

SAVING WATER WITH REFRIGERATION AND PROCESS COOLING PLANTS

Introduction

Water is a scarce and valuable resource in Australia, with all predictions of population growth and climate change pointing towards even greater scarcity in future. Conservation of our water supplies is seen as a moral obligation and increasingly also a good commercial proposition.

This paper outlines water consumption issues relating to refrigeration plant, causes of a water-inefficient plant and the measures to reduce these inefficiencies and overall site water consumption.

All refrigeration systems reject heat absorbed during cooling to the environment, in many different ways. Heat rejection could be to the air, to adjacent water bodies (rivers or lakes), to the ground or even by radiation. This paper is concerned with systems that reject heat to the air as these commonly consume potable water, and analyses the many ways in which this can be accomplished in a commercially feasible manner by using the least amount of water.

“Wet” and “Dry” Cooling:

Heat rejection to the air can be either “wet” or “dry” and “dry” cooling can be assisted with one of several evaporative pre-cooling techniques.

“Wet” cooling encompasses all devices in which the heat is rejected to water, which then evaporates to maintain its temperature. This is also known as latent cooling, as the latent heat of vaporization of water is used to absorb the rejected heat. “Wet” cooling occurs in all conventional cooling towers,

evaporative condensers and evaporative fluid coolers. It is commonly used in large systems due to its low initial cost and low sink temperatures. As a rule of thumb, “wet” cooling consumes about 40 litres/day/kW.

“Dry” cooling encompasses all devices that reject heat by heating the incoming air. This is also known as sensible cooling, as the air is sensibly heated to a higher temperature. “Dry” cooling occurs in all air cooled condensers and fluid coolers. It is commonly used in smaller applications where the maintenance of a “wet” system would be a burden or otherwise undesirable, but all dry systems suffer from

- high fan power costs,
- higher sink temperatures (hence lower system efficiency and higher power consumption),
- greater capital costs,
- greater space requirements and
- higher noise levels.

However “dry” systems do not consume water and have no associated legionella risks or water treatment costs.

To counter some of the disadvantages of “dry” cooling, systems have been devised to pre-cool the incoming air by evaporating water, generally using either a pad or spray arrangement. This reduces the sink temperature, sometimes to temperatures approaching those of “wet” cooling. The major drawback other than the high cost of these systems relative to “wet” cooling is the high water consumption while running “wet”. In Sydney conditions, this can be as high as 160 litres/day/kW. Water savings are achievable only in situations where, due to load and ambient conditions, extended dry operation is possible.

Hence finding the right balance between water and power consumption is not a trivial exercise.

Causes of high water consumption

The causes of high water consumption by a refrigeration plant are many:

1. Use of “wet” cooling where “dry” cooling could be feasible. Wet cooling, especially on large industrial refrigeration plants, will result in substantial amounts of water consumption, but dry cooling can be costly to install and increase system power consumption.
2. Inefficient operation of “wet” cooling devices. Excessive water purging from the evaporative condensers or cooling towers. Bad maintenance measures and poor equipment condition can also lead to excess water consumption.
3. Inefficient operation of the refrigeration plant, leading to excessive heat rejection. Reducing heat rejection reduces water consumption.
4. Lack of energy re-use on site. Re-using waste heat reduces heat rejection, hence saving water.

How to achieve a water efficient refrigeration plant

There are many water saving measures that can potentially be implemented on a refrigeration plant. These can be applied separately or in combination, and include:

1. Implementing a **combination of “wet” and “dry” cooling** techniques with or without water sprays. A careful analysis has to be conducted to analyse the commercial viability of this option. The higher the number of dry coolers, the greater is the fan power required but with reduced water consumption. The higher the number of wet coolers, the greater is the water consumption but with reduced fan power requirements. In addition, dry coolers occupy larger floor space.

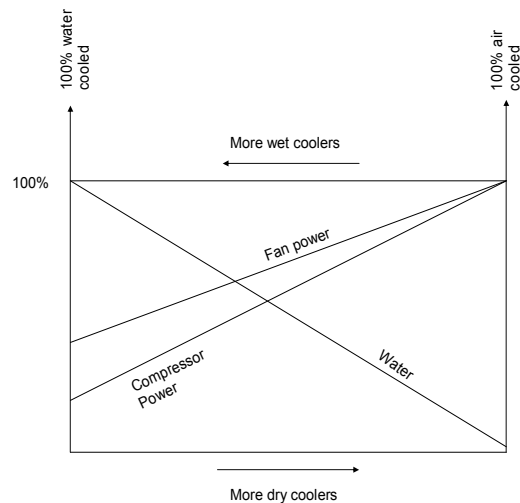


Fig 1: Water and energy efficiency chart

The selection of dry coolers can be done such that, during cold winter months, the dry coolers function as the sole heat rejection devices and the wet coolers are

SAVING WATER WITH REFRIGERATION AND PROCESS COOLING PLANTS

not in operation. During summer operation, the dry coolers with water spray assistance during the hot days, together with the wet coolers provide the total heat rejection capacity.

2. **Replace “wet” coolers with evaporatively pre-cooled “dry” coolers.** Under certain combinations of climatic conditions and heat rejection profiles, water savings can be achieved, whilst in others water consumption can increase. Generally water savings are possible in

- Cooler or temperate climates
- Loads that peak in summer, e.g., air conditioning

In some instances, water consumption can increase, such as

- Applications in warm temperate or tropical climates
- Constant or near constant cooling loads (e.g., process cooling)

An overall cost benefit analysis will reveal whether the added costs of an evaporative pre-cooled unit and the higher fan / pumping costs are sufficiently offset by water savings to achieve a return on the investment.

3. **Reclaiming waste heat** from the plant, thereby reducing the amount of discharge heat and hence the water consumed to reject it. In many cases the reduced heating costs pay for the recovery, and the water savings are a bonus.

Example: to generate warm water.

- Condensing heat can be used to generate warm water at 30-35 °C
- De-superheating can be used to generate hot water up to 60 °C. De-superheating is useful when hot water demand < 15-20% of refrigeration capacity
- When hot water demand >> 20% of refrigeration capacity, then a heat pump can be used to generate hot water at the required temperature.

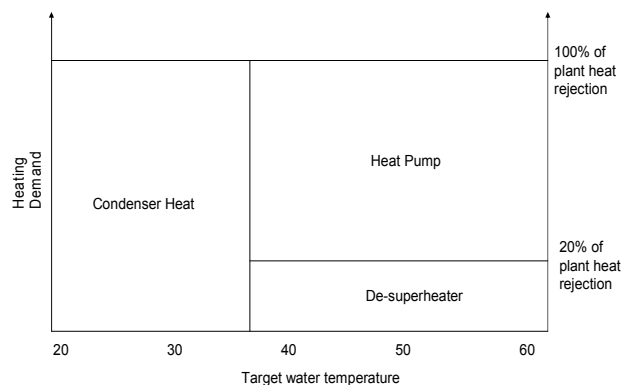


Fig 2: Indicative heat re-use chart

4. Implementing **rain water harvesting** techniques. Rain water recovered from the facility roof, for example, is directed into a rainwater tank, filtered and directed into the evaporative condensers/cooling towers as required. This results in water savings due to reduction of requirement of town-water in the evaporative condensers/cooling towers. An analysis is carried out on its feasibility, where the roof surface area, amount of collectable water, pipe routing, cost of implementation etc are considered. Plant usage and rainfall records are used to size the storage tanks for optimum economy.

SAVING WATER WITH REFRIGERATION AND PROCESS COOLING PLANTS

5. Implementing condensate recovery techniques. Condensate generated in fan coil units and/or air handling units in the facility can be fed directly to the evaporative condenser/cooling towers, hence reducing the town water feed into them. Generally, high condensate flows coincide with high cooling loads, such that the full condensate flow can be utilized at all times without the need for any storage tank.
6. Pre-heating all site water. On large water consuming sites (example: breweries), plant heat can be used to pre-heat all water entering the site up to around 20-25 °C, thus reducing heat rejection and hence water consumption in associated “wet” cooling devices. In many cases, the slightly elevated water temperatures have other benefits also, including reduced heating demand and domestic hot water use.



A V-block dry-cooler

How Minus40 can help

The Minus40 team can assist with the following:

1. Analyse the operation of the plant and advise on the feasibility of combining dry cooler condensers and evaporative condensers/cooling towers
2. Analyse the feasibility of evaporatively pre-cooled condensers/coolers as alternative to conventional evaporative condensers/cooling towers
3. Analyse site hot or warm water requirements and advise on the water savings possible with various heat reclaim and heat pump solutions.
4. Determine the feasibility of rainwater harvesting on the particular facility
5. Determine the feasibility of condensate recovery on the particular facility
6. Conduct preliminary and detailed return on investment studies on the above projects.
7. Assist with preparing government funding applications, e.g. NSW climate change fund.
8. Detailed design, bid support services and project management during project implementation.

Minus40 Pty Ltd

Refrigeration, Thermal Engineering and Process Cooling
Consultants, Designers and Project Managers
Tel: +61-2-8850 4811; Fax: +61-2-8850 4866

www.minus40.com.au