reduces the clean water requirement for the process and wastewater produced.

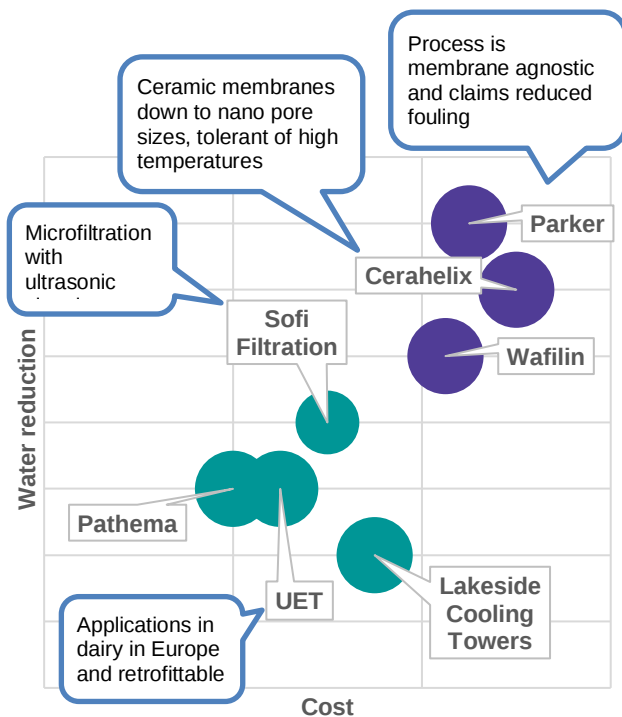


Figure 12 Mapping of water reuse and recycle technologies

The technology mapping in Figure 12 provides an indication of installation cost relative to water reduction. As previously mentioned due to the complexity of these technologies, all plants will need site-specific business cases generated.

Technologies prioritised

Following detailed discussions with Dairy Australia, the most applicable technologies, with the greatest potential cost benefit were prioritised, these were:

- **Pathema** – The low energy vortex system provides chemical free treatment of cooling tower water and lowers the viscosity of the water, increasing cooling
- **UET** – This process is an electrochemical method of chemical free treatment of cooling tower which removes scaling ions and uses the chloride in the water to disinfect

- **Wafilin Systems** – They focus on the application of membrane systems and can support in testing applications, pilot projects, consultancy, design and engineering

Sofi Filtration was also considered a technology of interest because of the ability of the filters to self-clean using cross-flow and ultrasonics. The system is fully automated, has a high throughput and has no internal moving parts. The filter is in the microfiltration range therefore the application in dairy processing is mainly for solids filtration as part of a water recycling process line.

Information on this technology and the others that were not prioritised can be found in Appendix B.

On the next pages are summary descriptions of each of the prioritised technologies including information on:

- Applicability
- Effectiveness of the technology
- Case Studies
- Indicative costs
- Contact details of the supplier

Conclusions

Water reuse and recycle is a much more complicated area to approach to achieve water intensity reduction. Many dairy processors are already reusing the cleanest streams from production such as the condensate. The next area that should be reviewed is cooling towers to assess whether the recirculation could be improved. The last consideration to reduce water intensity will be the possibility of fully recycling water from the wastewater. Despite the low cost of water and the high cost of fully treating water to potable quality, dairy processors should consider scoping this option for the future to protect against the potential of a drought.

Condensate reuse

Condensate is considered clean water and widely reused as process water with minimal treatment. This option though only provides significant amounts of water for reuse where there is a powder drying process, otherwise it will only partially cover water requirements.

Cooling tower water

There is potential for extending the length of time water is reused in the process, but due to concern over the water quality and associated risk, the best final use for the water from the system would be for cleaning non-product surfaces. There are several options for chemical free treatment that are simple, low energy systems that can be installed on a side stream and both Pathema and UET do this well.

Full recycle of wastewater

This option is usually only feasible if there are water pressure drivers such as water scarcity (either due to a drought or restriction on abstraction). Typically, these systems require full biological treatment of the wastewater followed by ultrafiltration or nanofiltration and RO. These technologies are all fully developed and on the market, but the key will be choosing the right technology for the application to ensure the best cost benefit. Wafilin Systems are specialists in this area and have a track record with dairy processors in Europe.

There are continued innovations in this area though and Cerahelix have been continuing to develop ceramic membranes with smaller pore sizes so they can be used on hot water streams, recovering heat as well as water.

Pathema IVG-CT

Chemical free IVG:C cooling tower water treatment system

Technology highlights:

- Chemical free
- Lowers the viscosity of the water, raising its surface area and enhancing cooling capacity
- Blowdown and intake water requirements reduced



Description: Water in evaporative condensers and cooling towers must be treated to control microbial growth, scale formation, and metal corrosion. Also, the heat transfer performance of the cooling tower must be maintained, which correlates to energy consumption. Chemical dosing in the cooling water is traditionally used to control these issues. Pathema's solution is based on low-energy Vortex Process Technology (VPT). When this physical treatment technique for cooling towers is combined with ongoing monitoring of performance, significant benefits can be realised compared to traditional treatment methods. The technology is a side stream water treatment process that uses a combination of these physical treatment disciplines – Hydrodynamic cavitation (through the VPT); side stream filtration of scale and other solids; UV-C light microbiological control system – with an integrated Monitoring and Control System. The VPT degasses micro bubbles present in the water and crystalizes lime into calcite and aragonite.

Applicability

- The solution is suitable for all cooling applications and industries that evaporate water for cooling.
- It is implemented separately from the cooling tower as part of a loop, circulating buffer water for continuous treatment and control of blowdown.

Effectiveness of the Technology

- The heat transfer capacity of degassed water is improved by 3-5%.
- Crystalized lime does not as readily precipitate on hot surfaces in the system.
- Water viscosity falls by 20%, creating a larger cooling surface.
- Particles of lime and other materials are continuously removed by manual or automatic filters (70 – 900 micron versions available).
- Continuous UV disinfection keeps biological growth to a minimum.

Case Studies

- The VPT has been applied to cooling towers at over 25 sites in Europe, such as breweries, food processing plants, ice rinks and data processing centres.
- Heineken Brewery – research was undertaken at the Hertogenbosch site to test the employability of the IVT-CT. After 16 weeks it was confirmed that the evaporative condenser can be operated chemical free without risk, provide 5% water saving by further cooling the water and allows 100% water savings by using rinse water from the brewery.

Indicative costs

- The CAPEX is approximately \$70,000 for the IVG20-C PRO skid
- ROI is typically 1.5 to 3 years. The savings are on discharge of blowdown water, chemicals, cooling water intake and chiller energy consumption (0.7% lower; only in evaporative condensers).

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UET

Non-chemical water treatment technology

Technology highlights:

- Removes excess minerals not all, avoiding metal oxidation
- Reduces intake water consumption
- Produces in-situ biocide



Description: The UET – CT process, developed by UET (Israel), solves scale, corrosion and biological contamination problems electrochemically, without the use of chemical additives. It is based around 2 electrodes; the cathode removes scaling ions and the anode produces chlorine gas from chloride already present in the water (subsequently transformed into hypochlorite). Disinfection can be continuous or via shocks. A control unit, utilizing patented algorithms, regulates chlorine production (to ensure full disinfection) and the removal of hard minerals (removing just enough to prevent scaling without causing corrosion). Scale is manually or automatically removed from the system several times per year.

Applicability

- UET – CT is primarily used for cooling tower water treatment, but can also be applied in RO pre-treatment
- It is used in a side stream configuration. Flow from the recirculation pump is introduced into the processing units, treated, then return to the cooling water basin.
- Each system is custom-designed according to the mineral composition of the local supply water.

Effectiveness of the Technology

- UET – CT actively removes excess hard minerals but leaves just the right amount of unbound minerals in the water to avoid oxidation of metal cooling tower components
- The result is a higher cycles of concentration (COC) in cooling towers and higher recoveries in RO systems. A cooling tower fed with potable water would typically run at a COC of 2 (half of the makeup water is discharged) due to oxidation and scaling factors. Using UET – CT, the same cooling tower would run at a COC of 10 (only 10% of the makeup water is discharged)

Case Studies

- A data centre in Amsterdam that replaced a conventional (chemical) water treatment system with UET – CT was able to switch its make-up water source from potable water to groundwater, with an 83% reduction in OPEX. CAPEX for the turnkey system was ~\$75,000, with a payback of 1.5 years.
- UET – CT was installed at a Parmalat dairy processing facility in Italy. The cooling circulation flows were 450m³/h and the system saved 8000m³/yr. of water, with a ROI of 1.5 years.

Indicative costs

- A simple 30m/sec flow Cooling Tower STD-CT1x4 Reactor Set is approximately \$15K supplied & commissioned, excluding works.

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Wafilin Systems (NL) / Hydrasyst (AU)

Design and construction of membrane systems.

Technology highlights:

- They have developed two applications in brining cheese and milk concentration
- High water recovery rate and quality
- Increased productivity



Description: Wafilin Systems and Hydrasyst merged in 2017. Both companies now focus on the application of membrane filtration in the food and process industries. They provide support for testing applications, supervising pilot projects, consultancy, design, engineering but also focuses on production of complete membrane filtration systems. Recent developments are focusing on concentrating milk at the farm and applications equipped with unique ceramic membranes to treat extreme process water streams.

Applicability

- Brine management in cheese production - a low energy ultrafiltration membrane process that is successfully treating the brine in cheese production, improving quality and production efficiency and reducing water consumption to make clean brine.
- Milk concentration at the farm - The concept involves integrating the concentration system with milking robots, which allows for continual use of the membrane system throughout the day.

Effectiveness of the Technology

- Brine management application - Extends life of brine bath used in cheese production, improving factory capacity and quality of cheese. Also reduces downtime in brine replacement effectively increasing the capacity of the cheese factory
- Milk concentration at the farm – The technology significantly reduces milk handling and storage costs. Moreover, the technology simplifies the cheese and milk powder production process resulting in significant savings in cheese factory plant capital and operational costs. The water extracted from the milk is of very high quality

Case Studies

- Brine management in cheese production – currently being used at a cheese production plant in the Netherlands
- Milk concentration at the farm - The prototype has been tested and improved, whilst several parameters have been analysed to validate the quality of the milk. The results of the last tests showed the milk is concentrated to a composition of 25% dry matter

Indicative costs

- Information pending

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Government Policy Developments for Water Intensity Reduction

The following section is a brief summary of the current/upcoming national and international policy developments which may provide risk or opportunity towards achieving the industry's water intensity reduction targets.

International conventions and agreements

Australia is party to a number of these international conventions and agreements relevant to water that have been reflected in national legislation. Below is a summary of the most relevant.

Paris Agreement 2015

The Paris Agreement sets in place a durable and dynamic framework for all countries to take climate action from 2020, building on existing international efforts in the period up to 2020.

Though the agreement is not strictly about water, climate policy will have far-reaching implications for the availability of water and vice versa. According to the OECD Environmental Outlook, the global demand for freshwater will increase by 55 per cent between 2000 and 2050 (OECD, 2014). Climate change will impact in a direct way, through water availability and use, on various livelihoods and numerous economic sectors (e.g. agriculture, energy and tourism). This impact will be seen in a number of ways:

- Increases in droughts and flooding
- Seasonal changes in rainfall
- Deterioration in water quality (e.g. the salinisation of freshwater).

Australia in particular has set an ambitious target to reduce emissions by 26-28 per cent below 2005 levels by 2030. This may result in policy changing to increase water resilience through:

- Greater water reuse and recycling to reduce pressure on resource
- Increased monitoring and measuring systems to ensure water quality

Kyoto Protocol 2012

The Kyoto Protocol (Kyoto Protocol to the United Nations Framework Convention on Climate Change), which entered into force in 2005, obligates certain developed countries (including Australia which ratified the Protocol in 2007) to reduce their emissions of six main greenhouse gases. The Kyoto Protocol was amended in 2012 to incorporate a second commitment period from 2013-2020. Similar to the Paris agreement, this will influence industry with regards to ensuring increased resilience against the impacts of climate change on water resources (i.e. requiring companies to

have greater flexibility to change and uncertainty in water supplies).

Australian legislation

Australia faces major challenges in ensuring sustainable water supply in the face of a drying climate and growing demand for water. National and State based water policy and legislation, partially influenced by international agreements, has been put in place to ensure best practice in water resource management. Below is a summary of National legislation that are relevant to the dairy industry in an indirect or direct manner.

Water Act 2007

The Water Act provides the legislative framework for ensuring that Australia's largest water resource, the Murray-Darling Basin, is managed in the national interest. In doing so the Water Act recognises that Australian States (Queensland, NSW, Victoria and South Australia) in the Murray-Darling Basin continue to manage Basin water resources within their jurisdictions.

National Water Initiative

The National Water Commission (NWC) was established under this National Water Commission Act 2004 and it was responsible for the implementation of the National Water Initiative (NWI). The Commission was abolished in 2014 with the repeal of the National Water Commission Act 2004. The NWI is an intergovernmental agreement representing a shared commitment by governments to increase the efficiency of Australia's water use, leading to greater certainty for investment and productivity, for rural and urban communities, and for the environment. The overall objective of the National Water Initiative is to achieve a nationally compatible market, regulatory and planning based system of managing surface and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes.

Under the NWI, governments have made commitments to:

- prepare water plans with provision for the environment
- deal with over-allocated or stressed water systems
- introduce registers of water rights and standards for water accounting
- expand the trade in water
- improve pricing for water storage and delivery
- meet and manage urban water demands.

State legislation

Many states have legislation and policies that far exceed the national governance on water.

Future of water reform in Australia

Recently there has been little detailed intergovernmental direction about the next steps in Australia's water law and governance journey. It is increasingly unclear how resilient Australia's water reform blueprint (NWI) will be in the face of shifting political agendas, growing complexity, reform fatigue, shrinking public resources at state levels and the absence of an independent oversight body like the NWC.

Even with this in mind, it is believed that the key priorities in the future will be:

- Greater regulation of market through educating water users to stick to abstraction limits and enforcing discharge limits
- Extension of metering, monitoring and accounting to ensure that water resources are not over allocated
- Protect environmental water through ensuring water flow and quality

What does this all mean for the dairy industry

The various National and State based legislation will influence operation of the dairy processing and will drive increased water intensity reduction either directly or indirectly through the local water authority. The impact will be felt in two main ways:

- Through tighter waste discharge volume and concentration limits, as well as increased associated charges
- Through availability of water as a resource, either through restriction of potable water supplies or abstraction limits. This may also pose an opportunity for some companies to trade excess water

Government Financial Support / Incentive Schemes

The following section is a brief summary of current/upcoming national funding programs available which have the potential to reduce water intensity in production (directly or indirectly) for Australian dairy processors.

Potential appropriate financial support /incentive schemes (Table 6)

- Dairy Australia Technology Assessment Scheme (DATA) Scheme
- Dairy Australia Grant Access Support (GAS) Scheme
- Sustainable Regions Grants
- The Project Fund
- Enterprise Solution Centre Programme (ESCP)
- Innovation Connections
- Blue and Green Business Program
- ACTSmart Business Energy and Water Program
- AgriGrowth Loan Scheme
- Advanced Food Manufacturing Grants Program
- Food and Beverage Implementation Grants

Schemes not directly relevant (Table 7)

The following schemes are not financial in nature but could provide dairy processors with relevant support in reducing water intensity

- Business Evaluation
- Environmental Upgrade Agreements
- Better Business Partnership
- ecoBiz Queensland
- Resource Productivity Assessments

R&D Tax Incentive

The R&D Tax incentive is a self-assessment program. It provides a tax offset for some of a company's cost of doing eligible research and development (R&D) activities by reducing a company's income tax liability. Tax offsets of 43.5% or 38.5% are available for costs incurred on eligible activities depending on a company's annual aggregated turnover. The 43.5% benefit is a refundable offset.

To be eligible for the R&D Tax Incentive the dairy processor must conduct at least one activity that meets the legislated definition of a core R&D activity. A core R&D activity involve at least one hypothesis guided experiment that is undertaken to generate new

knowledge. Other non-experimental activities that directly support a core R&D activity may be eligible as supporting R&D activities. Core and supporting R&D activities are defined under sections 355-25 and 355-30 of the Income Tax Assessment Act 1997.

More details can be found [here](#)

Table 6 Details of potential Government Financial Support / Incentive Schemes

Name	Link	State	Agency	Status	Description	Funding available	Ratio	Contact details
Dairy Australia Technology Assessment (DATA) Scheme		National	Dairy Australia	Open	An initiative providing financial assistance to Australian dairy processors to undertake a detailed commercial assessment of an innovative technology or practice which the project proponent can demonstrate has clear potential to significantly improve the Australian dairy industry's economic or environmental performance	\$50K	100%	Ian Olmstead Program Manager T: 03 9694 3811
Dairy Australia Grant Access Support (GAS) Scheme		National	Dairy Australia	Open	An initiative funded by Dairy Australia(DA) which provides financial assistance to Australian dairy processors to engage specialist grant writers and technical consultants to assist with developing submissions for project funding support.	\$10K	100%	Ian Olmstead Program Manager T: 03 9694 3811
Sustainable Regions Grants	Link	National	NAB	Open	The Sustainable Regions Grants from the NAB Foundation support the development and implementation of regional approaches to: strengthen co-ordination and collaboration between environmental groups, business, landholders and government, involve the community in practical on-ground action to improve the environment, and implement regional solutions to environmental challenges	\$10K to \$1M	100%	
The Project Fund	Link	National	FIAL	Open	The Project Fund aims to boost competitiveness and productivity in Australia in the Food and Agribusiness Sector, by providing matched funding for multiple collaborative industry partners (a 'Consortium') to deliver innovation projects that address one or more of the four objectives of the Growth Centre	\$10K to \$2M	50%	T: 03 9731 3422 info@fial.com.au
Enterprise Solution Centre Programme (ESCP)	Link	National	FIAL	Open	The programme aims to boost competitiveness and capability in the Australian Food and Agribusiness Sector by providing matched funding to industry partners to deliver innovation that addresses a technical challenge that is limiting a company's ability to maximize their market potential.	\$100K	50%	T: 03 9731 3422 info@fial.com.au
Innovation Connections	Link	National	AusIndustry	Open	Provides small and medium sized businesses with access to expert technology advice to address technology and knowledge gaps, and collaborate with the research sector in developing new ideas with commercial potential.	\$50K	50%	T: 13 28 46
Blue and Green Business Program	Link	NSW	Rous Regional Council	Open	The Blue and Green Business Program can provide financial assistance to businesses, schools and other non-residential water users of the Rous Water regional water system to: improve their water efficiency or reduce their demand for water from the water system.	\$25K	100%	T: 02 6623 3800 water@rouswater.nsw.gov.au.
ACTSmart Business Energy and Water Program	Link	ACT	ACT Government	Open	Rebates are available to eligible ACT businesses wanting to upgrade to more water-efficient and energy-efficient technologies, including with lighting, appliances, heating or cooling, refrigeration, insulation, toilets and tapware	\$5K	50%	T: 13 22 81. actsmartbusiness@act.gov.au

Name	Link	State	Agency	Status	Description	Funding available	Ratio	Contact details
AgriGrowth Loan Scheme	Link	TAS	Business Tasmania	Open	Scheme to provide low interest loans to Tasmanian farm businesses and agri-food businesses with the aim to increase the value of the agriculture and agri-food sectors in Tasmania.	\$1.5M		T: 1800 440 026 businessfinance@stategrowth.tas.gov.au
Advanced Food Manufacturing Grants Program	Link	SA	SA Food Innovation Centre	Round 4 Open	The AFM grants program is designed to encourage collaboration between food manufacturers and research and development providers, creating partnerships that will lead to future opportunities. Grants are available to support South Australian food businesses to partner with public or private research providers to develop innovative or novel products or processes.	\$200K		T: 08 8226 0109 PIRSA.foodinnovationcentre@sa.gov.au
Food and Beverage Implementation Grants	Link	SA	Green Industries SA	Open	Food and Beverage Implementation Grants offer eligible businesses the opportunity to install, upgrade, or add to trade waste management infrastructure at a reduced cost.	\$300K	50%	Oliver Lovat Project Officer, M: 0437 641 138

Table 7 Details of indirect schemes to provide support to reduce water intensity

Name	Link	State	Agency	Status	Description	Contact details
Business Evaluation	Link	National	AusIndustry	Open	Provides businesses with access to experienced, independent Business Advisers to review the business and provide a Business Evaluation Action Plan with recommended strategies for business improvement or growth. The Evaluation includes up to 12 months of mentoring to help implement the strategies.	T: 13 28 46
Environmental Upgrade Agreements	Link	NSW	NSW Government	Open	Building upgrade finance is private finance used to upgrade non-strata commercial buildings.	T: 131 555
Better Business Partnership	Link	NSW	Better Business Partnership	Open	Better Business Partnership aims to help reduce energy and water bills of businesses in Sydney's North Shore region. Businesses will gain recognition for joining the scheme and reducing their energy, water and waste. Participation in the Better Business Partnership is free for small to medium sized businesses located in Ku-ring-gai, North Sydney and Willoughby City Council areas.	Nathan John Manager T: 9777 7516
ecoBiz Queensland	Link	QLD	CCIQ	Open	The program provides Queensland businesses and organisations access to complimentary tools and events including one-to-one coaching, site survey, online benchmarking, workshops and webinars to reduce energy, water and waste	T: 1300 731 988 ecobiz@cciq.com.au
Resource Productivity Assessments	Link	SA	Green Industries SA	Open	Aims to identify opportunities for improving business operations by making it more efficient, saving resources (materials, water, energy), preventing waste and increasing productivity, all of which can help reduce operating costs and improve business performance and profitability.	Oliver Lovat Project Officer, M: 0437 641 138

Appendix A

Water Reduction – Technology profiles

Echologics

Leak detection

Description: The LeakfinderRT is used for cross-correlating the precise position of underground leaks within water networks. The LeakfinderRT is capable of detecting leaks using magnetic based accelerometer sensors, not only on metallic and asbestos pipes but also on plastic pipes. Traditionally leaks on plastic pipe have been difficult to detect using the correlation technique. This is due to the low amplitude; low frequency leak signals being easily attenuated on the plastic walled pipe.



Applicability:

- In an industrial setting Echologics' can accurately and efficiently locate a leak, without breaking ground or disrupting service
- Its proprietary sensor and signal conditioning technologies substantially reduce both electronic "white" noise as well as ambient background noise often created by running water, traffic or pumps,

Effectiveness of the Technology

- Traditionally, locating leaks in industrial facilities has been challenging because excessive noise that tends to characterize these environments makes it difficult to locate leaks without excavating sections of the pipe or temporarily shutting down operations

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Advanced Microwave Technologies (AMT)

Microwave volumetric liquid heating

Description: AMT has developed a unique method of heating liquids, suspensions and semi-solids using microwaves. The technical breakthrough is that for the first time microwaves can be instantly and evenly delivered into a flowing stream of material to a depth of 50 mm on a commercial scale. This is now known as Microwave Volumetric Heating (MVH) as the entire volume of the liquid is heated as opposed to the surface where subsequent conduction and convection is required to dissipate the heat.



Applicability:

- Commercially deployed within the food industry with several machines now operating 24/7 in fruit juice production throughout Europe
- The technology can treat difficult sticky liquids without fouling

Effectiveness of the Technology

- Efficiency kills microbes at a lower temperature in a shorter time
- The technology heats the entire volume of the liquid almost instantaneously to within 1°C without any hot surfaces. This reduces the pasteurisation temperature by 15-20°C

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Appendix B

Water Reuse and Recycle – Technology profiles

Lakeside Cooling Systems

Antimicrobial coated cooling tower

Description: Lakeside Cooling Towers have developed systems that protect against potential bacterial growth within cooling towers. This is achieved through the antimicrobial coating in its fibreglass components. The coating is also effective against bacteria such as E. Coli, Salmonella, Listeria, Streptococcus and Staphylococcus as well as fungi and algae growth. This is important in water conservation as Lakeside Cooling Towers can use recycled or untreated ground water and treated waste water in its cooling process. The new technology is approved for skin contact and also has approval from EU and US regulatory authorities for use in systems that include contact with food and water.



Applicability:

- The Lakeside Cooling Towers are applicable for all cooling applications and in particular for retrofitting or replacing existing cooling systems as they are much more compact than standard equipment.

Effectiveness of the Technology

- Once the coating is incorporated into the fibreglass it will kill and inhibit the growth of micro-organisms that come into contact with the material.

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Sofi Filtration

Self-cleaning microfilter

Description: Sofi Filter is a self-cleaning microfilter operating at the range of 0.1-20 micron. The design criteria for the filter was to accomplish a cross-flow filter that is compact and fully automated with a high microfiltration capacity and novel clean-in-place abilities to prevent clogging. The unit requires no internal moving parts to create a high cross-flow velocity, making it robust and economical to use. Computational fluid dynamics (CFD) modelling shows a cross-flow velocity of about 20 m/s is achieved.



Applicability:

- Sofi Filter is used to treat large streams of water containing fine particles that are difficult to treat with traditional methods.
- System can provide solids-free water for reverse osmosis.

Effectiveness of the Technology

- Sofi Filter utilises a patented cross-flow method to achieve high flux and prevent particle build-up, and therefore filter clogging.
- Integrated ultrasonic and back-pulsing functions automatically regenerate the filter element without the need for frequent filter changes or chemical wash.

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Cerahelix - PicoHelix

Ceramic membrane filtration

Description: The PicoHelix extends the ceramic filtration range beyond nanofiltration to picofiltration. It is a high purity ceramic filter that removes dissolved contaminants from wastewater at the molecular level with minimal fouling, while using less energy and pre-treatment than conventional filtration. The PicoHelix is manufactured using a patented technology that makes pores that are linear, nearly identical in size and incredibly small for a ceramic membrane.



Applicability:

- The combination of small pores in a ceramic material enables the removal of dissolved solids under a variety of challenging process conditions; low pH (2-4), elevated temperatures (>80 degrees C) and the presence of solvents and chlorine.

Effectiveness of the Technology

- The resulting ceramic membrane contains highly uniform pores less than a nanometre in size that can filter with high flux (10 LMH/bar) at a low cut off (<500 Daltons).
- Fouling resistance is enhanced because the surface is hydrophilic and resists build-up of organic materials.

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Parker

Fouling-resistant vibrating membrane system

Description: Fouling is a key challenge for membrane systems, especially in high suspended or dissolved solids applications. Parker's Momentum is a fouling-resistant membrane system. It features a unique vibrating mechanism which generates high shear force right at the membrane surface, preventing solids from attaching and keeping membrane pores open. Thus, the membrane surface stays clean longer, ensuring faster throughput and higher recovery. Since the vibration is generated by only one moving part, and takes advantage of the system resonance, very little energy is required.



Applicability:

- Momentum is best suited to applications where the highest level of recovery (or concentration) is required, or the feed stream contains high level of suspended and dissolved solids.
- Little or no pre-treatment is required therefore most applicable where conventional membrane systems are not feasible

Effectiveness of the Technology

- Momentum incorporates a vibration mechanism, providing very high shear at the membrane surface (much like a shaker) and keeping membrane surfaces free from fouling.
- In a recent study on brackish water RO reject (9,500 mg/L TDS), Momentum with RO membranes @ 400psi achieved 63% recovery with an average flux rate of 49.3 L/m²/d

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