Australian Government

WATER RATING

Technical background research on evaporative air conditioners and feasibility of rating their water consumption

Institute for Sustainable Systems and Technologies

UniSA

Prepared for	**the Water Efficiency Labelling and Standards (WELS) scheme** **Department of the Environment, Water, Heritage and the Arts**
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Executive summary

The installation of mechanical air conditioning appliances is gradually becoming a normal requirement in almost all new and existing Australian dwellings. While the use of refrigerated air conditioners have been rapidly increasing, the market share of evaporative air conditioners has witnessed a steady decline and currently makes up less than 20% of the installed systems in Australian dwellings. Domestic air conditioning has considerable impact on energy use and peak power demand. Evaporative air conditioners consume less energy but require water for their operation.

This report provides technical background material to inform the possible inclusion of evaporative air conditioners in the WELS Scheme with the aim of informing consumers on their water consumption. The report describes current and future evaporative air conditioner designs, principle of operation and main components. It lists and reviews the specifications of available models in the Australian market, which is dominated by four major Australian manufacturers. It also provides information on the suitability of evaporative cooling in major Australian geographical locations.

The water consumption of evaporative air conditioners includes the water evaporated to provide the cooling effect and the water dumped off for the purpose of cleaning and avoiding high salt concentration. The amount of water evaporation is determined by the local temperature and humidity, the air delivery rate as well as the saturation effectiveness. The cooling pad materials commonly in use are Aspen wood and more commonly Celdek. The amount of water dumped off is dependent on the bleeding/dumping method used and the quality of incoming water. The report reviews three bleeding/dumping systems employed, namely: constant bleed off; salinity level monitoring; and periodic/timed drain off systems. The report discusses the bleed off rates and the frequency of draining of the bleeding systems and also discusses different water qualities across Australia and their effect on water consumption and product maintenance.

The report includes available information on water consumption of evaporative air conditioners and calculations of amounts necessary for water evaporation in different Australian locations. On average, evaporative air conditioners consume 2-9% (approximately 4-18 kilolitres per annum) of the total annual water used in typical Australian households and the amount of water consumption is mainly dependent on the water evaporated for cooling purposes.

This report also reviews currently available local and international regulations and standards for testing, labelling and rating evaporative air conditioners. However, none were found that measured their water consumption. The report demonstrates that it is possible to test and rate evaporative air conditioners for water efficiency. A proposed test and evaluation methodology for rating water consumption is put forward. It is proposed that independent testing should be carried out alongside energy consumption testing using a single test facility.

The test requirements and conditions follow current Australian Standards AS/NZS 2913-2000 - *Evaporative air conditioning equipment* and require additional facilities to simulate standard outdoor design conditions, measure incoming water quality and monitor in-situ water consumption. Three key parameters will be evaluated from testing and subsequent computer modeling including (1) total water consumption per hour at design conditions; (2) total annual water consumption and (3) water

dumping rate per kg of cooled air. The last parameter is considered most appropriate for WELS labeling purposes.

The report confirms the suitability of including evaporative air conditioners into the WELS Scheme. However, in view of the relationship between water and energy consumption of evaporative air conditioners, it is recommended that performance rating/labelling of both water and energy should be introduced simultaneously.

Early consultation with manufacturers, suppliers and users groups is considered to be an important step in progressing a labelling/rating system for energy and water use in evaporative air conditioners. A technical study for developing a standard test procedure, testing facilities and methodology for independent testing, rating/labelling of both water and energy use in evaporative air conditioners, as well as modifying the current testing standard to provide for this, is also recommended.

1 Background information

1.1 Types of evaporative air conditioners

The utilisation of water evaporation for cooling purposes has its origins well entrenched in history. Evidence of evaporative cooling applications by ancient people of the Middle East is widely documented and some of these applications are still in use in the Middle East today. They include the use of porous water vessels, the wetting of pads made of dried vegetables which cover the doors and windows facing the prevailing wind and directing the prevailing wind into pools of running water in underground rooms (Saman, 1993). Early Australians also used different forms of evaporative air cooling to obtain some comfort in the hot dry climates of outback Australia.

Direct evaporative air conditioning is ideal for arid climates where water is available. The direct evaporative air conditioners currently produced have, by and large, overcome the drawbacks associated with older systems. In addition to more efficient fan and duct designs and control systems, the use of plastics for the bodywork and cellulose and other synthetic materials for the pads together with automatic water bleeding or flushing has resulted in more reliable operation with little maintenance. Many of today's evaporative air conditioners have quite sophisticated control systems with variable air speeds and pad wetting rates. The one remaining drawback associated with direct cooling is the water saturation limit inherent in the process. Even with saturation efficiency over 80%, which is common for many modern systems, the air supplied may not provide cooling comfort if the outside air temperature is high and/or its moisture content is high and close to saturation with water vapour. The lowest possible temperature limit attained by direct evaporative cooling is the wet bulb temperature at which the delivered air is fully saturated with moisture.

Evaporative air conditioners can be categorised as direct, indirect and two- and multi-stage. Direct evaporative air conditioners are the most popular in the market. As shown in Fig.1 (a), outside air is drawn through wetted filter pads, where the hot dry air is cooled and humidified through water evaporation. The evaporation of water takes some heat away from the air making it cooler and more humid. The dry-bulb temperature of the air leaving the wetted pads approaches the wet-bulb temperature of the ambient air. Direct evaporative air conditioners are more effective in dry climates. As they produce warmer, more humid air in comparison with refrigerated air conditioners, considerably more air volumes are required to produce the same cooling effect. The cool/humid air is used once and cannot be reused. Evaporation (saturation) effectiveness is the key factor in determining the performance of evaporative air conditioners. It is defined by Eqn.1. This property determines how close the air being conditioned is to the state of saturation. Usually, the effectiveness is 85-95% (ASHRAE Handbook, 2007).

$$\varepsilon_e = 100\frac{t_1 - t_2}{t_1 - t'} \tag{1}$$

Where

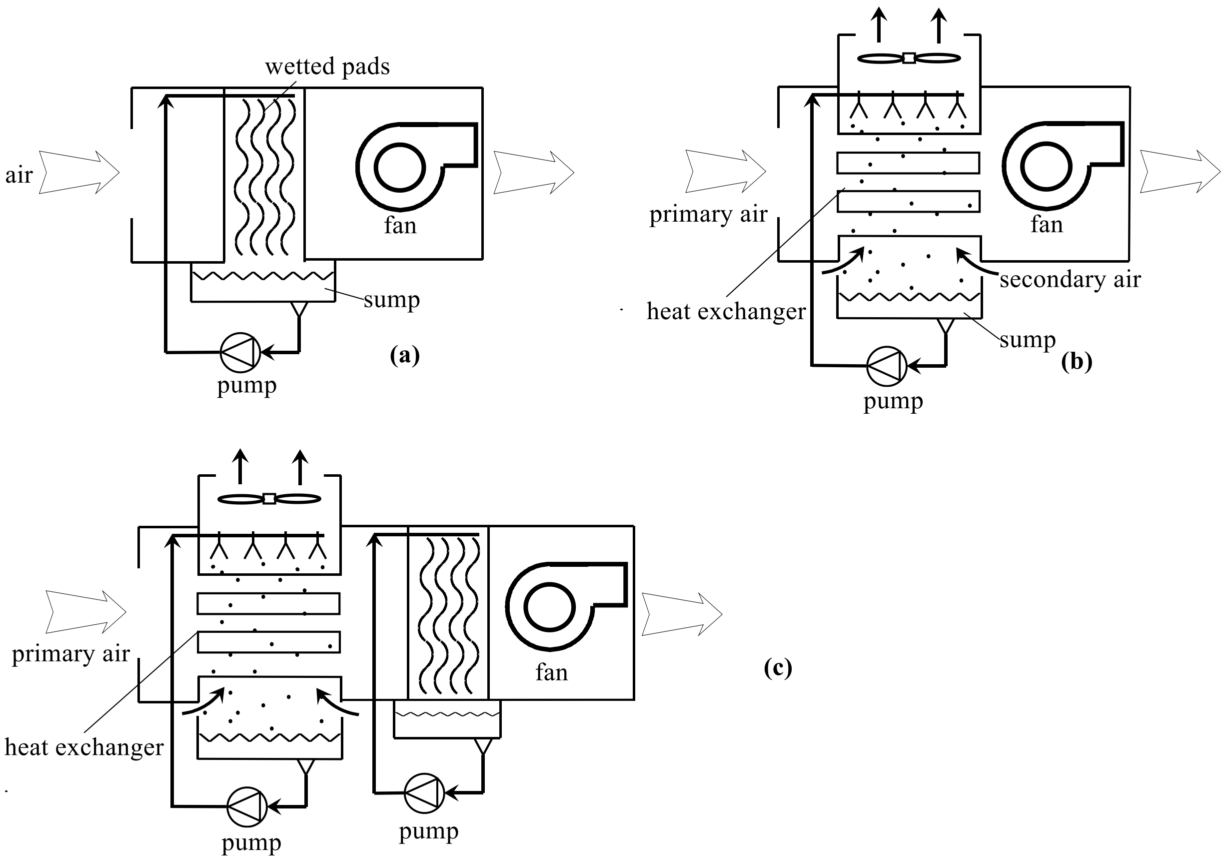
ε_e = direct evaporation (saturation) effectiveness, %

t_1 = dry-bulb temperature of entering air, °C

t_2 = dry-bulb temperature of leaving air, °C

t' = wet-bulb temperature of entering air, °C

Figure 1: Types of evaporative air conditioners: (a) direct; (b) indirect & (c) two-stage combined (Wang et al., 2000)



The saturation effectiveness also has an impact on water consumption. Increased saturation effectiveness is associated with higher water consumption. However, as higher saturation effectiveness produces conditioned air at lower temperatures, the overall impact of having higher saturation effectiveness is usually an improved energy and water consumption per unit cooling output.

Indirect evaporative air cooling is shown in Fig.1(b). The principle of operation of indirect evaporative cooling is the use of cool air produced by direct evaporative cooling (secondary air stream shown in Fig. 1(b)) to cool the air stream which is used for space cooling by the use of a heat exchanger. As cooling of the primary air stream takes place by heat transfer across the heat exchanger walls without the mixing of the 2 air streams, the primary air stream becomes cooler without an increase in its humidity. Indirect evaporative air conditioners are effective in regions with moderate/high humidity. Indirect evaporative cooling effectiveness is defined in Eqn.2. According to manufacturers' rating, this effectiveness ranges from 40 to 80% (ASHRAE Handbook, 2004).

$$\varepsilon_{ie} = 100\frac{t_1 - t_2}{t_1 - t_s'} \quad (2)$$

Where

ε_{ie} = indirect evaporative cooling effectiveness, %

t_1 = dry-bulb temperature of entering primary air, ^oC

t_2 = dry-bulb temperature of leaving primary air, ^oC

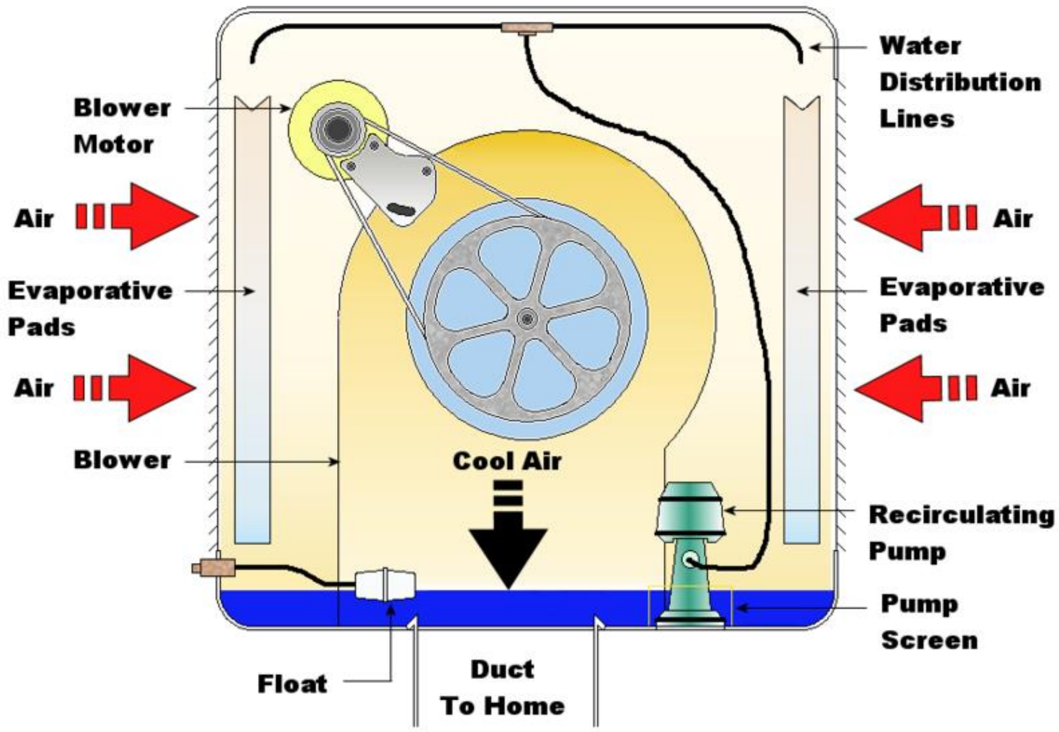
t'_s = wet-bulb temperature of entering secondary air, ^oC

Two stage or indirect/direct evaporative air conditioners combine both direct and indirect evaporative principles. In two-stage evaporative air conditioners, the first stage (indirect) sensibly cools the primary air (without increasing its moisture content) and the air is evaporatively cooled further in the second stage (direct) as shown in Fig.1(c). The dry-bulb temperature of the supplied primary air can be reduced to 6 K or more below the secondary air wet-bulb temperature (ASHRAE Handbook, 2004) without adding too much moisture. As two-stage evaporative air conditioners produce lower temperatures, they consequently require less air delivery in comparison with the direct systems. Heidarinejad *et al.* (2009) experimentally studied the cooling performance of two-stage evaporative cooling systems under the climate conditions of seven Iranian cities. It has been found that the saturation effectiveness (as defined in equation 1) of the indirect/direct evaporative air conditioner varies in a range of 108~111%. Also, over 60% energy can be saved using this system compared to a vapour compression system. However, it consumes 55% more water in comparison with direct evaporative cooling system for the same air delivery rate. Monitoring the electricity consumption of evaporative and conventional refrigerated cooling systems in a small commercial building has demonstrated considerable energy savings and improved thermal comfort with evaporative cooling (Saman, et al. 1995). Indirect evaporative cooling can also be used as a component of multistage air conditioning systems which also include refrigerated cooling stages. In such cases, the indirect evaporative cooling may be sufficient for the provision of typical summer cooling requirements. The refrigerated stage operation is limited to peak demand days.

The main focus of this report is direct evaporative air conditioners as most units in current use within Australia are of this variety. However, the scope of the report also includes indirect and two-stage systems in view of their anticipated entry into the Australian market.

A direct evaporative air conditioner is an enclosed metal or plastic box with louvers on the sides containing a fan or a blower with an electric motor, a number of cooling pads, a water circulation pump to wet the cooling pads and a float valve to maintain a proper water level in the reservoir. Fig. 2 illustrates the components in a typical evaporative cooler.

Figure 2: Schematic diagram of the components of a typical direct evaporative cooler



Types of evaporative air conditioners range from portable units, window/wall units and ducted units for residential and commercial use. Portable units cool one room at a time. They are fitted with legs and wheels and can be moved easily from room to room. A small pump is utilised to keep the cooling pads wet and water is needed to be periodically filled manually in the internal water storage tank. Typical portable evaporative air conditioners are shown in Fig.3. However, this report only examines plumbed units/systems and therefore the portable units will be excluded from the discussion.

Window/wall evaporative air conditioners are mounted through exterior windows or walls and they can cool larger areas than portable units. A window evaporative unit is presented in Fig. 4. Ducted evaporative air conditioners make up the vast majority in use in Australia. They are usually mounted on the roof and the cooled air is delivered through ducts to each room in the building. Fig. 5 shows residential roof ducted evaporative air conditioners with different profiles. Both window/wall and ducted units have water bleeding systems to control the water salinity under a certain level.

Figure 3: Portable evaporative air conditioners

(http://www.convair.net.au/convairnew/peac/ConvairPEAC.html)

Figure 4: (a) Window evaporative air conditioner; (b) View from cooled space; (c) View from outside

(http://www.bonaire.com.au/evaporativecooling/window/default.aspx)

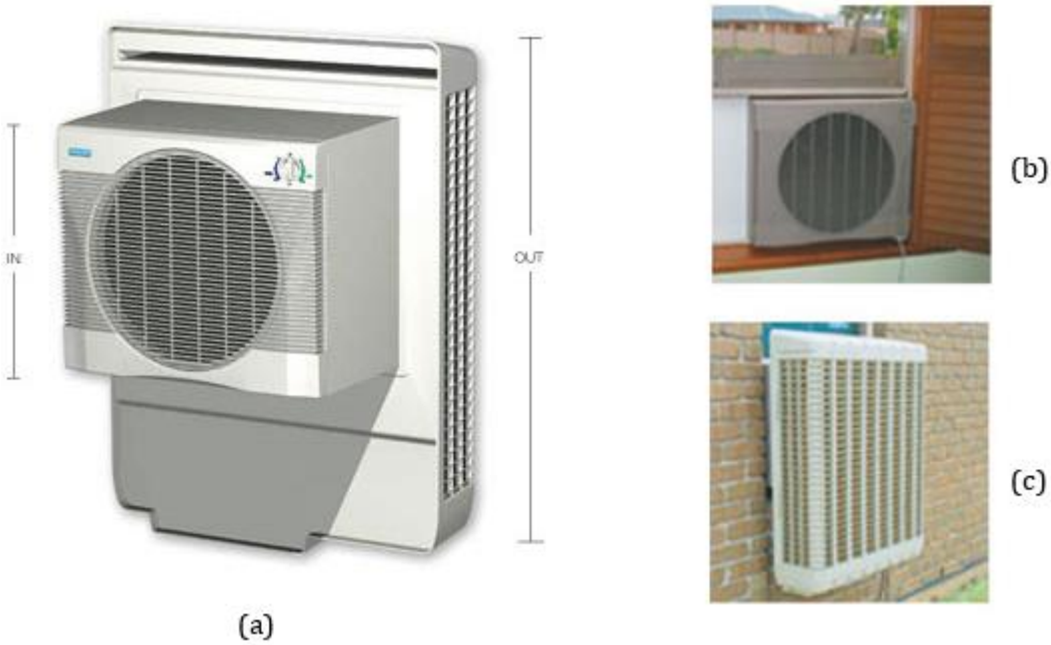


Figure 5: Residential roof ducted evaporative air conditioners with different profiles

1.2 Suitability for use in Australia

Table 1 includes an estimate of the expected dry and wet bulb temperatures for 13 Australian locations at the summer design conditions. Comfort expectation can be found by using the comfort chart. The table shows that comfort is achievable only in regions having relatively cool and/or dry summers (marked in green) with the conditions of all other locations falling outside the comfort zone (marked in red) (Saman, 1993, Saman, 1994).

Table 1: Temperature (dry bulb) and relative humidity (RH) levels for some Australian locations using direct and 2 stage cooling systems

Location	Summer Design Conditions dry bulb °C	Summer Design Conditions wet bulb °C	Direct dry bulb °C	Direct RH %	2 stage dry bulb °C	2 stage RH %
Adelaide SA	36.0	21.0	27.8 (green)	62% (green)	23.9 (green)	67% (green)
Albury NSW	39.0	24.0	30.8 (red)	63% (red)	27.2 (green)	68% (green)
Alice Springs NT	39.5	23.5	30.5 (red)	62% (red)	26.5 (green)	68% (green)
Anna Plains WA	41.0	29.0	36.0 (red)	64% (red)	32.6 (red)	75% (red)
Brisbane QLD	31.0	25.0	29.5 (red)	75% (red)	28.0 (red)	81% (red)
Canberra ACT	34.0	21.0	27.3 (green)	64% (green)	23.9 (green)	54% (green)
Cloncurry QLD	41.0	25.5	32.4 (red)	63% (red)	28.8 (red)	70% (red)
Darwin NT	34.5	28.5	33.0 (red)	76% (red)	31.6 (red)	80% (red)
Melbourne VIC	34.5	21.0	27.4 (green)	63% (green)	23.9 (green)	70% (green)
Mildura VIC	38.0	23.5	30.1 (red)	64% (red)	26.6 (green)	70% (green)
Perth WA	36.0	24.0	30.0 (red)	67% (red)	27.2 (green)	72% (green)
Sydney NSW	30.5	23.0	27.9 (green)	65% (green)	26.1 (green)	75% (green)
Woomera SA	39.5	22.0	29.4 (red)	58% (red)	25.0 (green)	66% (green)

One option for extending the climatic regions where evaporative cooling is effective is the use of 2 stage indirect/direct evaporative cooling. The use of a heat exchanger to cool the outside air without humidifying it by making use of indirect evaporative cooling systems was developed in Australia in the 1960s and 1970s; plate heat exchangers were manufactured and marketed (Pescod, 1968 & Pescod, 1979). From the manufacturing view point, the main challenge of the system is the size and cost of the heat exchanger required to achieve good effectiveness and low pressure loss. Work has been undertaken in Adelaide, Australia to develop low cost heat exchangers optimised for heat recovery as well as indirect evaporative cooling purposes (Saman & Kilsby, 1999).

Having indirectly cooled the outside air, its wet bulb temperature also drops. This makes the second stage of direct evaporative cooling more effective and enables the provision of thermal comfort for the occupants in many additional Australian locations as seen in Table 1. It is evident that occupants' thermal comfort is improved when using the two stage system in comparison with the direct or indirect system alone. Most locations in Australia, except the humid tropical regions, achieve comfort conditions with two-stage systems.

1.3 Market share of evaporative air conditioners

There are currently four major local evaporative air conditioner manufacturers: Air Group Australia Pty Ltd, Carrier Australia Pty Ltd, Climate Technologies Pty Ltd and Seeley International Pty Ltd. The evaporative air conditioners that are currently available in Australia together with their key available specifications (such as type, energy input, water bleeding system, fan and pad type, supply flow rate, control system and evaporation efficiency) are listed in Appendix 1.

Fig. 6 shows the national penetration of air conditioners and the number of air conditioners (including refrigerated and evaporative) utilised in residential houses in Australia from 1994 to 2008 (ABS, 2008). Penetration is the proportion of households having a particular type of air conditioner. The refrigerated air conditioners refer to the reverse cycle and cooling only refrigerated air conditioners, non-ducted or ducted. Between 1999 and 2008, there has been a sharp increase in penetration and the number of refrigerated air conditioners. The penetration rose from 34.7% in 1999 to 66.4% in 2008, which is nearly double in 10 years. The number of evaporative air conditioners slowly increased from 0.41 million in 1994 to 1.03 million in 2005, before slightly decreasing between 2005 and 2008.

Figure 6: National penetration and number of air conditioners (ABS, 2008)

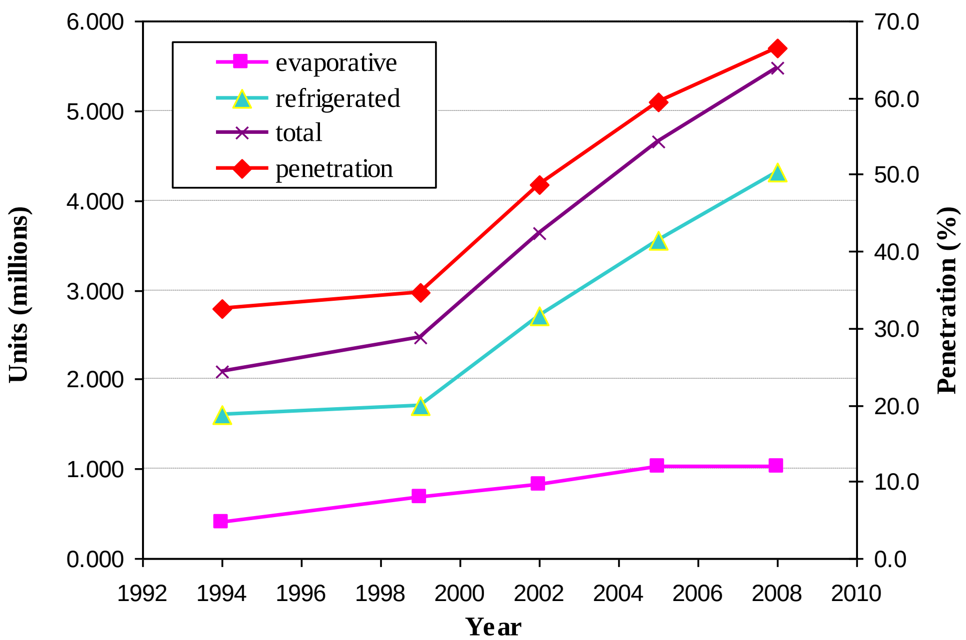
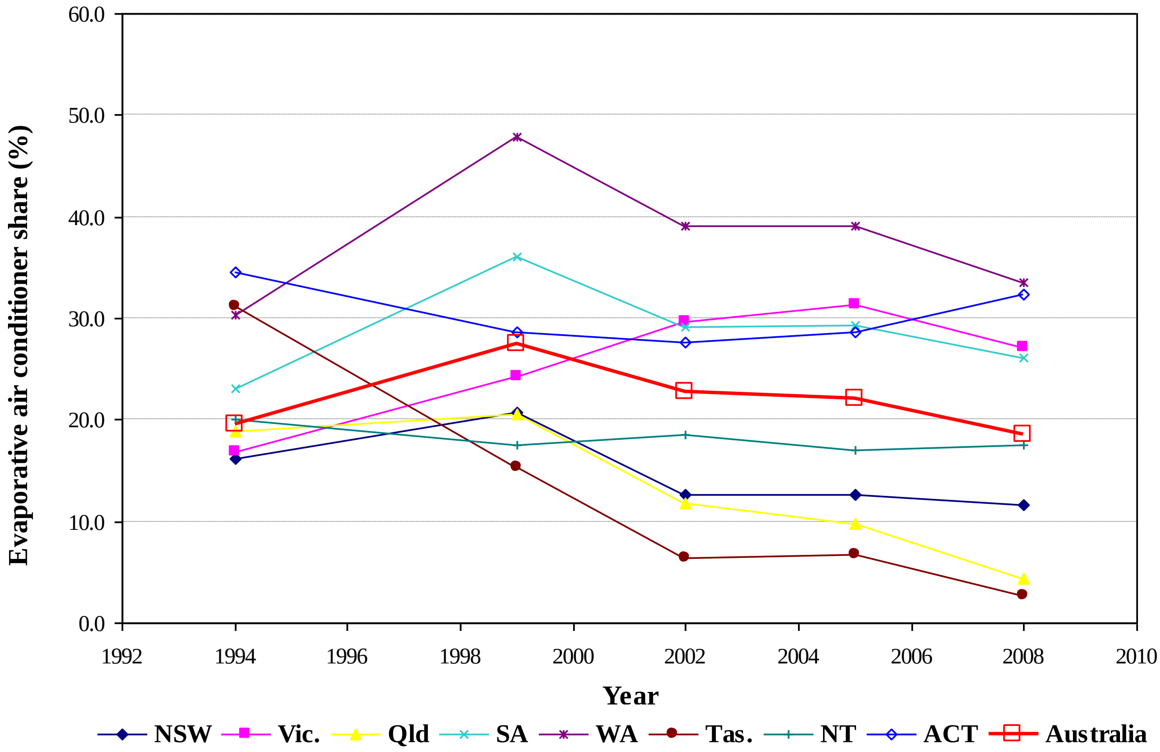


Fig. 7 illustrates some trends in the share of installed stock of air conditioners which are of the evaporative variety, both by state and nationally. The share of evaporative air conditioners reached a peak (27.4%) in 1999 and gradually went down to 18.6% in 2008. Also, for most of the states, the evaporative air conditioner share decreased since 1999. However, evaporative air conditioners are still popular in suitable climatic zones – Western Australia, Australian Capital Territory, Victoria and South Australia where their market share is around 30%. However, the general trend is a clear reduction of market share in the face of competition from refrigerated systems. The raw data for Figs. 6 and 7 is listed in Appendix 2.

Figure 7: Share of all installed stock of domestic air conditioners which are of the evaporative variety, by state and nationally (ABS, 2008)



Refrigerated air conditioner sales in Australia had a distinct increase over the past 25 years from less than 100,000 units per year in 1980 to more than 900,000 units per year in 2006 (Energy Efficient Strategies, 2008). The market is large and complex and at present there are around 200 brands. The vast majority of domestic refrigerated air conditioners are imported. The annual sales figure of rooftop evaporative air conditioners is approximately 60,000 units and this figure has been reasonably stable over the last 5 years. Most of the residential ducted evaporative air conditioners sold in Australia are manufactured domestically.

Despite the lower energy consumption of evaporative air conditioners in comparison with other cooling systems, and improvements in the quality of products produced by the Australian evaporative air conditioning industry, there is a general trend of a shrinking market share. This may be partly a result of the competition provided by international refrigeration system manufacturers and suppliers, particularly in marketing their products, as well as cost advantages associated with larger scales production.

1.4 Water consumption of evaporative air conditioners

The water consumed by evaporative air conditioners includes two portions: (1) water evaporated to provide the cooling effect and (2) water bled/dumped off for the purposes of cleaning and avoiding high salt concentration. The amount of water evaporation is determined by the inlet and outlet air temperatures and humidity as well as the air delivery rate. It is location sensitive and can be estimated using thermodynamic principles. As water evaporates, it leaves behind dissolved salts and other impurities; gradually increasing their concentration in the water remaining in the cooler. This leads to increased deposits and possible corrosion of metal components, blocking of pads and reduced cooling performance. Consequently, the sump water needs to be dumped regularly. The amount of water bled/dumped off is dependent on the bleeding method used and the quality of water supplied. It is product specific.

1.4.1 Water evaporation

The psychrometric chart in Fig. 8 illustrates the evaporation process (red line) when air passes through the pad of a direct evaporative air conditioner. At given entry air conditions (t_1, t') and evaporation effectiveness (ε_e), the dry-bulb temperature of the leaving air (t_2) can be calculated according to Eqn.1 and expressed in Eqn.3. The wet-bulb temperature of the leaving air is the same as the wet-bulb temperature of the entering air. Then the humidity ratios of both entering and leaving air can be determined from the psychrometric chart. The water consumption rate for cooling purpose can be estimated using Eqn.4.

$$t_2 = t_1 - \frac{\varepsilon_e}{100} \times (t_1 - t') \qquad (3)$$

$$\dot{m}_e = \rho \dot{V}(w_2 - w_1)/1000 \qquad (4)$$

Where

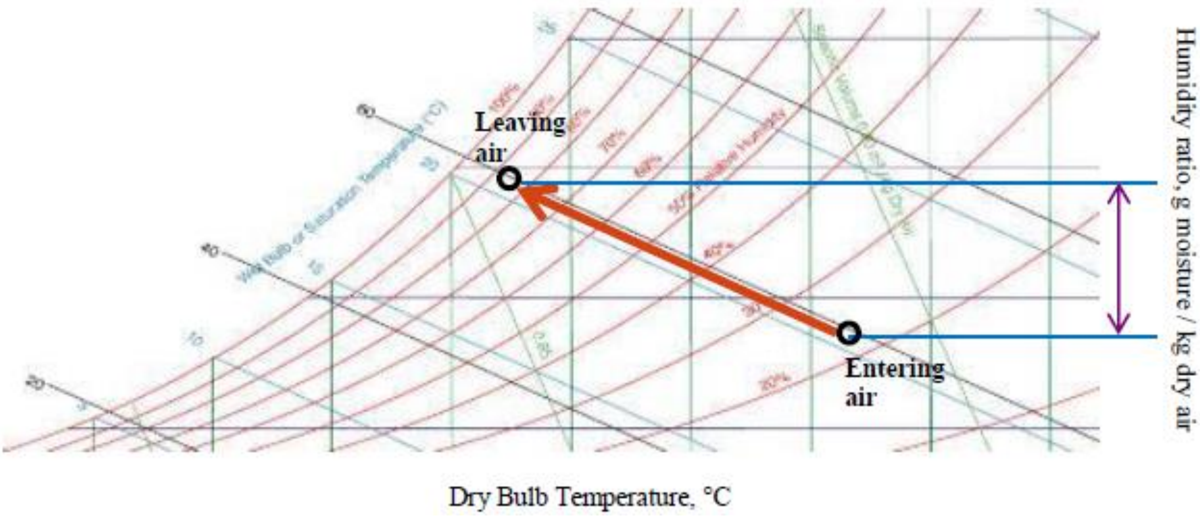
$\dot{m}_e$ = water consumption rate, kg/hr

$\dot{V}$ = air volumetric flow rate, m^3/hr

ρ = air density, 1.2041 kg/m^3

w_1, w_2 = humidity ratios of entering and leaving air, g moisture/kg dry air

Figure 8: Psychrometrics of direct evaporative cooling



The water consumption rate due to evaporation varies depending on the air flow rate, the temperature and humidity of the outside air and the pad characteristics. Some manufacturers quote indicative figures for water consumption but these can only be used as approximate values. In an effort to provide independent values of the water required for evaporation, the water consumption rates for cooling purposes have been calculated based on six Australian cities (Adelaide, Hobart, Melbourne, Perth, Sydney & Canberra) where evaporative cooling is effective and economically feasible. The air entering the evaporative air conditioners is at the design weather conditions (AIRAH technical handbook, 2007). The design temperature and humidity are based on typical historical data and are used to represent the maximum cooling conditions. The design conditions usually cover all the cooling season and they are only exceeded for short periods for ten days. The results are presented in Table 2. In carrying out the calculation, it is assumed that the evaporation/saturation effectiveness of the cooling pad is 85%. The calculation is also based on a rule of thumb design guide used by many suppliers which is that the evaporative air conditioner is assumed to be delivering the equivalent volume of 30 air changes per hour. Two sizes of residential ducted units were taken into consideration in the calculation:

- Residential house with a conditioned area of 130m^2 and a ceiling height of 2.4m. The rating air flow rate is 9360m^3/h.
- Residential house with a conditioned area of 200m^2 and a ceiling height of 2.7m. The rating air flow rate is 16200m^3/h.

Table 2: Evaporated water consumption rate for different unit sizes and Australia locations

Location	**AIRAH design condition (°C) DB**	**AIRAH design condition (°C) CWB**	**Entering air humidity ratio (g/kg)**	**Leaving air Dry Bulb temperature (°C)**	**Leaving air humidity ratio (g/kg)**	**Water consumption rate per kg of air (g)**	**Water consumption rate for various air flow rate (L/hr) 9360 (m³/h)**	**Water consumption rate for various air flow rate (L/hr) 16200 (m³/h)**
Adelaide	37	20.1	-	-	-	-	***67.1***	***116.1***
Hobart	27.1	16.8	7.8	18.3	11.4	3.6	***40.6***	***70.2***
Melbourne	34.3	19.4	8.1	21.6	13.3	5.2	***58.6***	***101.4***
Perth	36.6	20.1	8	22.6	13.8	5.8	***65.4***	***113.1***
Sydney	31.1	19.8	9.9	21.5	13.9	4.0	***45.1***	***78***
Canberra	34.3	18.1	6.3	20.5	12.1	5.8	***65.4***	***113.1***

Furthermore, the amount of water consumption for cooling purpose has been calculated based on hourly weather conditions in a typical hot day and a typical summer day from two available climate data sources in Adelaide: (1) data supplied by ACADS-BSG (a specialist building services simulation company) and (2) climate data from Australian Climate Data Bank (ACDB). The typical hot day in this report refers to a day in which the 3:00pm dry-bulb temperature is only exceeded on 10 days per year. The typical summer day refers to a day, in which the 3:00pm dry-bulb temperature equals the average 3:00pm temperature of the summer days requiring cooling. In the calculation, cooling is assumed to be switched on at full speed during hours when the outside temperature exceeds 27°C and represents the maximum water consumption on those days. The hourly water consumption rates in the typical hot day and the typical summer day are listed in the tables in Appendix 3 and Appendix 4 respectively. The total water consumption and the average consumption rate are shown in Table 3.

Table 3: Evaporated water consumption in typical days in Adelaide**

Location	Source of Climate Data	Period requires cooling	Total daily water consumption for various air flow rates (L/day) 9360(m^3/h)	Total daily water consumption for various air flow rates (L/day) 16200(m^3/h)	Average hourly water consumption rate for various air flow rates (L/hr) 9360(m^3/h)	Average hourly water consumption rate for various air flow rates (L/hr) 16200(m^3/h)
Adelaide typical hot day	ACAD-BSG	6:00am~24:00pm	***1083.3***	***1874.9***	***57.0***	***98.7***
Adelaide typical hot day	ACDB	11:00am~23:00pm	***771.9***	***1336.0***	***59.4***	***102.8***
Adelaide typical summer day	ACAD-BSG	10:00am~19:00pm	***481.5***	***833.3***	***48.1***	***83.3***
Adelaide typical summer day	ACDB	11:00am~20:00pm	***538.8***	***932.5***	***53.9***	***93.3***

As can be seen from Table 2, Adelaide, Perth and Canberra require the largest amount of water and Hobart has the least amount at the design conditions and the same air flow rate. The average evaporated water consumption rate in a typical hot day in Adelaide is less than that estimated using design weather conditions.

The water consumption rate for cooling purposes is dependent on the humidity ratio difference of the entering and leaving air and the air flow rate. The sizes selected in tables 2 and 3 are based on maximum cooling requirements on the hottest part of the day. Typically, the fan utilised in residential evaporative air conditioners has a variable speed and runs on low speeds for the majority of operating time. The evaporated water consumption in Tables 2 and 3 was calculated based on the maximum fan speed, thus it should be considered as overestimates. If, on average, the fan runs at half of the air flow rate, all the water consumption data in the tables will be halved. Air Group Australia Pty Ltd (2007) reports that the evaporated water consumption for a high-capacity whole-of-home ducted evaporative cooler is around 60 L/hr at full-speed fan operation.

1.4.2 Water bleeding/dumping system

A suitable bleeding/dumping system is an integral part of the system design and has consequences on the maintenance and warranty of the system. A number of water bleeding systems are employed by manufactures to dispose of water:

1) Constant bleed off system. This is a traditional way of disposing of the salt in the sump. When the cooler is switched on, the system will drain a small amount of water at a constant flow rate. This ensures that fresh water is continually added to dilute the salt accumulated in the water caused through evaporation. The bleed rate depends on the size of the evaporative cooler, local weather conditions and water quality. Usually, more bleed off is needed in hotter weather, for larger units or when the supply water is saltier or has high impurities. The bleed rate can be adjusted between 2 and 45 litres per hour depending on the size of the unit and the water

quality. For most residential installations, the flow rate would be in the range of 3~5 L/hr. Some manufacturers recommend this rate should be not less than 10 litres per hour in good water quality areas. For a small unit, a constant bleed rate system is satisfactory and economically feasible.

2) Salinity level monitoring system. This type of system is utilised in Braemar and Breezair brand evaporative air conditioners produced by Seeley International Pty Ltd. It is called WaterManager^{TM} system. In this system, salinity probes constantly examine the sump's water salinity level. When the level reaches a preset value, the WaterManager^{TM} will open the drain valve and release about 6~8 litres of water. Then fresh water will be added to dilute the minerals and salts accumulated. The WaterManager^{TM} system will continue to monitor the salinity level and drain water as required. For areas operating with poor water quality, the WaterManager^{TM} system will dump water more frequently to maintain the water quality in the cooler. In areas where bore water (ground water) is supplied, the salinity measuring circuit is disabled and 6~8 litres of water is drained from the tank every 65 minutes of operation.

   This kind of water bleeding system eliminates unnecessary dumping and minimises the water consumption. Data from Seeley International Pty Ltd claims the WaterManager^{TM} system can save 9000 litres of water annually compared to a constant bleed rate system.

3) Periodic/timed drain off system. This type of bleeding system is employed by Brivis Profiler and Brivis Advance brands evaporative air conditioners produced by Carrier Australia Pty Ltd and the products manufactured by Air Group Australia Pty Ltd. In this system, fresh water is filled into the sump when the water level drops below a pre-determined level caused by the water evaporation. No water is dumped during this process. The number of fill cycles or the drain-off time is pre-set. Once the number of fill cycles or the drain-off time has been reached, the evaporative cooler will automatically drain the entire tank and refill it with fresh water. Whilst the water is being refreshed, the cooler continues to operate.

   The system utilized by Air Group Australia has a default five hour drain cycle and it is adequate for most water supplies. However, the time can be varied for different water qualities. The sump capacity on all top/down discharge single fan units (almost all domestic installations and most commercial units) is 10 to 12 litres.

1.4.3 Total water consumption

Comparing the two major components of water usage in evaporative air conditioners (water used for the cooling effect and water dumped/bled off), it may be concluded that if the water bleeding/dumping system is well designed, set and maintained, the total water consumption will be largely dominated by the moisture evaporation which is essential in operating the evaporative cooler. However, if not properly adjusted, the water bleeding/dumping rate is of the same order of magnitude as the evaporation rate and can lead to considerable wastage of valuable water.

In this context, it is important to compare the water consumption of evaporative air conditioners with total domestic water consumption. According to the Australian Bureau of Statistics (2006), Australian households consumed on average 268 kL of water per household in 2004–05.Western Australia had the highest water consumption per household (468 kL) while Victoria had the lowest average water consumption per household (209 kL). The recent water saving efforts have reduced these values. As an indicative example, the average household consumption in South Australia is around 190 kL per annum (SA Water, 2008) compared with 244kL in 2004-2005 as per the previous ABS data.

Although no reliable data is available on annual monitored water consumption by evaporative air conditioners, our calculations suggest that, on average, evaporative air conditioners consume 2-10% of the total annual water use in typical Australian households. The estimate is based on anecdotal information and the above calculations in comparison with average values of household water consumption. Seeley International Pty Ltd estimates the annual water consumption by an evaporative air conditioner in Adelaide to be around 7000 litres (http://www.braemar.com.au). This amount accounts for around 3.7% of the total annual water use in typical South Australian households. The estimation is based on a 148m^2 house in a typical Adelaide summer with medium sized cooler operated for 358 hours.

1.5 Cooling pads

The cooling pads utilised in evaporative air conditioners provide sufficient water-to-air contact area to promote water evaporation. The cooling pad materials commonly in use are Aspen wood and Celdek as shown in Figure 9 (a) and (b). Aspen wood pad is a package of thin shredded wood slivers having a thickness of 3 to 5 cm and the material is spread equally over the pad-holder surface (Bom, 1999). Celdek cooling pads are made from specially impregnated and corrugated cellulose paper sheets with two different flute angles. These sheets are bonded together alternatively with one steep sheet and one flat sheet. Most medium/large evaporative air conditioners in Australia use Celdek pads or equivalent.

Figure 9: Two types of cooling pads. (a) Aspen wood pads & (b) Celdek pads (CELdek® 7060-15 manufactured by Munters Pty Ltd)

(a) (b)

Celdek cooling pads have higher saturation efficiency than Aspen pads. The saturation efficiency of a properly packed Aspen pad may reach 70% and it may decrease down to 50% after only a few weeks (Bom, 1999). The efficiency of Celdek pads varies from 70% to over 95%, depending on the thickness of the pad and air velocity (ASHRAE Handbook, 2004). Also, the Celdek pads can last 10 years or more but Aspen pads need to be replaced each cooling season or sometimes after two cooling seasons. However, Celdek cooling pads are more expensive than Aspen pads.

Regular maintenance of the pads is important to ensure the evaporative air conditioners operate efficiently for many years. Manufacturers recommend that both sides of the pads should be gently washed to remove the built up salts, dust and pollen. The pads should be replaced if they are in poor condition. The maintenance can be done annually either before or after the cooling season. For the evaporative air conditioners produced by Air Group Australia, the pads are automatically flushed with clean fresh water at the end of the day.

1.6 Effect of water quality

A survey of sources of water in Australia (ABS, 2007) shows that in March 2007, nearly all (99%) households in capital cities and 85% outside the capital cities were connected to mains/town water, which accounts for 93% of the total households. Slightly more than 1.5 million households (19%) used rainwater tanks for their dwelling, among which South Australia had the highest proportion (45% of households used rainwater tanks). It was also reported that 22.8% of households in Western Australia used bore or well water as a source of water.

Mains/town water, rainwater and bore/well water is utilised for supplying evaporative air conditioners. Usually, drinking water containing total dissolved salts (TDS) below 1000 mg/L is acceptable to consumers (World Health Organization, 2003). Australian Drinking Water Guidelines recommend the drinking water should have a TDS less than 500 mg/L (National Health and Medical Research Council, 2004). TDS is the main indicator for determining the inorganic salts dissolved in water. It is recorded in milligrams of dissolved solids in one litre of water. The principal constituents include calcium, magnesium, sodium and potassium cations and carbonate, hydrogen carbonate, chloride, sulphate and nitrate anions. An indirect method is to measure the electrical conductivity (EC) of the liquid in a measuring cell of specific dimensions. This method is utilised in the salinity level monitoring of evaporative air conditioners and specifically in determining the salinity level for use in the bleeding system used by Seeley International Pty Ltd and other manufacturers. The unit of EC is µS/cm. EC can be converted into TDS values by means of a factor varying from 0.5 to 1.0, depending on water type. For most Australian inland waters the relationship is:

$$\text{TDS (mg/L)} = \text{EC } (\mu\text{S/cm}) \times 0.6 \tag{5}$$

Customer tap water quality in the metropolitan Adelaide distribution systems in 2007-08 is detailed in Appendix 5. The mean TDS in metropolitan Adelaide is 350 mg/L (SA Water, 2008). In comparison, the drinking water in Sydney and Melbourne has a lower TDS value. The drinking water quality from Sydney delivery systems in 2008 is also shown in Appendix 5 and it has a mean TDS of 114.5 mg/L (Sydney Water, 2009). City West Water Ltd. supplies drinking water to the inner and western suburbs of Melbourne and the mean TDS is 55 mg/L (City West Water Ltd., 2008).

Rainwater is relatively mineral-free compared to the mains/town water. TDS in rainwater is as low as 2 mg/L (Beers, 2001). A survey has been carried out on 35 rainwater tanks in several Australia cities (Chapman *et al*., 2008). The TDS of tank water samples range from 9–160 mg/L with a mean value of 33.1 mg/L. As water of lower TDS, including rainwater, results in less salt build-up on the cooling pads, it provides more efficient cooling and requires less water dumping in well controlled systems and less maintenance. It is therefore recommended for use in evaporative air conditioners when available.

Bore/well water generally has a higher level of salt. The TDS of groundwater varies from that of rainwater to ten times the salinity of seawater (Economics Consulting Services, 2004), depending on the location, the season and the depth of aquifer. Gnangara and Jandakot are two main groundwater systems for public water supply in the Perth area. The TDS of the groundwater from the Gnangara system is variable, with some bores excellent at 200 mg/L and others reaching 1200 mg/L (WA Water Corporation, 2008).

The three water bleeding systems used in evaporative air conditioners (Section 1.4.2) are all adjustable according to different incoming water qualities. For areas operating with poor water quality (higher salinity levels), the evaporative air conditioners require bleeding/dumping of water at a higher flow rate or more frequently to maintain the water quality in the cooler. If the salt build up on the cooling pads is not removed in time, the evaporation effectiveness of the evaporative units and the life cycle of the pads will be reduced. This can also result in the onset of corrosion of metal parts and salt precipitation which may adversely affect the evaporative cooler components (fan, motor and water pump).

2 Review of available regulations and standards

2.1 Australian standards

AS/NZS 2913-2000: *Evaporative Air-conditioning Equipment*

In Australia, AS/NZS 2913-2000 is the only regulatory instrument available for testing evaporative air conditioners. This Standard was prepared by Standards Australia Committee ME-62, Ventilation and Air conditioning. It applies to evaporative air-conditioning devices which cool air by the evaporation of water. It prescribes a basis for rating specified features of evaporative air-conditioning equipment, and specifies the test procedures and equipment applicable for rating an evaporative air conditioner. It also includes basic minimum requirements for construction. The performance testing requirements are designed to evaluate:

- Air flow
- Evaporation efficiency
- Sound power measurements
- Electrical consumption

While the evaporation efficiency indicates how close the cooled air is to saturation point, which is the maximum limit for direct evaporative air conditioners, it does not give a direct indication of the cooling capacity or attempt to link it to the electricity consumption. Note that the evaporation (saturation) efficiency is given as a percentage. It is also quoted as evaporation effectiveness which is a fraction below 1. Typical evaporation efficiency values are 70 - 85% (effectiveness 0.7- 0.85).

The Standard also includes information for evaluating a nominal rating for the evaluation of the rated cooling performance for inlet dry and wet bulb temperatures of 38°C and 21°C respectively and a room dry bulb temperature of 27.4°C.

The Standard contains a requirement that the electricity consumption of a particular unit should be measured during the evaporation efficiency test. However, no energy rating is available. The Standard also lacks requirements to evaluate the water consumption.

In addition, this Standard does not include requirements for evaluating the performance of indirect or two stage evaporative air conditioners.

2.2 International regulations and standards

- **United States ANSI/ASHRAE Standard 133-2008: Method of Testing Direct Evaporative Air Coolers**

This Standard was prepared by the American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE). It establishes a uniform test method for rating the saturation effectiveness, airflow rate and total power of packaged and component direct evaporative air coolers. Other parameters to be measured under equilibrium conditions are the static pressure differential across the evaporative cooler, density of air and speed of rotation of the fan. The Standard does require the measurement of flow rate of the supplied water and its electrical conductivity as a measure of the water quality.

The Standard requires that the inlet plenum air dry-bulb temperature shall be 45°C maximum, the wet-bulb temperature shall be 5°C minimum, and the difference between these two temperatures shall be 11°C minimum during the testing period. It also requires that the conductivity of the water supplied shall be between 350 and 3500 μS.

- **United States ANSI/ASHRAE Standard 143-2000: Method of Testing for Rating Indirect Evaporative Coolers**

This Standard was prepared by ASHRAE. It provides standard test methods and calculational procedures for establishing the cooling capacities and power requirements for indirect evaporative coolers. The indirect evaporative coolers can be either self-contained or components of a packaged system. The parameters tested under steady-state conditions include:

- Air flow rates for primary and secondary airstreams
- Dry-bulb and wet-bulb temperatures of both primary and secondary airstreams when entering and leaving heat exchanger
- Electrical consumption

However, the Standard does not include coolers using mechanical refrigeration or thermal storage to cool the primary or secondary air streams. Also, it does not include coolers that dry the primary or secondary airstreams. The Standard does not require the evaluation of water consumption.

- **California Appliance Efficiency Regulations**

The California Appliance Efficiency Regulations include a procedure for evaluating and rating the energy performance of evaporative coolers. This is achieved by evaluating the Evaporative Cooler Efficiency Ratio (ECER). ECER is evaluated by Eqn.6. The conditions specified for the evaluation of ECER are intake dry and wet bulb temperatures of 32.8 and 20.6°C (91 and 69°F) respectively for testing the evaporation efficiency and assumed room outlet air temperature of 26.7°C (80°F).

$$ECER = 1.08 \times (t_{room} - (t_{db} - \varepsilon \times (t_{db} - t_{wb}))) \times Q/W \qquad (6)$$

Where

t_{room} = room dry-bulb temperature, °C

t_{db} = outdoor dry-bulb temperature, °C

t_{wb} = outdoor dry-bulb temperature, °C

ε = saturation effectiveness divided by 100

Q = air flow rate, cfm

W = total power, W

No water consumption requirements are included in the Regulations.

- **Iran Labelling Program**

Iran is the only country that currently conducts a mandatory comparative labelling program for energy consumption of evaporative air conditioners (see example of the label and rating, Fig. 10 and Table 6). The label design is based on the European label concept but as a mirror image with efficiency grades in numbers rather than letters (Persian script). It shows efficiency grades from 1 (most efficient - the shortest bar, which appears in green on the original label) down to 7 (least efficient - the longest bar, which appears as red). The aim of the Iranian program is to encourage local manufacturers to improve the energy efficiency of their products. Studies conducted in cooperation with manufacturers revealed that there are a variety of design changes possible, such as the use of more efficient fans and motors, pad density and improved water circulation rate. These changes would make a considerable impact on energy consumption without requiring major investment. Hence the labelling scheme was launched in 1999 to encourage these changes.

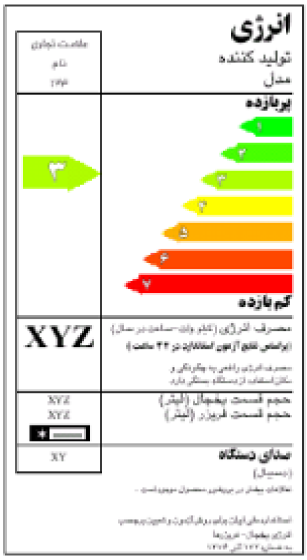
The scheme is run by the Iran Energy Efficiency Organisation. Being the first country to introduce labelling and MEPS has meant that Iran has had to develop its own test methods and rating levels. The units are rated using an EER (Energy Efficiency Ratio) measurement to compare products. Thresholds are shown in Table 3. Promotion of the energy label is largely done by manufacturers who have found it to be a useful marketing tool. The testing should comply with the Iranian Test Standards No. 4910 and No. 4911, which use the Australia Standard 2913-2000 as their reference test standard. To the authors' knowledge, water consumption evaluation has not been considered in this scheme.

It is evident from the above that current Australian Standards do not require the evaluation of water and energy use in evaporative air conditions. A standard procedure for evaluating both energy and water consumption of evaporative air coolers is proposed for inclusion in the Standards.

Table 4: Energy Efficiency Thresholds for Iranian Energy Label (Iran Energy Efficiency Organisation)

Rating	EER Value
1	EER≥ 65
2	58≤EER<65
3	50≤EER<58
4	42≤EER<50
5	34≤EER<42
6	26≤EER<34
7	EER<26

Figure 10: Example of the Iranian energy label (Iran Energy Efficiency Organisation)



2.3 Merits of inclusion in the WaterMark certification scheme

WaterMark is a certification trademark used in relation to water supply, sewerage, plumbing and drainage products. WaterMark is intended to assure consumers of the quality of plumbing products by certifying that all products carrying the WaterMark logo are suitable for use in contact with drinking water, protecting public health and safety, as well as infrastructure and buildings.

There are currently no issues associated with the quality of evaporative air conditioners or their specific components in handling water that would warrant inclusion into the WaterMark certification scheme.

3 Testing to evaluate water consumption

3.1 Development of a test methodology for rating water consumption

In view of the need to inform the public, manufacturers and water authorities about the level of water needed for operating evaporative air conditioners, a test and evaluation methodology and procedure are necessary. The test should take into account both the amounts of water evaporated and dumped for a particular cooler design at the range of speed settings. Direct monitoring of the water consumption and dumping during a set time period is proposed. In view of the dependence of water consumption on the air temperatures and flow rates, the water consumption test can be carried out simultaneously with that proposed by the authors for the energy efficiency rating test at the rated thermal conditions (Saman and Bruno, 2008). In addition, the duration of the test, including the number of starts/stops should be based on data representing typical daily domestic operation.

It is proposed that water consumption testing be carried out alongside the energy consumption testing using a single test facility. A test rig presented in Fig. 11 is proposed to implement the testing for rating both the energy and water consumption under controlled simulated outdoor temperature and humidity conditions. The test requirements and conditions are to supplement current Australian Standards AS/NZS 2913-2000 for measurement and will require additional facilities for strict control to simulate outdoor design conditions and input water quality, and for monitoring water consumption.

The test must comply with the following conditions:

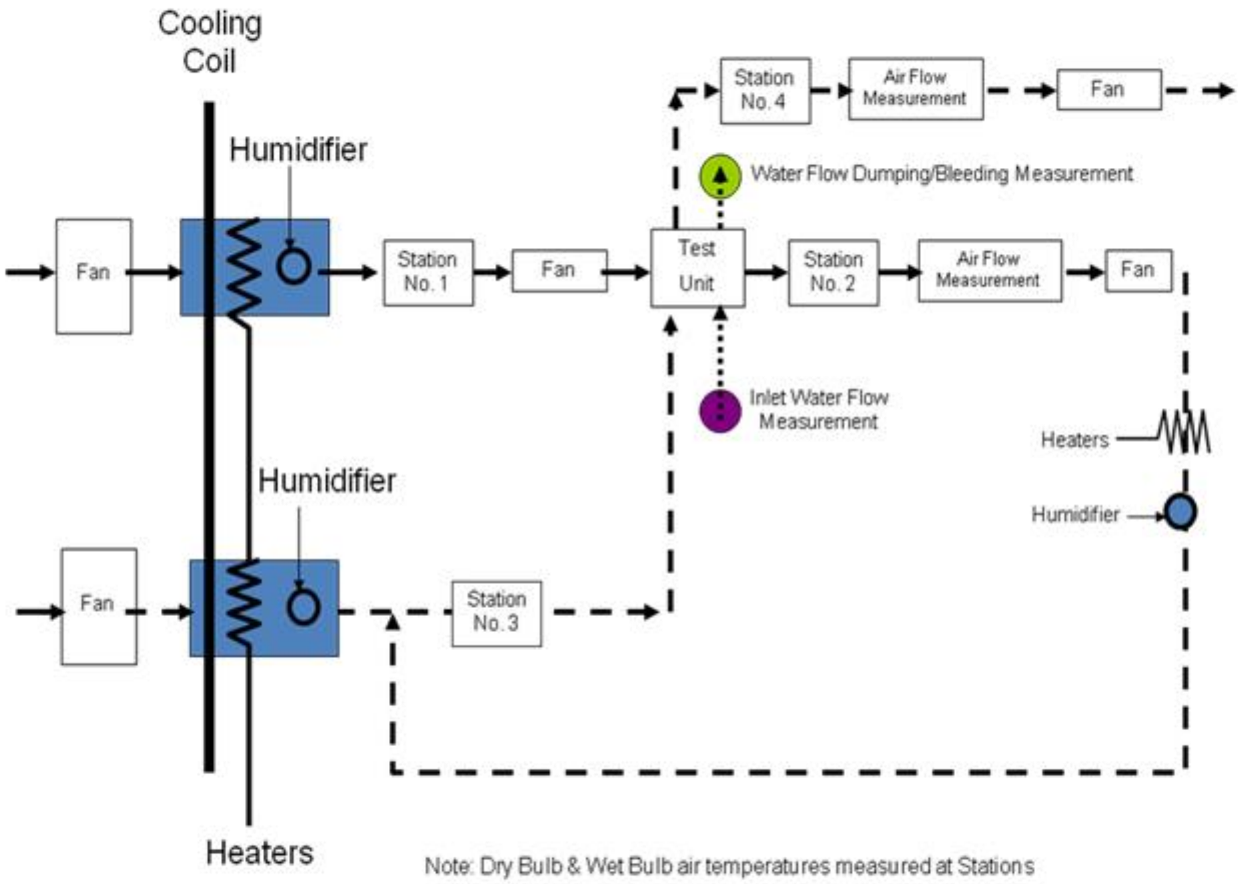
- Preset air temperature and humidity to simulate rating conditions with variation allowed within specified tolerances
- Input water quality to simulate mains water salinity level (measured by electrical conductivity) within specified tolerances
- Test measurements of new product to be carried out after a minimum number of hours of operation, which would be a standardised time period

The following parameters need to be measured during the test after steady conditions have been reached for the purpose of evaluating both water and energy performance:

- Inlet and outlet dry and wet bulb temperatures
- Air flow rate
- Electrical power consumption by the fan, water circulation pump and control/remote systems
- Pressure drop across the cooling system
- Inlet water quality
- Total water consumption

- Total water dumped/bled off

Figure 11: Schematic diagram of the proposed test rig



3.2 Development of a procedure for rating/labelling water consumption

The test results collected above under specific rating conditions, together with typical weather data for different climatic zones will enable the estimation of the following key parameters associated with water consumption. The parameters will be based on simulating the cooling and water requirements for all speed settings of a cooling unit in different locations:

Total water consumption per hour at design conditions:

This parameter indicates the likely maximum hourly water consumption at different speed settings in different locations around Australia. This is based on the cooling design conditions (AIRAH technical handbook, 2007).

Total annual water consumption to satisfy the cooling requirement during a typical summer season:

This parameter enables consumers and local authorities to evaluate the total annual water consumption and associated costs and to compare with total household water consumption.

Water dumping rate per kg of cooled air:

This is the key parameter in rating/labeling how well water is being utilised in maintaining the evaporative air conditioner in good working conditions. This parameter is considered most appropriate for WELS labeling purposes as the dumping rate should not be artificially reduced through compromising good working conditions of the system.

It may be argued that the total water consumed rather than the water dumped should form the basis for labelling water use. However, the water consumption for evaporation is by no means being wasted. In fact, the water evaporation taking place in an evaporative air conditioner is a direct measure of its cooling capacity. In addition to providing water consumption information, the WELS labelling scheme aims to cut down on water wastage in appliances. With this in mind, it needs to focus on optimising the amount of water dumping/bleeding from evaporative air conditioners to ensure continuous good thermal performance with minimum wastage. There appears to be a considerable range of water dumping/bleeding systems in use with a wide range of dumping rates being observed, some of which are due to poor settings by the suppliers/installers. The introduction of water labelling is likely to encourage manufacturers to use improved technologies for controlling water dumping or to encourage them to preset the dumping rate in accordance with the minimum requirements for particular climatic regions.

4 Conclusions and recommendations

1) It is possible to test and rate evaporative air conditioners for water efficiency and to evaluate their water consumption in different climatic regions.
2) Evaporative air conditioners would be suitable for inclusion into the WELS Scheme. However, in view of the relationship between water and energy consumption of evaporative air conditioners, it is recommended that performance rating/labelling of both energy and water consumption should be introduced simultaneously. Incorporating evaporative air conditioners in the WELS program without incorporating an energy rating/labelling system may highlight a potentially negative aspect without promoting their positive energy saving/peak demand impacts. This may place evaporative air conditioners at a less favourable market position in comparison to refrigerated air conditioners.
3) The two main components of water consumption for evaporative air conditioners are water used for cooling and water dumped/bled off for preventing the accumulation of salts. In view of the range of water consumption rates of evaporative air conditioners, particularly the portion used in water dumping/bleeding, the development of independent rating/labelling methodology for water consumption is likely to lead to the use of improved systems and reduced water consumption.
4) Although the WELS Scheme aims to provide consumers with information on the total water use of labelled appliances, it is recommended that the water labelling should focus on water dumping/bleeding from evaporative air conditioners, as the water used for cooling is a measure of the cooling effect. The introduction of water labelling is likely to encourage manufacturers to use improved technologies for controlling water dumping or to preset the bleeding rate in accordance with the minimum requirements for particular locations.
5) Even after allowing for increased water tariffs, it is estimated that evaporative air conditioners have lower running costs as they use less electrical energy compared with reverse cycle air conditioners. The use of evaporative cooling also has a positive impact on reducing peak electrical power demand in comparison with refrigerated systems.
6) With depleting water resources, the water consumption of evaporative air conditioners has become an important issue in Australia and may impact on the evaporative air conditioning market. Little independent evidence or monitoring data exists to quantify water consumption rates of evaporative air conditioners. This report has attempted to quantify the water consumption; however more in situ monitoring data collection is necessary.
7) Although no reliable data is available on annual monitored water consumption by evaporative air conditioners, our computations suggest that, on average, evaporative air conditioners consume approximately 4-18 kilolitres per annum, which is 2-9% of the total annual water use in typical Australian households.
8) Through international literature search, no water labelling/rating system for evaporative air conditioners is currently in use. Only a small number of energy rating/labelling methods are available.

9) A study to develop a standard testing procedure, required testing facilities and methodology for independent testing, rating/labelling of both water and energy use in evaporative air conditioners is recommended as the next step for progressing the rating of these systems. This is likely to incorporate modifications to the current testing standard in **AS/NZS 2913-2000 Evaporative air conditioning equipment**.

10) Early consultation with manufacturers, suppliers and users groups will be an important step in progressing a labelling/rating system for energy and water use in evaporative air conditioners.

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Appendix 1: Available evaporative air conditioners in Australia and their key specifications

AIR GROUP AUSTRALIA

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
CoolBreeze	D095	residential ducted (Heritage)	600	7	Water Manager (timed drain off system)	Variable speed axial fan	7500	100mm Celdek pads (larger model)	wall-mounted controller with variable speed fan control/thermostat control (optional remote control)	-
CoolBreeze	D125	residential ducted (Heritage)	600	9	Water Manager (timed drain off system)	Variable speed axial fan	10000	100mm Celdek pads (larger model)	wall-mounted controller with variable speed fan control/thermostat control (optional remote control)	-
CoolBreeze	D160	residential ducted (Heritage)	750	11	Water Manager (timed drain off system)	Variable speed axial fan	12500	100mm Celdek pads (larger model)	wall-mounted controller with variable speed fan control/thermostat control (optional remote control)	-
CoolBreeze	D195	residential ducted (Heritage)	1000	13	Water Manager (timed drain off system)	Variable speed axial fan	15000	100mm Celdek pads (larger model)	wall-mounted controller with variable speed fan control/thermostat control (optional remote control)	-

Brand	**Model**	**Type**	**Energy input (W)**	**Cooling power (kW)**	**Water bleeding system**	**Fan type**	**Supply flow rate (m³/h)**	**Pad type**	**Control system**	**Evaporation efficiency**
CoolBreeze	D230	residential ducted (Heritage)	1000	15	Water Manager (timed drain off system)	Variable speed axial fan	18000	100mm Celdek pads (larger model)	wall-mounted controller with variable speed fan control/thermostat control (optional remote control)	-
CoolBreeze	D255	residential ducted (Heritage)	1000	17	Water Manager (timed drain off system)	Variable speed axial fan	19500	100mm Celdek pads (larger model)	wall-mounted controller with variable speed fan control/thermostat control (optional remote control)	-
CoolBreeze	C125	residential ducted (Cascade)	600	9	Water Manager (timed drain off system)	Variable speed axial fan	10000	100mm Celdek pads (larger model)	wall-mounted controller with variable speed fan control/thermostat control (optional remote control)	-
CoolBreeze	C160	residential ducted (Cascade)	750	11	Water Manager (timed drain off system)	Variable speed axial fan	12500	100mm Celdek pads (larger model)	wall-mounted controller with variable speed fan control/thermostat control (optional remote control)	-
CoolBreeze	C205	residential ducted (Cascade)	1000	14.5	Water Manager (timed drain off system)	Variable speed axial fan	16000	100mm Celdek pads (larger model)	wall-mounted controller with variable speed fan control/thermostat control (optional remote control)	-

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
CoolBreeze	C240	residential ducted (Cascade)	1000	16.5	Water Manager (timed drain off system)	Variable speed axial fan	18500	100mm Celdek pads (larger model)	wall-mounted controller with variable speed fan control/thermostat control (optional remote control)	-
Commercial Air	FD400	commercial twin fan unit	2×750	-	Water Manager (timed drain off system)	Variable speed axial fan	28000	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FD500	commercial twin fan unit	2×1000	-	Water Manager (timed drain off system)	Variable speed axial fan	36000	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FD095	commercial unit, roof mounted for ducted & plenum applications	600	-	Water Manager (timed drain off system)	Variable speed axial fan	7500	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FD125	commercial unit, roof mounted for ducted & plenum applications	600	-	Water Manager (timed drain off system)	Variable speed axial fan	10000	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FD160	commercial unit, roof mounted for ducted & plenum applications	750	-	Water Manager (timed drain off system)	Variable speed axial fan	12500	Celdek pads	wall-mounted controller with variable speed fan control	-

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m³/h)	Pad type	Control system	Evaporation efficiency
Commercial Air	FD195	commercial unit, roof mounted for ducted & plenum applications	1000	-	Water Manager (timed drain off system)	Variable speed axial fan	15000	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FD230	commercial unit, roof mounted for ducted & plenum applications	1000	-	Water Manager (timed drain off system)	Variable speed axial fan	18000	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FD255	commercial unit, roof mounted for ducted & plenum applications	1000	-	Water Manager (timed drain off system)	Variable speed axial fan	19500	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FT095	commercial top discharge unit, floor mounted	600	-	Water Manager (timed drain off system)	Variable speed axial fan	7500	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FT125	commercial top discharge unit, floor mounted	600	-	Water Manager (timed drain off system)	Variable speed axial fan	10000	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FT160	commercial top discharge unit, floor mounted	750	-	Water Manager (timed drain off system)	Variable speed axial fan	12500	Celdek pads	wall-mounted controller with variable speed fan control	-

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
Commercial Air	FT195	commercial top discharge unit, floor mounted	1000	-	Water Manager (timed drain off system)	Variable speed axial fan	15000	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FT230	commercial top discharge unit, floor mounted	1000	-	Water Manager (timed drain off system)	Variable speed axial fan	18000	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	FT255	commercial top discharge unit, floor mounted	1000	-	Water Manager (timed drain off system)	Variable speed axial fan	19500	Celdek pads	wall-mounted controller with variable speed fan control	-
Commercial Air	S240	commercial side discharge unit, wall/floor mounted	1000	-	Water Manager (timed drain off system)	Axial fan	18500	100mm Celdek pads	variable speed fan control	-
Commercial Air	S100	commercial, wall mounted	600	-	Water Manager (timed drain off system)	Axial fan	18500	75mm Celdek pads	variable speed fan control	-
Commercial Air	FM240	mobile	1000	-	Water Manager (timed drain off system)	Axial fan	18500	100mm Celdek pads	variable speed fan control	-

CARRIER

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
Brivis Contour	L13	residential ducted	-	6	-	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Contour	L23	residential ducted	-	8.9	-	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Contour	L33	residential ducted	-	12.4	-	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Contour	L43	residential ducted	-	14	-	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Contour	L53	residential ducted	-	15.8	-	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Contour	L63	residential ducted	-	16.7	-	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Profiler	P23	residential ducted	-	8.6	AutoRefresh water management system (periodic drain off system)	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
Brivis Profiler	P33	residential ducted	-	10.9	AutoRefresh water management system (periodic drain off system)	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Profiler	P43	residential ducted	-	13.2	AutoRefresh water management system (periodic drain off system)	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Profiler	P53	residential ducted	-	14.7	AutoRefresh water management system (periodic drain off system)	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Profiler	P63	residential ducted	-	16	AutoRefresh water management system (periodic drain off system)	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Advance	F23D	residential ducted	-	8.6	AutoRefresh water management system (periodic drain off system)	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
Brivis Advance	F33D	residential ducted	-	11	AutoRefresh water management system (periodic drain off system)	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Advance	F43D	residential ducted	-	13	AutoRefresh water management system (periodic drain off system)	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-
Brivis Advance	F53D	residential ducted	-	15.4	AutoRefresh water management system (periodic drain off system)	Axial fan	-	Celdek pads	Wall-mounted controller with thermostat control	-

CLIMATE TECHNOLOGY

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
Celair	Profile500	domestic	600	-	"Dialflo" (constant bleed off system)	Low noise axial fan	9326	Celdek® filter pads	Wall mounted thermostatic control	-
Celair	Profile600	domestic	750	-	"Dialflo" (constant bleed off system)	Low noise axial fan	11810	Celdek® filter pads	Wall mounted thermostatic control	-
Celair	Profile750	domestic	750	-	"Dialflo" (constant bleed off system)	Low noise axial fan	13810	Celdek® filter pads	Wall mounted thermostatic control	-

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
Celair	Profile850	domestic	750	-	"Dialflo" (constant bleed off system)	Low noise axial fan	15986	Celdek® filter pads	Wall mounted thermostatic control	-
Bonaire Integra	VSS50	Residential ducted	970	-	-	Low noise axial fan	9085	Celdek® filter pads	Remote controller & touch pad controller with thermostat control	-
Bonaire Integra	VSS55	Residential ducted	970	-	-	Low noise axial fan	10834	Celdek® filter pads	Remote controller & touch pad controller with thermostat control	-
Bonaire Integra	VSM60	Residential ducted	1040	-	-	Low noise axial fan	12584	Celdek® filter pads	Remote controller & touch pad controller with thermostat control	-
Bonaire Integra	VSM65	Residential ducted	1040	-	-	Low noise axial fan	14677	Celdek® filter pads	Remote controller & touch pad controller with thermostat control	-
Bonaire Integra	VSL70	Residential ducted	1540	-	-	Low noise axial fan	16211	Celdek® filter pads	Remote controller & touch pad controller with thermostat control	-
Bonaire Integra	VSL75	Residential ducted	1540	-	-	Low noise axial fan	17766	Celdek® filter pads	Remote controller & touch pad controller with thermostat control	-
Bonaire Summer Breeze	SBS50	Residential ducted	970	-	-	Low noise axial fan	9085	Celdek® filter pads	variable speed control & thermostat control	-

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
Bonaire Summer Breeze	SBS55	Residential ducted	970	-	-	Low noise axial fan	10834	Celdek® filter pads	variable speed control & thermostat control	-
Bonaire Summer Breeze	SBM60	Residential ducted	1040	-	-	Low noise axial fan	12584	Celdek® filter pads	variable speed control & thermostat control	-
Bonaire Summer Breeze	SBM65	Residential ducted	1040	-	-	Low noise axial fan	14677	Celdek® filter pads	variable speed control & thermostat control	-
Bonaire Summer Breeze	SBL70	Residential ducted	1540	-	-	Low noise axial fan	16211	Celdek® filter pads	variable speed control & thermostat control	-
Bonaire Summer Breeze	SBL75	Residential ducted	1540	-	-	Low noise axial fan	17766	Celdek® filter pads	variable speed control & thermostat control	-
Bonaire Durango	-	Window-mounted	-	-	-	3 speed axial fan	4500	-	Variable speed control	-
Bonaire B&C	B18	Commercial ducted	750	-	"Dialflo" (constant bleed off system)	centrifugal fan with 2 speed motor	9360	Celdek®/Aspen	Wall-mounted 2 speed motor control	-
Bonaire B&C	B23	Commercial ducted	750	-	"Dialflo" (constant bleed off system)	centrifugal fan with 2 speed motor	11484	Celdek®/Aspen	Wall-mounted 2 speed motor control	-
Bonaire B&C	B33	Commercial ducted	1500	-	"Dialflo" (constant bleed off system)	centrifugal fan with 2 speed motor	14040	Celdek®/Aspen	Wall-mounted 2 speed motor control	-
Bonaire B&C	B36	Commercial ducted	1500	-	"Dialflo" (constant bleed off system)	centrifugal fan with 2 speed motor	14583	Celdek®/Aspen	Wall-mounted 2 speed motor control	-

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m³/h)	Pad type	Control system	Evaporation efficiency
Bonaire B&C	700C	Commercial ducted	2200	-	"Dialflo" (constant bleed off system)	centrifugal fan with 2 speed motor	19798	Celdek®/Aspen	Wall-mounted 2 speed motor control	-
Bonaire B&C	900C	Commercial ducted	4000	-	"Dialflo" (constant bleed off system)	centrifugal fan with 2 speed motor	32757	Celdek®/Aspen	Wall-mounted 2 speed motor control	-
Bonaire B&C	1200C	Commercial ducted	4000	-	"Dialflo" (constant bleed off system)	centrifugal fan with 2 speed motor	42660	Celdek®/Aspen	Wall-mounted 2 speed motor control	-
Bonaire B&C	1400C	Commercial ducted	7500	-	"Dialflo" (constant bleed off system)	centrifugal fan with 2 speed motor	52200	Celdek®/Aspen	Wall-mounted 2 speed motor control	-
Bonaire B&C	1500C	Commercial ducted	10000	-	"Dialflo" (constant bleed off system)	centrifugal fan with 2 speed motor	57060	Celdek®/Aspen	Wall-mounted 2 speed motor control	-
Bonaire	Seasonmaker DF	commercial, window-mounted	425	-	"Dialflo" (constant bleed off system)	direct dive dual fan	13300	Celdek® 100mm pads	2 speed control	-

SEELEY INTERNATIONAL

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m³/h)	Pad type	Control system	Evaporation efficiency
coolair	CPL450	Residential ducted	335	7.3	constant bleed off system	Axial fan	2340 (fan at low speed) &10080 (fan at high speed)	Chilcel cooling pads	Wall mounted control, variable speed motor	85%
coolair	CPL700	Residential ducted	420	9.1	constant bleed off system	Axial fan	2340 (fan at low speed) &10080 (fan at high speed)	Chilcel cooling pads	Wall mounted control, variable speed motor	85%

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
coolair	CPL850	Residential ducted	600	11.5	constant bleed off system	Axial fan	2340 (fan at low speed) &10080 (fan at high speed)	Chilcel cooling pads	Wall mounted control, variable speed motor	85%
coolair	CPL1100	Residential ducted	750	14.1	constant bleed off system	Axial fan	2340 (fan at low speed) &10080 (fan at high speed)	Chilcel cooling pads	Wall mounted control, variable speed motor	85%
Braemar	LCB250	Residential ducted	360	8	WATERmanager ™ (salinity level monitoring system)	Axial fan	2340 (fan at low speed) &10080 (fan at high speed)	Chilcel® cooling pads (self-clean)	Wall mounted control, variable speed motor	85%
Braemar	LCB350	Residential ducted	500	9.5	WATERmanager ™ (salinity level monitoring system)	Axial fan	2340 (fan at low speed) &10080 (fan at high speed)	Chilcel® cooling pads (self-clean)	Wall mounted control, variable speed motor	85%
Braemar	LCB450	Residential ducted	700	12.3	WATERmanager ™ (salinity level monitoring system)	Axial fan	2340 (fan at low speed) &10080 (fan at high speed)	Chilcel® cooling pads (self-clean)	Wall mounted control, variable speed motor	85%
Braemar	LCB550	Residential ducted	930	14.7	WATERmanager ™ (salinity level monitoring system)	Axial fan	2340 (fan at low speed) &10080 (fan at high speed)	Chilcel® cooling pads (self-clean)	Wall mounted control, variable speed motor	85%
Breezair	EXH130	Residential ducted	500	8.4	WATERmanager ™ or constant bleed off system	Ultra quiet centrifugal fan (super efficient Hushpower moter)	2340 (fan at low speed) &10080 (fan at high speed)	90 mm thick Chilcel® pads	SensorTouch® wall controller or remote control, thermostatic control	85%

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
Breezair	EXH150	Residential ducted	550	9.8	WATERmanager ™ or constant bleed off system	Ultra quiet centrifugal fan (super efficient Hushpower moter)	2340 (fan at low speed) &10080 (fan at high speed)	90 mm thick Chilcel® pads	SensorTouch® wall controller or remote control, thermostatic control	85%
Breezair	EXH170	Residential ducted	750	12.6	WATERmanager ™ or constant bleed off system	Ultra quiet centrifugal fan (super efficient Hushpower moter)	2340 (fan at low speed) &10080 (fan at high speed)	90 mm thick Chilcel® pads	SensorTouch® wall controller or remote control, thermostatic control	85%
Breezair	EXH190	Residential ducted	1100	14.4	WATERmanager ™ or constant bleed off system	Ultra quiet centrifugal fan (super efficient Hushpower moter)	2340 (fan at low speed) &10080 (fan at high speed)	90 mm thick Chilcel® pads	SensorTouch® wall controller or remote control, thermostatic control	85%
Breezair	EXH210	Residential ducted	1500	15.5	WATERmanager ™ or constant bleed off system	Ultra quiet centrifugal fan (super efficient Hushpower moter)	2340 (fan at low speed) &10080 (fan at high speed)	90 mm thick Chilcel® pads	SensorTouch® wall controller or remote control, thermostatic control	85%
Breezair	EZH175	Residential ducted	750	11.6	WATERmanager ™ or constant bleed off system	Ultra quiet centrifugal fan (super efficient Hushpower moter)	2340 (fan at low speed) &10080 (fan at high speed)	90 mm thick Chilcel® pads	SensorTouch® wall controller or remote control, thermostatic control	85%

Brand	**Model**	**Type**	**Energy input (W)**	**Cooling power (kW)**	**Water bleeding system**	**Fan type**	**Supply flow rate (m^3/h)**	**Pad type**	**Control system**	**Evaporation efficiency**
Breezair	EZH215	Residential ducted	1500	15.4	WATERmanager ™ or constant bleed off system	Ultra quiet centrifugal fan (super efficient Hushpower moter)	2340 (fan at low speed) &10080 (fan at high speed)	90 mm thick Chilcel® pads	SensorTouch® wall controller or remote control, thermostatic control	85%
Convair	Magicool	portable	-	0.47	No bleeding system	3 speed centrifugal fan	675	Chilcel® pads	3 speed fan control	85%
Convair	Megacool	portable	-	0.95	No bleeding system	3 speed centrifugal fan	1150	Chilcel® pads	3 speed fan control	85%
Convair	Mastercool	portable	-	0.95	No bleeding system	3 speed centrifugal fan	1125	Chilcel® pads	3 speed fan control	85%
Convair	M3000 Coolmaster	portable	-	1.475	No bleeding system	3 speed centrifugal fan	1355	Chilcel® pads	3 speed fan control	85%
Braemar Commercial EA series	EA90	commercial	550	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	6840	Aspen fibre	2 speed fan control	85%
Braemar Commercial EA series	EA120	commercial	750	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	9540	Aspen fibre	2 speed fan control	85%
Braemar Commercial EA series	EA150	commercial	1500	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	11340	Aspen fibre	2 speed fan control	85%
Braemar Commercial RPA series	RPA400	commercial	1100	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	14760	Aspen fibre or Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPA series	RPA450	commercial	2000	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	15912	Aspen fibre or Chilcel® pads	2 speed fan control	85%

Brand	**Model**	**Type**	**Energy input (W)**	**Cooling power (kW)**	**Water bleeding system**	**Fan type**	**Supply flow rate (m³/h)**	**Pad type**	**Control system**	**Evaporation efficiency**
Braemar Commercial RPA series	RPA500	commercial	2000	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	17136	Aspen fibre or Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPA series	RPA600	commercial	2500	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	21096	Aspen fibre or Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPA series	RPA700	commercial	2500	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	25272	Aspen fibre or Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPA series	RPA900	commercial	4500	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	31716	Aspen fibre or Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPB series	RPB600	commercial	2000	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	22032	Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPB series	RPB700	commercial	2500	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	25920	Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPB series	RPB900	commercial	4500	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	31716	Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPB series	RPB1000	commercial	6000	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	35604	Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPB series	RPB1200	commercial	4500	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	41292	Chilcel® pads	2 speed fan control	85%

Brand	Model	Type	Energy input (W)	Cooling power (kW)	Water bleeding system	Fan type	Supply flow rate (m^3/h)	Pad type	Control system	Evaporation efficiency
Braemar Commercial RPB series	RPB1300	commercial	6000	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	45900	Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPB series	RPB1400	commercial	8000	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	50688	Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPB series	RPB1500	commercial	10000	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	54180	Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPB series	RPB1800	commercial	15000	-	WATERmanager ™ or timed drain off system	2 speed centrifugal fan	63684	Chilcel® pads	2 speed fan control	85%
Braemar Commercial RPC series	RPC250	commercial ducted	560	-	WATERmanager ™ or timed drain off system	2/variable speed centrifugal fan	6840	Aspen fibre or Chilcel® pads	2/variable speed fan control	85%
Braemar Commercial RPC series	RPC320	commercial ducted	750	-	WATERmanager ™ or timed drain off system	2/variable speed centrifugal fan	9360	Aspen fibre or Chilcel® pads	2/variable speed fan control	85%
Braemar Commercial RPC series	RPC400	commercial ducted	1100	-	WATERmanager ™ or timed drain off system	2/variable speed centrifugal fan	10980	Aspen fibre or Chilcel® pads	2/variable speed fan control	85%
Braemar Commercial RPC series	RPC450	commercial ducted	1500	-	WATERmanager ™ or timed drain off system	2/variable speed centrifugal fan	12240	Aspen fibre or Chilcel® pads	2/variable speed fan control	85%

Appendix 2: Raw air conditioner data in Figures 2 and 3 (ABS data)

Mar-08

Air conditioner type	NSW	Vic.	Qld	SA	WA	Tas.	NT(b)	ACT	Aust.
Total No. of Air Conditioners ('000)	1579.0	1428.3	1043.4	550.2	661.9	71.5	56.6	80.0	5470.9
Penetration	-	-	-	-	-	-	-	-	66.4
Proportion (%)	-	-	-	-	-	-	-	-	-
Reverse cycle	77.7	41.9	70.2	59.4	52.0	96.1	21.3	56.3	61.3
Cooling only	8.5	28.4	21.1	13.2	13.5	0.0	58.7	0.0	17.6
Evaporative	11.6	27.1	4.4	26.2	33.6	2.7	17.5	32.3	18.6
Refrigerated	86.2	70.3	91.3	72.6	65.5	96.1	80.0	56.3	78.9
No.('000)	-	-	-	-	-	-	-	-	-
Evaporative	183.2	387.1	45.9	144.2	222.4	1.9	9.9	25.8	1017.6
Refrigerated	1361.1	1004.1	952.6	399.4	433.5	68.7	45.3	45.0	4316.5

Mar-05

Air conditioner type	NSW	Vic.	Qld	SA	WA	Tas.	NT(b)	ACT	Aust.
Total No. of Air Conditioners('000)	1391.2	1152.1	886.2	541.0	542.5	37.7	50.3	60.0	4661.0
Penetration	-	-	-	-	-	-	-	-	59.4
Proportion (%)	-	-	-	-	-	-	-	-	-
Reverse cycle	78.0	36.3	61.2	53.4	41.6	90.8	16.2	59.1	56.6
Cooling only	7.6	29.4	26.6	16.5	17.8	2.0	65.1	11.1	19.4
Evaporative	12.7	31.3	9.8	29.4	39.1	6.7	17.1	28.7	22.0
Refrigerated	85.6	65.7	87.8	69.9	59.4	92.8	81.3	70.2	76.0
No.('000)	-	-	-	-	-	-	-	-	-
Evaporative	176.7	360.6	86.8	159.1	212.1	2.5	8.6	17.2	1025.4
Refrigerated	1190.9	756.9	778.1	378.2	322.2	35.0	40.9	42.1	3542.4

Mar-02

Air conditioner type	NSW	Vic.	Qld	SA	WA	Tas.	NT(b)	ACT	Aust.
Total No. of Air Conditioners ('000)	1074.7	972.4	551.1	487.9	444.4	19.5	48.8	35.7	3634.6
Penetration	-	-	-	-	-	-	-	-	48.6
Proportion (%)	-	-	-	-	-	-	-	-	-
Reverse cycle	71.4	30.3	47.7	50.5	35.6	93.6	9.2	54.3	48.8
Cooling only	12.5	35.7	37.7	19.8	23.7	0.0	70.8	15.9	25.6

Air conditioner type	NSW	Vic.	Qld	SA	WA	Tas.	NT(b)	ACT	Aust.
Evaporative	12.6	29.7	11.8	29.2	39.1	6.4	18.5	27.6	22.7
Refrigerated	83.9	66.0	85.4	70.3	59.3	93.6	80.0	70.2	74.4
No.('000)	-	-	-	-	-	-	-	-	-
Evaporative	135.4	288.8	65.0	142.5	173.8	1.2	9.0	9.9	825.1
Refrigerated	901.7	641.8	470.6	343.0	263.5	18.3	39.0	25.1	2704.1

Mar-99

Air conditioner type	NSW	Vic.	Qld	SA	WA	Tas.	NT(b)	ACT	Aust.
Total No. of Air Conditioners('000)	659.2	757.8	330.3	329.1	324.9	4.7	43.6	23.5	2473.0
Penetration	-	-	-	-	-	-	-	-	34.7
Proportion (%)	-	-	-	-	-	-	-	-	-
Reverse cycle	59.4	30.3	23.5	35.4	23.9	53.7	4.3	56.4	36.8
Cooling only	16.6	40.8	49.7	27.6	27.2	19.0	77.2	12.2	32.3
Evaporative	20.8	24.3	20.5	36.0	47.8	15.4	17.6	28.7	27.4
Refrigerated	76.0	71.1	73.2	63.0	51.1	72.7	81.5	68.6	69.1
No.('000)	-	-	-	-	-	-	-	-	-
Evaporative	137.1	184.1	67.7	118.5	155.3	0.7	7.7	6.7	677.6
Refrigerative	501.0	538.8	241.8	207.3	166.0	3.4	35.5	16.1	1708.8

Mar-94

Air conditioner type	NSW	Vic.	Qld	SA	WA	Tas.	NT(b)	ACT	Aust.
Total No. of Air Conditioners('000)	664.7	593.5	201.2	349.1	217.0	4.3	35.3	17.3	2082.4
Penetration	-	-	-	-	-	-	-	-	32.5
Proportion (%)	-	-	-	-	-	-	-	-	-
Reverse cycle	67.5	41.6	36.6	52.9	33.2	51.5	15.0	50.7	50.0
Cooling only	14.2	36.7	39.1	23.4	33.3	8.9	63.3	13.6	27.4
Evaporative	16.1	16.8	18.9	23.1	30.3	31.2	20.0	34.6	19.5
Refrigerated	81.7	78.3	75.7	76.3	66.5	60.4	78.3	64.3	77.4
No.('000)	-	-	-	-	-	-	-	-	-
Evaporative	107.0	99.7	38.0	80.6	65.8	1.3	7.1	6.0	406.1
Refrigerative	543.1	464.7	152.3	266.4	144.3	2.6	27.6	11.1	1611.8

Appendix 3: Evaporated water consumption in a typical hot day

ACAD-BSG 18th of Feb.

Time	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)	Entering air humidity ratio (g/kg air)	Leaving air dry-bulb temperature (°C)	Leaving air humidity ratio (g/kg air)	Humidity ratio difference (g/kg air)	Water consumption rate for various air flow rate (L/hr) 9360(m^3/h)	Water consumption rate for various air flow rate (L/hr) 16200(m^3/h)
1	26.8	17.2	8.31	18.6	11.70	3.40	-	-
2	27	16.7	7.63	18.2	11.27	3.64	-	-
3	26.9	16.1	6.98	17.7	10.77	3.80	-	-
4	26.7	15.5	6.38	17.2	10.30	3.91	-	-
5	26.7	15.1	5.94	16.8	10.01	4.07	-	-
6	***27.2***	15	5.62	16.8	9.90	4.28	***48.2***	***83.4***
7	***28***	15.4	5.74	17.3	10.14	4.40	***49.6***	***85.9***
8	***29.2***	15.8	5.70	17.8	10.39	4.69	***52.9***	***91.5***
9	***30.5***	16.5	5.97	18.6	10.87	4.90	***55.2***	***95.6***
10	***31.9***	17.1	6.10	19.3	11.29	5.19	***58.5***	***101.3***
11	***33.1***	17.7	6.32	20.0	11.73	5.41	***60.9***	***105.4***
12	***34***	18.4	6.81	20.7	12.31	5.50	***61.9***	***107.2***
13	***34.8***	19.1	7.37	21.5	12.87	5.50	***62.0***	***107.4***
14	***35.5***	19.7	7.86	22.1	13.41	5.55	***62.6***	***108.3***
15	***36.2***	20.1	8.10	22.5	13.78	5.68	***64.1***	***110.9***
16	***36.6***	19.9	7.67	22.4	13.55	5.88	***66.3***	***114.8***
17	***36.2***	19.4	7.18	21.9	13.10	5.92	***66.7***	***115.4***
18	***34.8***	18.5	6.61	20.9	12.35	5.74	***64.7***	***112.0***
19	***32.8***	17.6	6.32	19.9	11.65	5.32	***60.0***	***103.8***
20	***30.9***	16.8	6.15	18.9	11.10	4.95	***55.7***	***96.5***
21	***29.5***	16.3	6.14	18.3	10.76	4.61	***52.0***	***90.0***
22	***28.6***	16.1	6.28	18.0	10.65	4.37	***49.2***	***85.2***
23	***28.2***	16.3	6.68	18.1	10.84	4.17	***47.0***	***81.3***
24	***28.2***	16.7	7.14	18.4	11.19	4.05	***45.6***	***79.0***
-	-	-	-	-	-	Total water consumption for various air flow rate (L)	***1083.3***	***1874.9***

Time	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)	Entering air humidity ratio (g/kg air)	Leaving air dry-bulb temperature (°C)	Leaving air humidity ratio (g/kg air)	Humidity ratio difference (g/kg air)	Water consumption rate for various air flow rate (L/hr) 9360(m^3/h)	Water consumption rate for various air flow rate (L/hr) 16200(m^3/h)
-	-	-	-	-	-	Average water consumption rate for various air flow rate (L/hr)	***57.0***	***98.7***

ACDB-ADEL 19th of Feb.

Time	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)	Entering air humidity ratio (g/kg air)	Leaving air dry-bulb temperature (°C)	Leaving air humidity ratio (g/kg air)	Humidity ratio difference (g/kg air)	Water consumption rate for various air flow rate (L/hr) 9360(m^3/h)	Water consumption rate for various air flow rate (L/hr) 16200(m^3/h)
1	21.7	9.1	0.00	11.0	6.40	4.35	-	-
2	21	9.6	0.00	11.3	6.73	3.95	-	-
3	20.6	10.1	0.00	11.7	7.02	3.63	-	-
4	20.1	11.2	0.00	12.5	7.74	3.11	-	-
5	20.1	12	0.00	13.2	8.24	2.83	-	-
6	20.6	12.6	0.00	13.8	8.59	2.79	-	-
7	21.2	13.2	0.00	14.4	8.96	2.80	-	-
8	22.5	13.7	0.00	15.0	9.24	3.08	-	-
9	23.9	14.3	0.00	15.7	9.59	3.37	-	-
10	26.3	14.8	0.00	16.5	9.80	4.03	-	-
11	***28.7***	15.5	0.00	17.5	10.17	4.61	***51.9***	***89.9***
12	***31.3***	15.9	0.00	18.2	10.34	5.38	***60.7***	***105.0***
13	***33.2***	17.1	0.00	19.5	11.21	5.64	***63.6***	***110.0***
14	***35***	18	0.00	20.6	11.85	5.94	***66.9***	***115.8***
15	***35.8***	19.5	0.00	21.9	13.23	5.76	***64.9***	***112.3***
16	***36.8***	19.2	0.00	21.8	12.88	6.20	***69.9***	***120.9***
17	***36.7***	19.5	0.00	22.1	13.15	6.04	***68.1***	***117.8***
18	***36.9***	18.7	0.00	21.4	12.40	6.40	***72.1***	***124.8***
19	***34.7***	19.2	0.00	21.5	13.00	5.47	***61.6***	***106.6***
20	***33.1***	18.8	0.00	20.9	12.74	5.05	***56.9***	***98.6***
21	***30.2***	18.3	0.00	20.1	12.43	4.19	***47.2***	***81.7***
22	***29.5***	17.7	0.00	19.5	11.94	4.14	***46.6***	***80.7***

Time	**Dry-bulb temperature (°C)**	**Wet-bulb temperature (°C)**	**Entering air humidity ratio (g/kg air)**	**Leaving air dry-bulb temperature (°C)**	**Leaving air humidity ratio (g/kg air)**	**Humidity ratio difference (g/kg air)**	**Water consumption rate for various air flow rate (L/hr) 9360(m^3/h)**	**Water consumption rate for various air flow rate (L/hr) 16200(m^3/h)**
23	***27.7***	17.2	0.00	18.8	11.62	3.68	***41.5***	***71.8***
24	26.5	17.2	0.00	18.6	11.70	3.27	-	-
-	-	-	-	-	-	Total water consumption for various air flow rate (L)	***771.9***	***1336.0***
-	-	-	-	-	-	Average water consumption rate for various air flow rate (L/hr)	***59.4***	***102.8***

Appendix 4: Evaporated water consumption in a typical summer day

ACAD-BSG 12th of Dec.

Time	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)	Entering air humidity ratio (g/kg air)	Leaving air dry-bulb temperature (°C)	Leaving air humidity ratio (g/kg air)	Humidity ratio difference (g/kg air)	Water consumption rate for various air flow rate (L/hr) 9360(m^3/h)	Water consumption rate for various air flow rate (L/hr) 16200(m^3/h)
1	15.8	13.9	9.12	13.6	9.78	0.66	-	-
2	15	13.6	9.13	13.1	9.63	0.50	-	-
3	14	13.1	9.02	12.4	9.35	0.33	-	-
4	13.4	12.5	8.66	12.0	8.99	0.33	-	-
5	13.6	12.1	8.17	12.3	8.71	0.54	-	-
6	15.2	12.2	7.61	13.8	8.64	1.03	-	-
7	17.8	13	7.35	16.2	9.04	1.69	-	-
8	21	14.2	7.30	19.1	9.69	2.39	-	-
9	24.4	15.6	7.44	22.1	10.53	3.10	-	-
10	***27.6***	16.8	7.50	25.0	11.31	3.80	***42.9***	***74.2***
11	***30.0***	17.8	7.71	27.2	12.02	4.30	***48.5***	***84.0***
12	***31.4***	18.6	8.13	28.5	12.65	4.52	***50.9***	***88.1***
13	***32.0***	19.1	8.52	29.2	13.08	4.56	***51.4***	***89.0***
14	***32.0***	19.4	8.91	29.3	13.35	4.44	***50.1***	***86.7***
15	***31.7***	19.3	8.90	29.2	13.26	4.36	***49.1***	***85.1***
16	***31.1***	18.9	8.63	28.8	12.95	4.32	***48.6***	***84.2***
17	***30.3***	18.2	8.08	28.3	12.35	4.27	***48.1***	***83.2***
18	***29.4***	17.5	7.60	27.7	11.77	4.18	***47.1***	***81.5***
19	***28.2***	16.9	7.37	26.8	11.34	3.97	***44.7***	***77.4***
20	26.7	16.5	7.52	25.7	11.12	3.60	-	-
21	24.8	16.3	8.07	24.2	11.05	2.98	-	-
22	22.9	16	8.51	22.8	10.95	2.44	-	-
23	21.5	15.7	8.74	21.7	10.77	2.03	-	-
24	20.9	15.2	8.43	21.4	10.41	1.99	-	-

Time	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)	Entering air humidity ratio (g/kg air)	Leaving air dry-bulb temperature (°C)	Leaving air humidity ratio (g/kg air)	Humidity ratio difference (g/kg air)	Water consumption rate for various air flow rate (L/hr) 9360(m³/h)	Water consumption rate for various air flow rate (L/hr) 16200(m³/h)
-	-	-	-	-	-	Total water consumption for various air flow rate (L)	***481.5***	***833.3***
-	-	-	-	-	-	Average water consumption rate for various air flow rate (L/hr)	***48.1***	***83.3***

ACDB-ADEL 7th of Dec.

Time	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)	Entering air humidity ratio (g/kg air)	Leaving air dry-bulb temperature (°C)	Leaving air humidity ratio (g/kg air)	Humidity ratio difference (g/kg air)	Water consumption rate for various air flow rate (L/hr) 9360(m³/h)	Water consumption rate for various air flow rate (L/hr) 16200(m³/h)
1	22.2	14.6	7.24	15.7	9.90	2.66	-	-
2	21.6	14.2	7.05	15.3	9.64	2.59	-	-
3	20.8	13.8	6.95	14.9	9.41	2.45	-	-
4	20.7	13.7	6.89	14.8	9.34	2.45	-	-
5	20.6	13.6	6.83	14.7	9.28	2.45	-	-
6	21	13.3	6.35	14.5	9.04	2.69	-	-
7	21.5	13.8	6.67	15.0	9.36	2.69	-	-
8	22.6	14.1	6.53	15.4	9.51	2.97	-	-
9	24.3	15	6.81	16.4	10.07	3.26	-	-
10	26	15.2	6.34	16.8	10.12	3.78	-	-
11	***27.9***	15.8	6.23	17.6	10.46	4.24	**47.8**	**82.6**
12	***29.5***	16.6	6.49	18.5	11.01	4.52	**51.0**	**88.2**
13	***31.2***	17	6.26	19.1	11.24	4.98	**56.1**	**97.1**
14	***32.2***	17.4	6.33	19.6	11.52	5.19	**58.5**	**101.2**
15	***32.6***	17	5.69	19.3	11.15	5.46	**61.5**	**106.5**
16	***32.5***	17.7	6.57	19.9	11.76	5.19	**58.5**	**101.3**
17	***31.8***	17.6	6.73	19.7	11.72	4.98	**56.2**	**97.2**

Time	Dry-bulb temperature (^oC)	Wet-bulb temperature (^oC)	Entering air humidity ratio (g/kg air)	Leaving air dry-bulb temperature (^oC)	Leaving air humidity ratio (g/kg air)	Humidity ratio difference (g/kg air)	Water consumption rate for various air flow rate (L/hr) 9360(m^3/h)	Water consumption rate for various air flow rate (L/hr) 16200(m^3/h)
18	***31.4***	18.2	7.63	20.2	12.27	4.64	**52.3**	**90.6**
19	***29.7***	17.1	7.00	19.0	11.42	4.42	**49.9**	**86.3**
20	***28.6***	16.7	6.98	18.5	11.15	4.18	**47.1**	**81.5**
21	26.6	15.5	6.42	17.2	10.31	3.89	**-**	**-**
22	26.8	15.6	6.45	17.3	10.38	3.92	-	-
23	26.2	14.9	5.92	16.6	9.88	3.95	-	-
24	26.5	14.5	5.37	16.3	9.56	4.19	**-**	**-**
-	-	-	-	-	-	Total water consumption for various air flow rate (L)	**538.8**	**932.5**
-	-	-	-	-	-	Average water consumption rate for various air flow rate (L/hr)	**53.9**	**93.3**

Appendix 5: Tap water quality in Adelaide, Sydney and Melbourne

Table A5.1: Tap water quality in 2007-08 metropolitan Adelaide distribution systems (SA Water, 2008)

Metropolitan Adelaide - Total Distribution System								
Parameter	Health Guideline	Aesthetic Guideline	Samples	Min	Max	Ave	Median	% Compliance
E. coli [cfu /100 mL]	98% free from *E. coli*	–	2240	0	0	0	0	100
Coliforms [cfu /100 mL]	95% free from Coliforms#	–	2240	0	>200	0	0	98
Chlorine Residual – Free [mg/L]	≤ 5 mg/L	–	2690	<0.1	1.7	0.3	0.2	100
Chlorine Residual – Free [mg/L]	–	≤ 0.6 mg/L#	2690	<0.1	1.7	0.3	0.2	88
Colour – True [HU]	–	≤ 15 HU	369	<1	7	1	1	100
Fluoride [mg/L]	≤ 1.5 mg/L	–	86	0.74	0.98	0.86	0.86	100
Total Hardness [as $CaCO_3$] [mg/L]	–	≤ 200 mg/L	86	80	157	120	120	100
Iron – Total [mg/L]	–	≤ 0.3 mg/L	198	<0.005	0.171	0.014	0.009	100
Manganese [mg/L]	≤ 0.5 mg/L	–	197	<0.001	0.020	0.002	0.001	100
Manganese [mg/L]	–	≤ 0.1 mg/L	197	<0.001	0.020	0.002	0.001	100
pH Units	–	6.5 - 8.5	369	7.0	8.0	7.4	7.4	100
Total Dissolved Solids [mg/L]	–	≤ 500 mg/L	86	250	470	358	350	100
Turbidity [NTU]	–	≤ 5 NTU	369	<0.10	3.40	0.24	0.19	100
Trihalomethanes – Total [µg/L]	≤ 250 µg/L	–	369	33	254	131	129	99.5

SA Water Guideline Value
Data provided by United Water

Table A5.2: Tap water quality in 2008 Sydney distribution systems (Sydney Water, 2009)

SWC Summary																		
Characteristic	Analyte Name	2004 Guideline Aesthetic Value	Quarter 2 2008-09								Rolling 12 months							
			From 1/10/2008 To 31/12/2008								From 1/01/2008 To 31/12/2008							
			Performance								Performance							
		Units in mg/L unless otherwise specified	% Passed	Expected No. of Samples	Actual No. of Samples	No. of Exceptions	Max Value	Min Value	Mean Value	95th Percentile	% Passed	Expected No. of Samples	Actual No. of Samples	No. of Exceptions	Max Value	Min Value	Mean Value	95th Percentile
Physical Characteristics	Dissolved Oxygen (% Saturation)	> 85% Sat	97.8	91	91	2	136	82.8	110.5	125.7	97.8	364	364	8	153.5	63.4	109	129
	Hardness (Total)	200	100	91	91	0	64.5	41.5	50.6	60	100	364	364	0	74	30	51.2	67
	Flavour	Acceptable	#	#	#	#					100	14	14	0	3	2	3	^
	Odour	Acceptable	#	#	#	#					100	14	14	0	3	2	2	^
	Total Dissolved Solids	500	100	9	9	0	198	82	113.6	^	100	36	36	0	200	70	114.5	198
Other Inorganic Chemicals	Ammonia	0.5	100	91	91	0	0.35	<0.01	0.13	0.33	100	364	364	0	0.35	<0.01	0.12	0.33
	sulphide	0.05	97.4	78	78	2	0.114	<0.002	0.0033	<0.002	98.7	156	156	2	0.114	<0.002	0.0022	<0.002
Characteristics with Health and Aesthetic Guidelines	Free Chlorine	0.6	85.2	1,977	1,977	292	1.16	0	0.17	0.8	86.2	7,888	7,888	1,087	1.48	0	0.17	0.8
	Monochloramine	0.5	31.7	1,977	1,977	1,351	1.64	0	0.81	1.42	35.7	7,888	7,888	5,070	1.74	0	0.8	1.46
	Total Copper	1	100	91	91	0	0.255	0.003	0.033	0.145	100	364	364	0	0.264	0.002	0.026	0.076
	Manganese	0.1	100	390	390	0	0.072	<0.001	0.002	0.004	99.8	1,560	1,560	3	0.186	<0.001	0.003	0.007
	Sulphate	250	100	9	9	0	20	2	7.7778	^	100	36	36	0	20	<1	6.9306	15
	2,4,6-trichlorophenol	0.002	#	#	#	#					#	#	#	#				
	2,4-dichlorophenol	0.0003	#	#	#	#					#	#	#	#				
	2-chlorophenol	0.0001	#	#	#	#					#	#	#	#				
	ethylbenzene	0.003	#	#	#	#					#	#	#	#				
	Styrene	0.004	#	#	#	#					#	#	#	#				
	Toluene	0.025	#	#	#	#					#	#	#	#				

Table A5.3: Tap water quality in 2007-08 City West Water distribution systems in Melbourne (City West Water Ltd, 2008)

PARAMETER	UNIT	GUIDELINE VALUE (ADWG 2004)	CONCENTRATION OR VALUE (all samples) MIN	MEAN[$]	MAX	NO. OF SAMPLES TOTAL	PASSING	PERFORMANCE AGAINST STANDARD / GUIDELINE
Total Plate Count (37ºC)	orgs/mL	1000*	<1	1	1,600	2492	2490	99.9%
Total Coliforms	orgs/100mL	N	<1	<1	200	2492	–	–
E. coli #	orgs/100mL	98%<1	<1	<1	<1	2492	2492	within standard (actual 100%)
Free Chlorine	mg/L	5	0.01	0.09	0.91	2492	2492	100%
Total Chlorine	mg/L	5	0.01	0.15	1.2	2492	2492	100%
Alkalinity (as $CaCO_3$)	mg/L	N	11	16	42	15	–	–
Aluminium	mg/L	0.2	<0.01	0.03	0.14	399	399	100%
Arsenic	mg/L	0.007	<0.001	<0.001	<0.001	15	15	100%
Cadmium	mg/L	0.002	<0.002	<0.002	<0.002	15	15	100%
Calcium	mg/L	N	3.6	5.4	9.2	15	–	–
Chloride	mg/L	250	6.0	10.4	15.0	15	15	100%
Chromium	mg/L	0.05	<0.01	<0.01	<0.01	15	15	100%
Colour	Pt/Co	25**	<2	5	30	399	398	99.8%
Conductivity	µS/cm	~750	58	113	190	396	396	100%
Copper	mg/L	1	<0.01	0.019	0.090	15	15	100%
Cyanide	mg/L	0.08	<0.005	<0.005	<0.005	15	15	100%
Dissolved Oxygen	mg/L	N	6.7	9.3	10.5	27	–	–
Fluoride	mg/L	1.5	0.06	0.96	1.30	399	399	100%
Hardness (as $CaCO_3$)	mg/L	200	14	19	28	15	15	100%
Iron	mg/L	0.3	<0.02	0.06	0.27	399	399	100%
Lead	mg/L	0.01	<0.01	<0.01	<0.01	15	15	100%
Magnesium	mg/L	N	1.1	1.4	1.8	15	–	–
Manganese	mg/L	0.1	<0.001	0.003	0.021	399	399	100%
Mercury	mg/L	0.001	<0.001	<0.001	<0.001	15	15	100%
Nitrate (NO_3)	mg/L	50	0.11	0.60	0.93	15	15	100%
pH	units	6.5-8.5	6.5	7.1	9.5	409	396	96.8%
pH	units	6.5-9.2	6.5	7.1	9.5	409	405	99.0%
Potassium	mg/L	N	0.7	0.9	1.2	15	–	–
Silica (SiO_2)	mg/L	N	1.8	6.0	11.0	15	–	–
Sodium	mg/L	180	4.5	5.8	7.8	15	15	100%
Sulphate	mg/L	250	2.0	5.0	10.0	15	15	100%
Temperature	ºC	N	12	19	25	36	–	–
Total Organic Carbon	mg/L	N	1.0	2.1	3.0	15	–	–
Total Phosphorus	mg/L	N	<0.005	<0.005	0.008	15	–	–
Total Dissolved Solids	mg/L	500	30	55	110	15	15	100%
Turbidity	NTU	5[1]	<0.2	0.9[1]	6.7	779	–	within standard
Zinc	mg/L	3	<0.01	<0.01	0.020	15	15	100%
Dibromochloromethane	mg/L	N	<0.001	0.004	0.012	220	–	–
Dichlorobromomethane	mg/L	N	0.003	0.011	0.026	220	–	–
Bromoform	mg/L	N	<0.001	<0.001	0.003	220	–	–
Chloroform	mg/L	N	0.006	0.026	0.079	220	–	–
Total Trihalomethanes	mg/L	0.25	0.011	0.041	0.096	220	220	100%
Chloroacetic acid	mg/L	0.15	<0.005	<0.005	<0.005	221	221	100%
Dichloroacetic acid	mg/L	0.1	<0.005	<0.005	0.013	221	221	100%
Trichloroacetic acid	mg/L	0.1	<0.005	0.009	0.037	221	221	100%
Bromate	mg/L	0.02	<0.01	<0.01	<0.01	15	15	100%
Formaldehyde	mg/L	0.5	<0.1	<0.1	<0.1	15	15	100%

Appendix 6: Industry contact list

The authors acknowledge the cooperation of the major evaporative air conditioning system manufacturers listed below in providing technical specifications of their products and additional information which was included in the report. The information was gathered from the companies' websites and directly through the contact persons listed below:

1. Air Group Australia

Website: http://www.airgroup.com.au/

Contact person: Mr Michael Woodhouse

E-mail: michael@glidestrategic.com.au

Telephone: +61 8 9218 8888

2. Seeley International

Website: http://www.seeley.com.au/

Contact person: Mr Paul Schwarz

E-mail: pschwarz@seeleyinternational.com

Telephone: +61 8 8275 3265

3. Climate Technologies

Website: http://www.climatetechnologies.com.au

Contact person: Mr Robert Cebulski

E-mail: robert.cebulski@climtech.com.au

Telephone: +61 8 8307 5100

4. Carrier

Website: http://www.brivis.com.au

Contact person: Mr Theo Karamanis

E-mail: Theo.Karamanis@carrier.utc.com