UNIVERSITY OF TECHNOLOGY SYDNEY

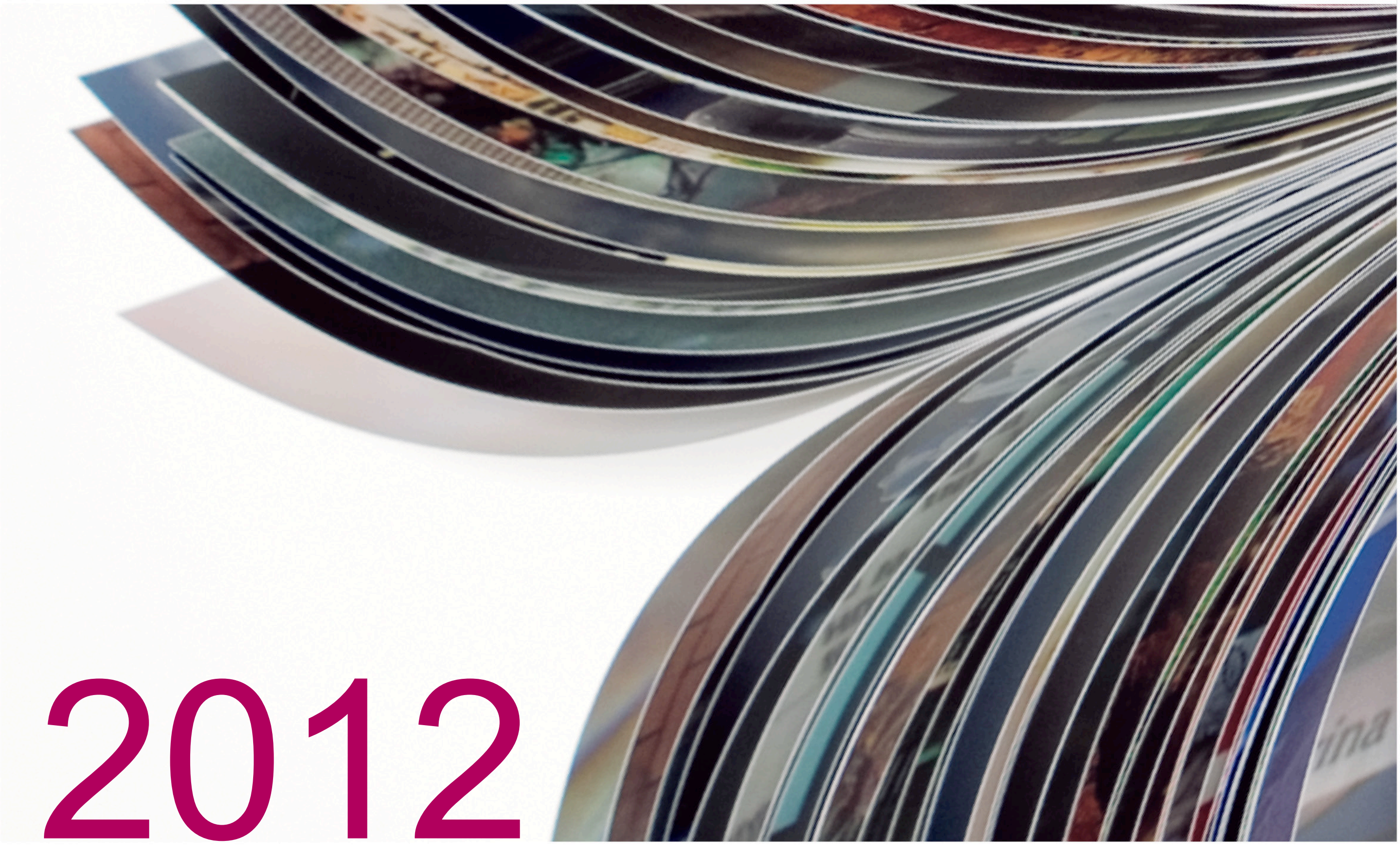
INSTITUTE FOR SUSTAINABLE FUTURES

WATER AND ENERGY USE EFFICIENCY OF EVAPORATIVE AIR CONDITIONERS

STAGE 1 – SCOPING STUDY

Institute for Sustainable Futures

savewater!® WATER DIRECTORATE RIVERINA WATER COUNTY COUNCIL DUBBO CITY COUNCIL



2012

ABOUT THE AUTHORS

The Institute for Sustainable Futures (ISF) was established by the University of Technology, Sydney in 1996 to work with industry, government and the community to develop sustainable futures through research and consultancy. Our mission is to create change toward sustainable futures that protect and enhance the environment, human well-being and social equity. We seek to adopt an inter-disciplinary approach to our work and engage our partner organisations in a collaborative process that emphasises strategic decision-making.

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Stage 1 – Scoping Study

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EXECUTIVE SUMMARY

Evaporative air conditioners (EACs) are used extensively in drier coastal and inland regions of Australia. However, very little attention has been paid to their impact on water and energy consumption. The opportunity to investigate potential water and energy savings through the efficient use of EACs prompted the savewater!® Alliance and its partners, the Water Directorate, Riverina Water and Dubbo City Council to engage the Institute of Sustainable Futures (ISF) at the University of Technology in December 2011.

ISF was engaged to prepare a scoping study of water and energy use efficiency of EACs in Australia. Based on the review of existing studies and interviews with key stakeholders, this study identifies key issues affecting the inefficient operation of EACs and major knowledge gaps. The report discusses measures to address these issues and provides recommendations on further research, as well as interim actions to promote the efficient use of EACs.

There is strong indication that excessive amounts of water are being used in the operation of EACs. It is estimated that these systems consume up to 10% of total annual water in households where EACs are used. This corresponds to an annual water usage of 22GL Australia-wide. This figure does not include water use by non-residential EACs. In contrast to their high water usage, EACs use less than one-fifth of the energy used by refrigerative systems to provide the same level of cooling, and have around 80% lower peak electricity demand.

Overall, this study concludes that there is very limited Australian based water usage data of EACs in general and particularly for non-residential systems. One study on residential EACs estimated that about 2.5GL, or 17% of total residential EAC water usage, could be saved each year in Victoria through improved efficiency of existing systems.. Another study on non-residential systems estimated that in Victoria alone 1.8GL, or about 35% of total non-residential EAC water usage, could be saved each year through best practice operation. However, there is insufficient information available on the water use, level of ownership and usage patterns of non-residential systems to determine the appropriate measures or options that could be deployed to save water.

Electricity consumption for cooling is projected to increase by about one third between 2010 and 2020. It is estimated this will be about 10% of total residential electricity consumption by 2020. This trend can potentially create major problems for electricity distribution systems on peak demand summer days. In addition, it is projected that the proportion of households with EACs is going to decrease by 4.2% from 2005 to 2020, whereas the share of households with non-ducted reverse cycle systems will increase by 10.7% in the same period (DEWHA 2008).

Promoting ownership of EACs over refrigerative systems holds enormous potential to save energy and reduce greenhouse gas emissions. However, direct EACs are only suitable in low humidity climates, which include the drier coastal and inland regions of Australia. An option to extend the climatic regions where EACs are effective is to use indirect EACs, as these are effective in a wider range of climatic conditions than direct EACs.

Further research to review the performance and suitability of direct and indirect EACs in a range of climates is required to determine their impacts on energy usage, greenhouse gas emissions, peak demand, and water usage. This research should to be supported by a wide range of stakeholders to ensure maximum water and energy savings are achieved nationally.

The recommendations outlined in Section 7.1 clearly identify the research gaps that need to be addressed including:

- Expanded end use monitoring of the energy and water use of residential EACs in order to identify the most cost efficient water and energy use reduction options.
- Expanded end use monitoring of the energy and water use of non-residential EACs in order to identify the most cost efficient water and energy use reduction options.
- Identify the gaps in existing EAC information and collate this material in a way that is useful across the whole industry Australia-wide.
- Review the performance and suitability of direct and indirect EACs in a range of climates, particularly to determine the impacts and benefits on energy use, water use and peak electricity demand.

The recommendations outlined in Section 7.2 identify the interim actions that should be undertaken by the partners of this scoping report to promote greater industry awareness about water and energy savings that can achieved from the efficient use of EACs, including:

- Dissemination of existing sources of information on EAC best practice maintenance procedures to householders and service personnel, including the identification of any gaps in the existing materials and the development of additional resources.
- Utilisation of existing training resources to establish training programs for service personnel, including possibly a web-based self-study format.

1 INTRODUCTION

Evaporative cooling has been used for centuries to cool buildings. The Egyptians historically hung wet mats in doorways and windows to enable evaporation to provide cool air when the wind blew through them. This idea has been refined over time, culminating in the modern evaporative air cooler (EAC).

EACs use considerably less energy than refrigerative systems to provide the same level of cooling. However, if not properly commissioned, regularly serviced and operated efficiently EACs can use excessive amounts of water. A study conducted by the University of South Australia (Saman et al. 2009) estimated that these systems consume up to 10% of total annual water use in typical Australian households where EACs are used. Similar high usage has been measured in locations such as Melbourne (Roberts 2004; Roberts 2005) and Alice Springs (Turner et al. 2002). A study undertaken by the Institute for Sustainable Futures (ISF) for the National Water Commission, found from a combination of analysis of customer meter readings and local industry interviews that in the city of Wagga Wagga, EACs not only contribute significantly to overall household demand but are likely to have a major impact on peak day demand (ISF, 2011).

Improving water and energy efficiency of EACs can be achieved through:

- the use of standards, rating and labelling for new EACs
- supporting the efficient operation and maintenance of existing EACs.

The Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) of South Australia is currently undertaking a project to investigate the water and energy efficiency of new residential EACs. Funded in part by the Water Efficiency Labelling and Standards (WELS) Scheme, the Ministerial Council on Energy and DMITRE, the project has the objective of revising AS/NZS 2913-2000, leading to a water and energy labelling scheme, and the development of a climate-based decision making tool. This tool will inform consumers of air conditioning choices and ultimately influence energy and water efficiency into the future.

The present study (commissioned by the savewater!® Alliance, Riverina Water County Council, Water Directorate and Dubbo City Council) aims to complement the project being undertaken by DMITRE by focusing on ways to improve water and energy efficiency of existing residential EACs as well as new and existing non-residential EACs.

1.1 Scope and objectives of the study

This study involves two stages:

- **Stage 1** (the focus of this report which has been commissioned by the savewater!® Alliance and partners) – is a scoping study to provide a situation analysis of EACs in Australia and to identify key research gaps. It aims to develop a report (this document) that provides sufficient background and recommendations to enable the savewater!® Alliance and partners to approach individual federal government bodies to engage with the subject of EACs and collaborate on undertaking Stage 2 of this study. It also aims to highlight key interim actions that can potentially be taken forward immediately by interested parties.
- **Stage 2** – aims to investigate the research gaps indentified in Stage 1 for both residential and non-residential EACs, to identify and analyse options for improving the water efficiency of EACs (including analysis of the costs and benefits), and to explicitly consider the trade-offs of water and energy.

To assist in undertaking Stage 2 and potentially some of the interim actions recommended in Chapter 8, it is proposed to approach the following three key federal government bodies for resources, due to their interest in improving water and/or energy efficiency and reducing the impact of greenhouse gases (GHGs). These include:

- the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)
- the Commonwealth Department of Climate Change and Energy Efficiency (DCCEE)
- the National Water Commission (NWC).

Other potentially interested organisations to be approached include the Water Services Association of Australia (WSAA), the Water Corporation in Western Australia, the South Australian Water Corporation, Victorian water utilities and the Power and Water Corporation in the Northern Territory, due to their specific interests in EACs.

1.2 Stage 1

As already identified the DMITRE project is investigating the water and energy efficiency of **new residential** EACs. Hence, this scoping study provides a situation analysis of the water and energy efficiency of **existing residential** EACs. Stage 1 concentrates on residential units as there is very little data available on non-residential systems. However, for completeness and due to the significant opportunities in this sector, non-residential systems are briefly covered in this report.

The main objectives of stage 1 (the scope of this report) are to:

A. provide a situation analysis of EACs in Australia and identify research gaps

B. identify key issues affecting the water and energy efficiency of existing residential EACs

C. identify strategies to address these issues and improve water and energy efficiency of existing residential EACs

D. provide recommendations on further investigations needed to improve water and energy efficiency of both residential and non-residential EACs

E. provide recommendations on interim actions the savewater!® Alliance and the Water Directorate may take to start implementing some of the strategies identified to improve the efficiency of EACs.

1.3 Methodology

The methodology used in stage 1 of this study has consisted of a combination of a literature review of relevant studies on EACs conducted in Australia and phone interviews with key informants, using the snowball sampling method. Overall, eighteen interviews were conducted.

Key informants included people from the following stakeholder groups and/or organisations:

- Australian Institute of Refrigeration, Air-conditioning and Heating (AIRAH)
- Manufacturers: Seeley International, Brivis, and Climate Technologies
- Two installation and servicing companies based in New South Wales

- Water utilities/water supply services providers including Griffith City Council (NSW), Power Water (Northern Territory), SA Water, Yarra Valley Water (VIC), Central Highlands Water (VIC) and Water Corporation (WA)
- Arid Lands Environment Centre Environmental (a non-governmental organisation based in Alice Springs leading a program to reduce household water consumption, including consumption of water by EACs)
- Department of Sustainability and Environment (DSE) of Victoria, who funded the most recent national study on EACs[1], conducted by AIRAH
- Company energy efficiency strategies.

1.4 Structure of the Report

This report consists of eight chapters as follows:

Chapter 1 describes the scope, objectives and methodology of the study.

Chapter 2 provides background information on how the different types of EACs operate and their water and energy usage.

Chapter 3 provides a situation analysis of EACs in Australia in terms of their market share and available information on their water and energy usage (stage 1 objective A).

Chapter 4 discusses non-residential EACs as potential major water users and the potential cost-effectiveness advantages of addressing these systems compared to residential systems (stage 1 objective A).

Chapter 5 presents perspectives on EACs water efficiency issues expressed by the key informants and identified in the relevant literature (stage 1 objective B)

Chapter 6 discusses some of the measures and instruments to improve water and energy efficiency of EACs and ways to address some of the issues identified in chapter 5 (stage 1 objectives A and C).

Chapter 7 summarises the study findings and provides recommendations for further investigations and interim actions to address water and energy efficiency issues of EACs (stage 1 objectives D and E).

[1] See reference to the study in Table 1.

2 BACKGROUND INFORMATION

There are two main types of EACs – direct and indirect. Sometimes a combination of both is used in the one unit. Almost all residential units in Australia are the direct type, as are the majority of non-residential systems.

With direct evaporative cooling, dry outside air is drawn through water-saturated pads and cooled by evaporation. The cooled air is circulated by a fan. Direct evaporative cooling adds moisture to the air stream until the air stream is close to saturation. The lowest temperature the cooler can achieve in theory is the wet-bulb temperature[2], although due to less than 100% evaporation efficiency this is never actually reached. Typical evaporation efficiencies are in the range of 70–80%.

Direct coolers are most suited to warm dry climates where there is a significant difference between the wet and dry-bulb temperatures. They are not effective in humid tropical climates as they cannot achieve a large temperature drop and they add more moisture to the already humid air.

Figure 1 illustrates the mechanical operation of a typical direct EAC. Note most Australian domestic units use axial fans rather than centrifugal fans.

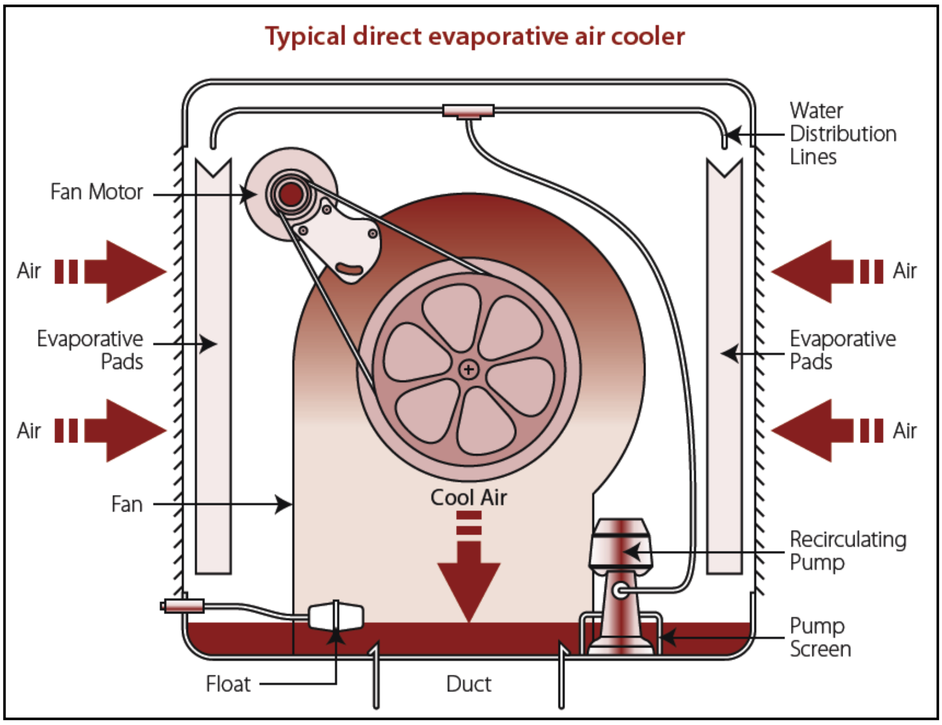

Figure 1: Diagram illustrating a typical EAC. Source: AIRAH 2010c

Most EACs are usually used to cool the whole building with the cool air distributed to different areas by ductwork in the roof. However, some residential systems use a simple single drop in one central room to provide air to the whole house. Portable and window mounted room units are also available, but they are not in the scope of this study as they are not as significant.

[2] Dry bulb temperature is the air temperature measured by a standard thermometer. Wet bulb temperature is the air temperature as measured by a thermometer with its bulb covered by a wet piece of cloth (referred to as a wick) and exposed to moving air. At relative humidity levels below 100% water will evaporate from the wick, cooling the bulb of the thermometer and causing it to read a temperature below that of the ambient dry bulb temperature. The difference between these two temperatures allows the amount of water vapour present in the air to be calculated (AIRAH 2010c).

With indirect cooling, a heat exchanger is used to cool the supply air. There is no direct contact between the supply air and the evaporated water. This means no moisture is added to the supply air stream.

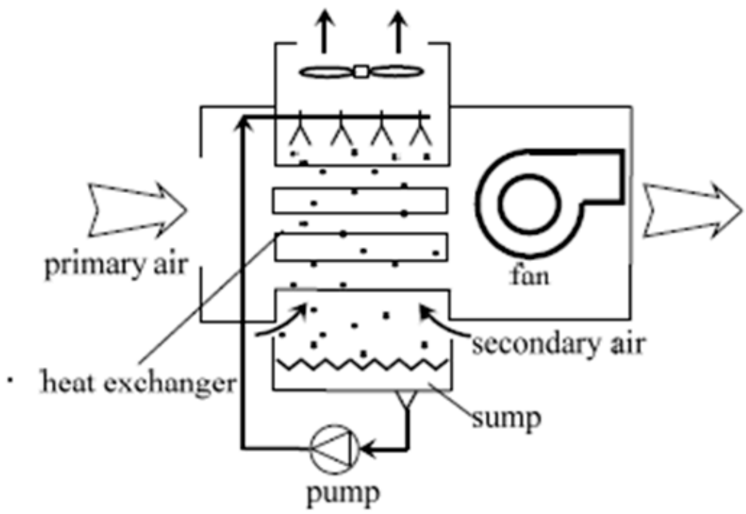

Figure 2: Diagram illustrating an indirect EAC. Source: Saman et al. 2009

Indirect coolers are mainly used in the non-residential sector for space cooling and pre-cooling for air conditioning systems. Indirect EACs are widely used in houses in the USA, but there are currently none on the market in Australia suitable for houses. One manufacturer, Seeley, is developing an indirect cooler for the Australian residential market which will allow the geographical range of EACs to be expanded into more humid areas. There is very little information available regarding the operation of indirect EACs in the residential sector in Australia. The Ausgrid and Sydney Water 'SmartHome' in Newington in Sydney uses an indirect EAC for cooling but no detailed usage data is available yet, except that it was responsible for about 17% of total household water use. Indirect EACs are not currently incorporated within existing regulatory arrangements such as BASIX.

2.1 EACs water usage

Evaporative coolers use water in several ways. These include:

Evaporation of water from the pads to cool the air. This is essential for the cooler to work effectively and little can be done to improve the efficiency of its consumption – for a set amount of cooling a corresponding amount of evaporation is required. Only the water required for cooling is evaporated and the rest is returned to the system. In fact, the more efficient the cooler is, the more water it will evaporate. However, water consumption can be influenced through other means such as behaviour, user controls and improving the thermal efficiency of the building fabric. For a typical domestic unit, approximately 40–50 litres of water per hour (L/h) can be evaporated on a 35°C day with 30% relative humidity (AIRAH 2009). The evaporation rate can be 80 L/h or more on a very hot dry day. On a cooler day it could be as low as 5–10 L/h. Non-residential units can use up to 350 L/h (AIRAH 2010c).

Lost water. This can be through splashing if the water flow through the filter pads is too strong or if they are partially blocked. Water can also be lost due to overflows from the reservoir if the water top-up valve is not working properly. These can be addressed through proper commissioning and regular servicing.

Dumping water to ensure the unit is free of microbial growth. All modern EACs have dump systems to empty the reservoir at the end of operation for this purpose. Some units do this after the unit is switched off whilst others allow the time before dumping to be adjusted by up to about 72 hours. Dumping too soon after switch off can be wasteful if the unit is only turned off for a short time, or if it has been shut down by a thermostatic control.

Discarding water from the reservoir to maintain water quality. As water evaporates from the pads, the total dissolved solids (TDS) level of the water in the system will gradually increase. This will ultimately cause deposits on the pads and in the distribution lines, reducing their efficiency, and in extreme cases it will damage the mechanical components. Manufacturers specify maximum TDS levels for their products, typically about 2,500 ppm. These have increased slightly over the years as less corrosion-susceptible components have been used and pads have become less prone to TDS build up and blockage.

2.2 Water quality controls

In some cases, where the water supply quality is good (i.e. very low TDS such as when using rain water), EACs can operate without any water quality control. However, in almost all cases some form of control will be needed. There are four main ways used in EACs in Australia to control the water quality.

Continuous bleed: A fixed amount of water is constantly drained from the reservoir when the cooler is operating in cooling mode, as opposed to just providing ventilation with the water flow turned off. This is in theory set at a rate that will keep the TDS level below the maximum allowable depending on the local water quality when the cooler is installed and serviced. A low bleed rate can be used in areas with good water quality and a high rate for poor water quality areas. This is the most common system used in non-residential EACs. All systems, except systems using automatic conductivity control, usually include a continuous bleed system in case it is needed.

Timed dump: Many EACs are now fitted with timed dump systems. These use a dump valve to periodically dump about half of the reservoir water at fixed time intervals to dilute the TDS level. The time interval should be set according the incoming water quality. This is typically set to about 8 hours at the factory. This is used on a small number of non-residential systems.

Periodic dump: The total volume of the reservoir is dumped after a specified volume of makeup water has been introduced to the system to replace evaporation losses. This is typically after a makeup volume equivalent to about 20 fills of the unit, but is adjustable. This should result in more efficient water use as the dump rate is controlled by the evaporation rate.

Conductivity control: This regulates the TDS level by measuring the conductivity of the reservoir water, and drains about half the volume when the TDS reaches the maximum allowable level. It is the most water efficient way to manage water quality. This is currently only offered by one Australian manufacturer, Seeley. It appears that currently no non-residential systems use TDS control. TDS control also has the added benefit that it does not require adjustment at the time of installation, whereas constant bleed, timer and periodic drain based systems will usually require adjustment from the default factory settings depending on the supply water quality.

2.3 EAC energy usage

The use of EACs instead of refrigerative air cooling in appropriate areas can have significant benefits in terms of energy use, greenhouse emissions and peak electricity demand reduction.

Air conditioning ownership is projected to rise significantly over the next 10 years. The report on Energy Use in the Australian Residential Sector 1986-2020 (DEWHA 2008) estimates that ownership of reverse cycle split systems will rise from about 45% of households in 2005 to about 56% in 2020. The total number of households in Australia is projected to rise from about 7.8 million to 9.9 million over the same timeframe (ABS 2010). This will result in an additional 2 million reverse cycle units in Australian homes by 2020.

At the same time ownership of EACs is projected to fall from 22% to 18% of households (DEWHA 2008). Although space cooling uses a relatively small percentage of total household energy, it accounts for about 10% of household electricity use and is increasing. Perhaps more importantly, the growth in air conditioning has the potential to place considerable strain on the electricity generation, transmission and distribution systems on peak summer days.

EACs use considerably less energy than refrigerative systems to provide the same level of cooling. A 5-star rating refrigerative air conditioner produces approximately 2.8 kW of cooling from 1 kW of electricity, whereas an EAC will consume one-fifth of this to produce the same cooling effect (Mark Ellis & Associates 2001). A study for the Queensland Government estimated that EACs reduce energy consumption by approximately 80% (GHD 2003). However, actual energy savings will depend on usage patterns. It may be that households use their EACs more than they would refrigerative systems, as they are much cheaper to run. There is very little data available on the usage patterns of the different systems.

The Sustainable Energy Authority Victoria (SEAV) estimated that it costs about seven times less to run an EAC compared to an equivalent whole house refrigerative system, but notes EACs may be used for longer periods, possibly reducing the savings (SEAV 2002). The efficiency of refrigerative systems is, however, improving with the introduction of inverters other energy efficiency technologies.

The energy use of EACs can be reduced through a number of technical measures such as using high efficiency inverter motors, direct drive fans, improved fan design and the choice of filter medium. However, the implementation of these is largely restricted to new units and there is little that can be done to improve the technology of existing units. Energy reductions for existing systems are largely limited to factors such as regular cleaning and maintenance, usage patterns and improving the thermal performance of the house.

EACs also have much lower peak demand than refrigerative systems. A whole house EAC will typically use a 0.75-1kW motor, whereas a zoned ducted refrigerative system could use a compressor rated at 5kW or more. At peak demand times EACs can therefore reduce demand by 80% or more. A study in the USA estimated that peak demand can be reduced by a factor of four or more by using EACs instead of refrigerative systems (SWEEP undated). Another study estimated an 80 to 89% peak demand reduction could be achieved by substituting EACs for refrigerative systems for typical applications in California (CEC 2004).

A significant peak energy demand benefit can therefore be achieved by encouraging the ownership of EACs over refrigerative systems in suitable areas. In Alice Springs, where historically 80 to 90% of households have had EACs (Turner et al. 2003), the Power and Water Corporation has observed a noticeable increase in the load on the power system in recent years and has associated this with an increase in the use of refrigerative air cooling (pers. comm. Alan White).

The introduction of indirect EACs into the residential sector in Australia, which will allow EACs to be used in a wider range of climates, has the potential to significantly reduce the increase in peak demand being driven by the uptake of residential air conditioning systems. This could result in considerable network cost savings.

The WA Office of Energy has estimated that “an air-conditioner costing around $1000 (around 2 kW input power) could require around $6000 of expenditure on new generation and network infrastructure to enable it to be used whenever required, however rarely that may be.”(WA Office of Energy 2004). However, few data sources are available on the energy and water use of indirect EACs compared to direct EACs and refrigerative systems, and this needs to be understood before recommending widespread adoption.

3 EACs IN AUSTRALIA

EACs are more effective in high temperature and low humidity climates. As Figure 3 shows, in Australia, EACs are suitable in the southern coastal area and most of the inland areas (Zones 2 and 3).

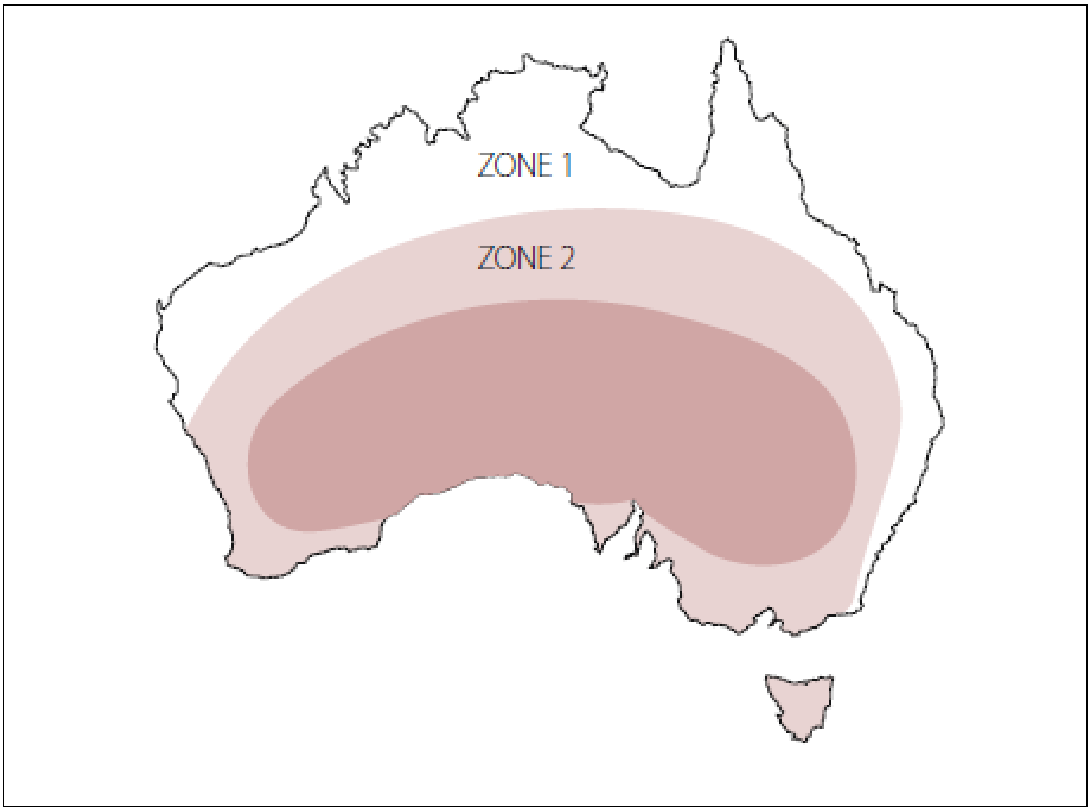

Figure 3: Zones in Australia suitable for EACs (zone 2 and 3 are the suitable zones). Source: AIRAH 2011

3.1 Market share

The general perception of the key informants of this study is that the market share of residential EACs is slowing and even dropping in some locations. In locations where EACs are appropriate they are still being installed in new and existing buildings but other forms of air conditioners are now becoming more prevalent (refer to Figure 4). This is also indicated by data from the ABS. Possible reasons for this, presented by some of the key utilities informants, are:

- Low cost and low maintenance requirements of split air conditioner systems.
- Reverse cycle systems also provide winter heating, avoiding the cost of a gas heater.
- In areas such as Alice Springs, the water is relatively hard according to water quality guidelines ($CaCO_3 \approx 200$ mg/L). This complicates maintenance issues due to salt build up in the system.
- As observed by one of the key informants, who has lived in the region of Alice Springs for thirty years, the climate has been getting more humid over the summer period, making EACs less suitable. There were consecutive wet summers between

2000 and 2002 during which EACs did not perform well. These events may have influenced people's perceptions of EACs.

- EACs are mostly located on the roof. This presents safety issues if the maintenance is conducted by the householder, particularly the elderly.
- Changing perceptions of comfort. People now expect to be comfortable all year round, not just comfortable most of the time and slightly uncomfortable on extreme days.

However, one manufacturer (Seeley) thought that EACs are starting to increase their market share again as people become more conscious of energy prices. Developments in technology through the use of indirect cooling, which they expect to have on the residential market in the next year or two, could mean a boost for EACs as they will be able to be used in a wider range of climates.

3.2 Ownership of EACs

Figure 4 shows the trend in the total number, or stock, of residential EACs across Australia compared to other types of air conditioners based on ABS data. As shown, a decline in the stock of EACs has been observed between 2005 and 2008. The seven air conditioners considered include:

- split cooling only (split CO)
- split reverse cycle (split RC)
- window wall cooling only (WW CO)
- window wall reverse cycle (WW RC)
- ducted cooling only (ducted CO)
- ducted reverse cycle (ducted RC)
- evaporative.

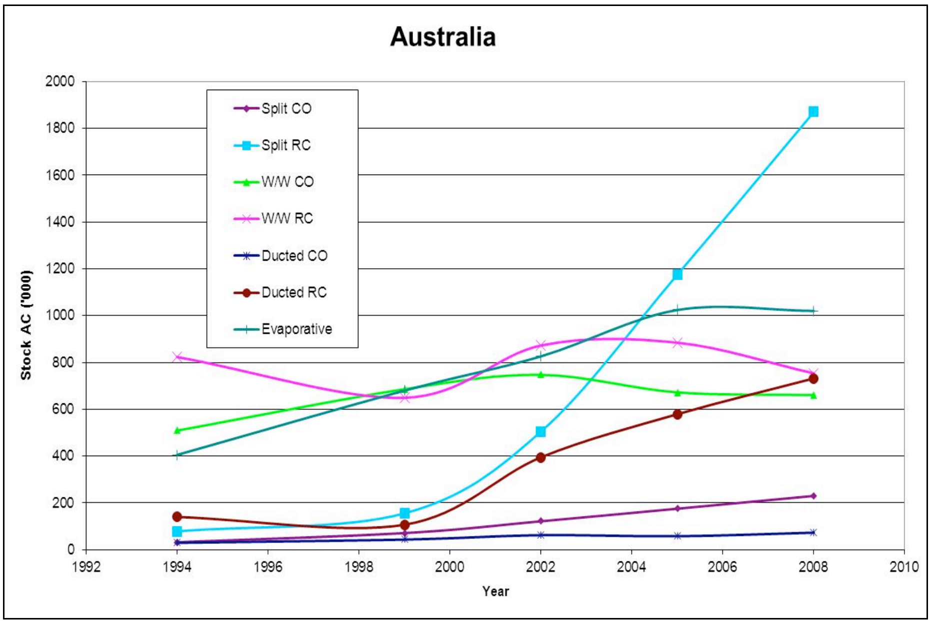

Figure 4: Stock trends of different types of air conditioners/coolers in Australia. Source: provided by Energy Efficient Strategies

Trends in stock numbers vary from state to state, with some states such as Victoria (refer to Figure 5) and WA continuing to show growth in the numbers of EACs, although there are signs that this growth is slowing.

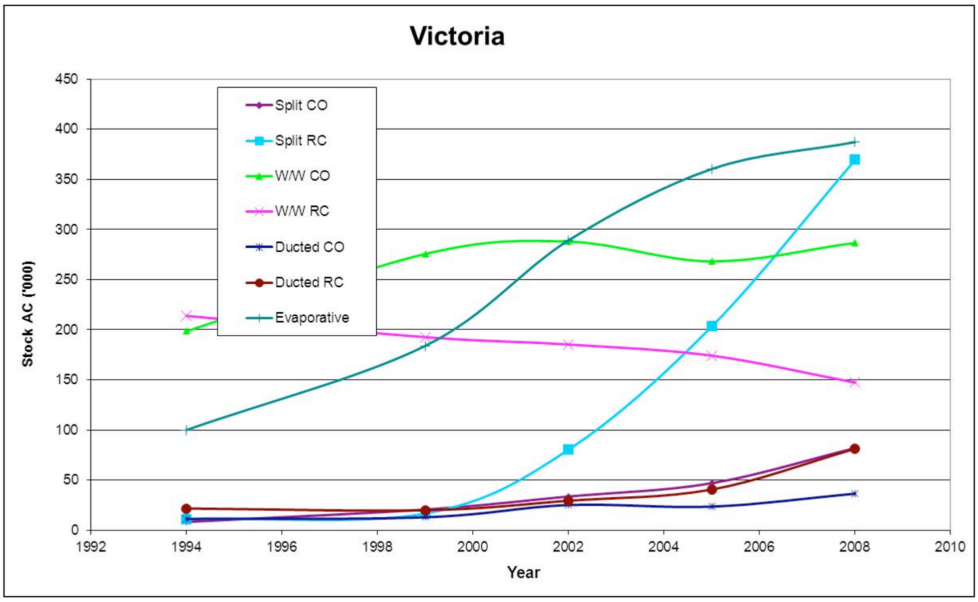

Figure 5: Stock trend of different types of air conditioners/coolers in Victoria. Source: provided by Energy Efficient Strategies

In the case of New South Wales, the total EAC stock numbers have levelled off since 2005 (refer to Figure 6) suggesting that, despite strong ongoing sales in some areas, EACs are being replaced by refrigerative units. In areas suitable for EACs in New South Wales, generally west of the Divide, numbers are possibly increasing. It is estimated that in Wagga Wagga, about 90% of new houses have EACs, an installation rate of more than 350 per year (Pers. comm. Greg Finlayson). The photograph in Figure 7 shows EACs installed on new homes in Wagga Wagga.

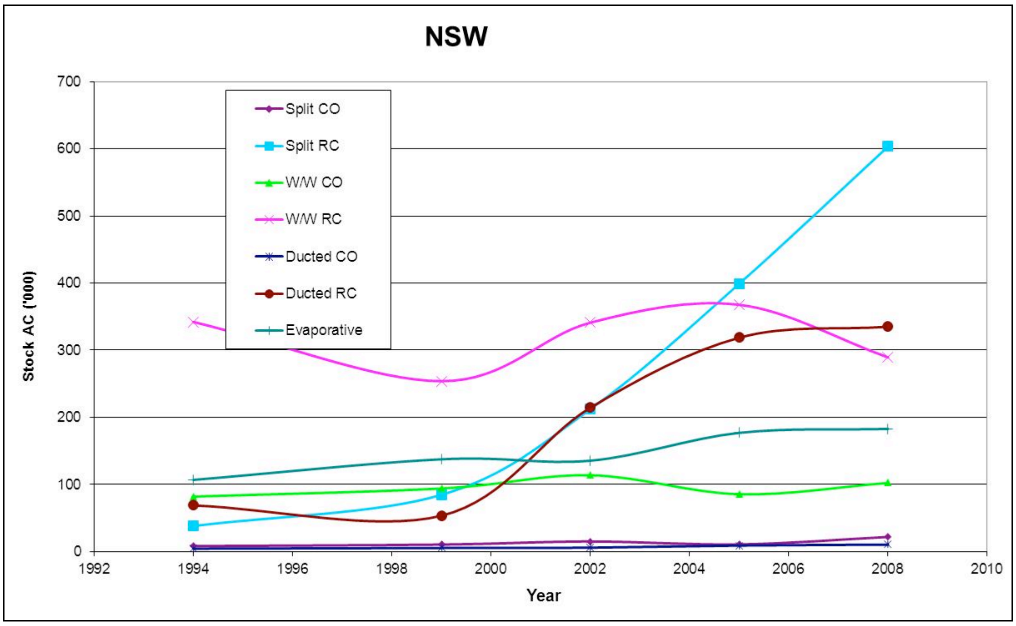

Figure 6: Stock trend of different types of air conditioners/coolers in New South Wales: Source: provided by Energy Efficient Strategies.

Figure 7: Photograph of EACs installed on new homes in Wagga Wagga (EACs are circled in yellow). Source: provided by Greg Finlayson, Riverina Water.

3.3 Existing studies

A number of studies on EACs have been conducted in Australia. Table 1 provides a description of these. As indicated, only one study has dealt specifically with non-residential systems.

Table 1: EACs-related studies conducted in Australia

Study	Description
AIRAH 2010, *Industry perspective of water inefficiencies in evaporative coolers*	Outcomes of a forum and interviews with a wide range of industry representatives on water use of EACs and potential **residential** savings through improved efficiency.
AIRAH 2010, *Domestic evaporative cooler water use efficiency assessment study*	A study of water use in 50 **residential** EACs in regional and metropolitan Victoria.
AIRAH 2010, *Non-residential evaporative water cooler study*	A study of water use in 51 **non-residential** EACs in regional and metropolitan Victoria
Roberts 2005, *Evaporative Air Conditioner Study*	End use measurement study conducted by Yarra Valley Water in conjunction with the Water Services Association of Australia. The study was an extension of the measurement undertaken for the 2004 **Residential** End Use Measurement Study on just the homes with evaporative coolers. Data on frequency and duration of use of EACs was collected for 11 homes with EACs for approximately six weeks from late January through to mid March 2005. A model estimation of the average daily usage of EACs is presented. This was then combined with daily maximum temperatures in Melbourne over the last 35 years to formulate an estimate of average annual usage.
Roberts 2004, *Yarra Valley Water's Residential End Use Measurement*	Research study undertaken by Yarra Valley Water to understand **residential** water usage at the end-use level. Collected appliance usage data from over 90 homes for two fortnightly periods in February and August 2004. Twenty of the monitored households had evaporative coolers and the first of the two logging periods contained evaporative cooler usage data from

Study	Description
Technical Background Research on Evaporative Air Conditioners and feasibility of Rating their Water Consumption	locations, and includes available information on water consumption of **residential** EACs and calculations of amounts necessary for water evaporation in different Australian locations. Provides technical background material to inform possible inclusion of EACs in the WELS scheme and reviews currently available local and international regulations and standards for testing, labeling and rating EACs.
GHD 2003, *Water Industry Compliance. Queensland Evaporative Air Conditioning Water Usage*	Comparative analysis of the operating cost of refrigerative systems and EAC systems. Used a typical **residential** installation in Longreach as a case study.
Mark Ellis & Associates 2001, *Analysis of Potential for Minimum Energy Performance Standards for Evaporative Air Conditioners*	Study conducted for the Australian Greenhouse Office. Explores the potential for energy and greenhouse savings through the introduction in Australia of Minimum Energy Performance Standards (MEPS) for EACs. Provides estimates of Green House Emissions due to EACs in Australia.
Turner *et al* 2003, *'Alice Springs water efficiency study stages 1 and 2'*	Study conducted for the Northern Territory Government. EACs investigated as part of a comprehensive end use demand forecasting and options model. **Residential** EAC investigations included: establishing current stock as part of a residential questionnaire (80 to 90% of houses); interviews with local suppliers to establish water usage, settings, maintenance and typical behavior; experiments on a small sample of typical units to understand evaporation and bleed-off rates (typically 24 L/hr usage and 6 L/hr bleed-off rate on hot day); additional interviews with maintenance crews such as public housing to understand maintenance protocols (e.g. found some bleed-off rates set at 30 L/hr as standard). Investigations generally found that due to transient nature of Alice Springs residents there appears to be a lack of understanding of how EACs work and their associated water and energy use. Hence many residents run the units 24 hrs a day over several months of the year.
Turner *et al* 2007, *Alice Springs water efficiency study stage 3: implementation feasibility study*	Report prepared for Northern Territory Government. Builds on the significant demand forecasting and options work undertaken in 2003, in Stages 1 and 2 (see Turner et al, 2003 above). This stage of the Study completed in 2007 consisted of a feasibility study into the implementation of a demand management program, including options to save water in EACs.
Marshall, G & Hoyal, S 2006, *Impacts and use of*	Study conducted by the Centre for Sustainable Arid Towns for the Desert Knowledge Corporate Research Centre. Areyonga Community Council converted all but one of 32 Indigenous houses in the community from evaporative to refrigerative air

Study	Description
refrigerative air conditioning at Areyonga community, NT	conditioners due to ongoing maintenance difficulties and costs. The study monitored six **residential** household air conditioners at Areyonga from November 2005 to March 2006. Evidence suggests that the Daikin reverse cycle refrigerative air conditioners may cost significantly less over 10 years than the combination of evaporative coolers and winter bar heaters. This is due to higher installation and maintenance costs for evaporative air conditioners (ducted). However the cooling outcomes from evaporative air conditioners seem to be better, particularly their ability to cool the entire house leading to better outcomes for residents (e.g. not all crowding into one living room to sleep). Heating outcomes were not monitored.
Marshal 2005, *Air conditioner performance at Canteen Creek community, NT*	Study conducted by the Centre for Sustainable Arid Towns in Canteen Creek, Northern Territory which monitored the water flow of Bonaire B27 light commercial evaporative air conditioners of three new **residential** houses over the summer of 2004/05.

3.4 Water consumption of EACs

A number of studies estimate the average water usage of EACs in different are Australia. Table 2 presents these.

Table 2: Estimates of residential EACs water usage in Australia

Region	Water usage data	Source
Australia	5.4–26.8 kL/a[3] , 2%–10% of average residential use	Saman et al. (2009
Adelaide	7 kL/a, 3.7% of average residential use	Estimated by Seel International Pty L indicated by Sama (2009)
Yarra Valley	18.8 kL/a, 1.6% of average residential use	Roberts (2005)
Victoria	4–15 kL/a	AIRAH (2010b)
Queensland	10%–25% of total yearly water consumption/hh 40%–75% of daily indoor water consumption in peak summer months	GHD (2003)
Alice Springs	32 kL/a, 7% of average residential use	Turner *et al* (2007)
Canteen Creek, NT	21.9–65.9 kL/month (measurement done from October 2004 to July 2005)	Marshall (2005)
Perth, WA	4 kL/a.person, 4% of overall household indoor use	Water Corporation

As can be seen the water usage data illustrates a wide range in usage figures locations like the Northern Territory where EACs are prevalent, can be significa though the cost to householders might be relatively low, the impact on the mar utilities might be significant. Water usage can be affected by multiple factors su

- the technology requirements (e.g. how it operates with respect to bleed
- the environment in which the technology is situated (e.g. if the house is the EAC will work more effectively)
- the climate (e.g. the number of days over for example 30 deg C which p trigger for people to switch the units on)
- the behaviour of householders (e.g. comfort levels which dictate when t to switch the machines on and for how long and their knowledge of how should be used)

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[3] Based on ABS 2006 data

- the behaviour of the technicians fitting and/or maintaining the units (e.g. adjusting settings correctly to the situation).

In Alice Springs (Turner et al. 2003) it was found that many houses are poorly insulated and residents are transient and unsure of how to effectively use EACs, often leaving units running for much longer than necessary. In addition, service personnel are known to set bleed-off rates higher than manufacturers' requirements. Hence, for multiple reasons the EAC water usage is likely to be high in Alice Springs. The water usage is therefore much higher than theoretically necessary and there is significant conservation potential.

However, it is important to note that while some studies (Roberts 2005 and Marshall 2005) base their water usage figures on end use monitoring, it is not clear how the water usage data presented by other studies was determined. It is also important to note that there are almost no studies that show the impact on peak day water demand of EACs. This type of data is particularly important for demand management in areas where: water treatment costs are high; infrastructure constraints are imminent; and for inland cities like Wagga Wagga, which does not have a major storage system like a dam, is on a regulated river supply and is therefore vulnerable to seasonal and peak day demand.

Saman et al. (2009) estimated that on a typical hot day in Adelaide, EACs can consume up to 116 L/hr of evaporated water. Considering that settings available to allow bleeding or dump rates to be adjusted range from approximately 3 to 40 L/hr (AIRAH 2010b), peak day demand could be as high as 150 L/hr. This may serve as an indicative figure of peak day demand for regions with similar climates to Adelaide. Observations of residential metered demand from locations such as Alice Springs (Turner et al. 2003) and Wagga Wagga (ISF 2011) indicate that the combination of evaporative air conditioners and outdoor water usage on hot days has a significant peaking effect that warrants further investigation to aid conservation.

3.5 Water quality controls

AIRAH undertook a study of the water use by the different water quality control systems in 50 homes in Victoria, 40 in Melbourne and 10 in regional areas. Table 3 presents the breakdown of water quality control systems found by the study (AIRAH 2010b).

Table 3: Water quality controls found in AIRAH (2010b)

Control type	Number of units	% of units
Constant bleed-off	7	14
Timed drain off	17	34
Periodic drain off	20	40
Conductivity control	6	12

One installation company in Wagga Wagga estimated that about 30% of their new sales are constant bleed systems.[4] Following industry consultation, AIRAH concluded that for constant bleed systems "*in practice the installer just makes sure that there is some bleed*

[4] They also suggested about a $1,000 price difference between a bottom of the range constant bleed system and a top of the range TDS system. EACs cost between $2,500 and $5,500 depending on size and type (pers comm. Harrison & Higgins).

but does not necessarily measure the rate." At best it is "*a subjective assessment made by the installer*" (AIRAH 2009).

The factory default is typically 10–12 L/h, although the adjustment range is usually 3–40L/h. Most manufacturers recommend a bleed rate of at least 10 L/h regardless of the water quality. The following is a typical recommendation from the owner's or installer's manual:

> *With normal town water supply, in good water quality areas, bleed rate should be adjusted so that the discharge is not less than 10 litres per hour subject to unit size. Increased water hardness may require a higher bleed rate and increased maintenance* (Celair nd).

However, manufacturers are inclined to be conservative in their recommended settings to avoid problems with their systems due to TDS build up.

Continuous bleed was the almost universal control system up to about 20 years ago, and rates were often set very high. For example, in 1978 one manufacturer recommended that the bleed rate should be set at "*approximately one-half of the calculated peak evaporation rate of the unit*." This could therefore be as high as 40 L/h. Excessive bleed rates could contribute significantly to peak water demand, which in some areas such as Wagga Wagga is a more important issue than overall water use (pers. comm. Greg Finlayson).

Other systems have since been introduced to improve water efficiency. However, all systems apart from conductivity control described below usually include a continuous bleed system in case it is needed.

As part of its study AIRAH (2010a) engaged a water chemist to assess the efficiency of the different water control systems for the local conditions. This assessment concluded that in all cases, except for conductivity controls excessive amounts of water would be used if the typical manufacturers' recommended settings were followed. For example in Melbourne the water quality is high with TDS at only about 50 ppm. If the conductivity control systems maintained the correct TDS level the bleed-off rate would be about 1.5 L/h compared to the typical manufacturers' recommendation of at least 10 L/h. With a continuous bleed rate of 10 L/h at an evaporation rate equivalent to a day of 35^{o}C dry bulb and 21^{o}C wet bulb, the system would reach a maximum TDS level of 500 ppm after 8 hours of continuous operation, well below the maximum allowable level of 2,500 ppm. Figure 8 illustrates this.

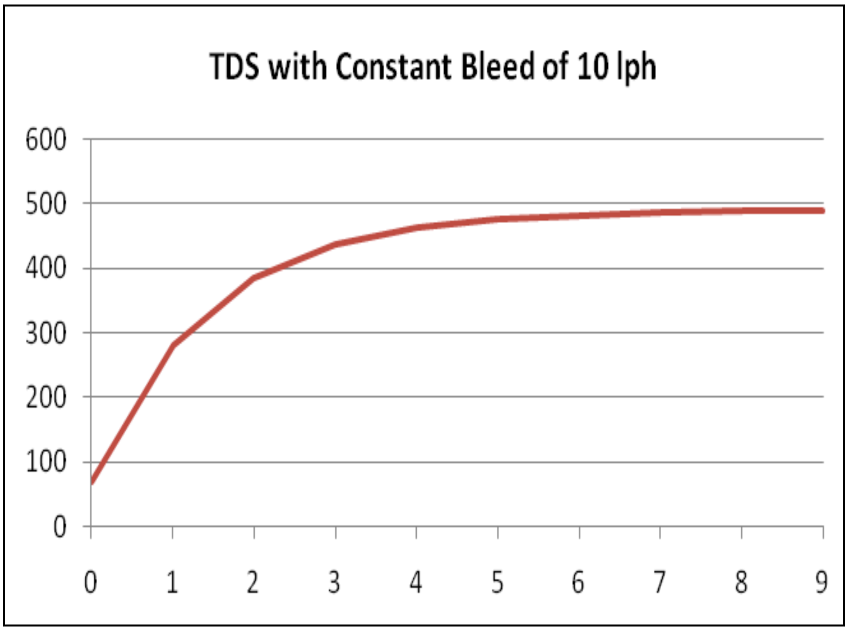

Figure 8: TDS level (vertical axis) versus time (hours – horizontal axis) at a bleed rate of 10 L/h and an evaporation rate equivalent to a day of 35°C dry bulb and 21°C wet bulb. Source: AIRAH 2010b

Similarly, for other control types, to achieve the same level of efficiency, timed units would have to do a half dump about every 15 hours (typical default 8 hours), and periodic dumps set to 40 fills before draining the reservoir (typical default 20 fills).

These factory default settings therefore result in significant water wastage.

AIRAH estimated that 2.5GL of water, or about 17% of total residential EAC water use, could be saved in Victoria each year through improved water management.

4 NON-RESIDENTIAL EACs

As previously identified, although this study concentrates mainly on residential EACs, for completeness and due to the water saving potential in non-residential EACs, these are briefly covered in this section.

There is very little information available on the water use or even the level of ownership and the patterns of use of non-residential EACs, and there is insufficient information to determine the potential measures or options that could be deployed. There are more manufacturers of non-residential systems than residential. Some manufacturers of residential systems also make non-residential EACs.

Non-residential EACs appear to be widely used in regional Australia (pers. comm. Greg Finlayson; manufacturer). They are concentrated in fewer facilities, and therefore would be easier to target than residential systems. One manufacturer considered that it would be far more cost effective to initially target non-residential systems than residential systems as there are fewer systems, fewer people servicing them, and the potential savings per system are much larger.

They are potentially major users of water. AIRAH undertook a study of 51 non-residential systems in regional and metropolitan Victoria. Seventy-five per cent of them were direct systems used to cool commercial and health facilities (AIRAH 2010c). They ranged from residential scale units to very large systems.

Figure 9: Large commercial direct EAC. Source: AIRAH 2010c

The study found an average usage of about 190 kL/a per unit. Roberts (2005) estimated annual usage of about 19 kL/a for residential systems in Melbourne, and AIRAH (2010a) estimated a range of 4–15 kL/a. The water usage by non-residential systems was estimated to be about 47% more than if they were operated according to best practice, with performance of those units in country areas being much worse than those in the city and metropolitan areas.

AIRAH estimated that 1.8GL of water, about 35% of non-residential EAC water usage, could be saved each year in Victoria alone through best practice operation.

Generally non-residential systems have rudimentary water quality controls that are not as sophisticated as the best residential models. None in the AIRAH study was found to have TDS controls. Forty-nine of the units examined had either manual bleed (42), or no bleed (7) relying instead on daily dumping of the system water.

> *"Bleed control on non-residential evaporative cooling devices tends to be primitive, typically limited to manual control (adjusting flow from a needle valve) or timer controlled dumping of some (or all) of the recirculating water"* (AIRAH 2010c).
>
> *"With the largest commercial machines on the market (18,000 L/s air flow), it is recommended to bleed 42 litres per hour. Even though commercial buyers can more easily absorb the cost of a salinity-sensing device, $500 capital cost is deemed too expensive in the current tendering environment."* It was suggested by a member of the stakeholder group that if it was compulsory, it would be in the commercial units tomorrow (AIRAH 2009).

Given the potential savings there may be more of a financial incentive for non-residential systems to be retro-fitted with TDS controls, particularly larger systems.

Dumping cycles were found to vary widely, with about half the systems dumping daily and the rest varying from weekly to never, but generally either quarterly or bi-annually. Again, residential systems appear to have more sophisticated dumping controls.

All the units were serviced at least annually, with some having quite frequent maintenance intervals. About half were serviced either quarterly or bi-annually. There was no discernible relationship between maintenance frequency and water efficiency, suggesting that not all service personnel know how to correctly adjust the water quality control systems.

Given the potentially large savings to be made, a demand management program targeted at non-residential systems could be highly cost effective for many urban areas. An option to promote the uptake of these systems could involve the development of a retrofitting cost benefit tool for service personnel. In addition collating and using existing material would be highly beneficial including a best practice guidelines booklet for non-residential EACs produced by AIRAH (AIRAH 2011b).

5 KEY EAC WATER EFFICIENCY ISSUES IDENTIFIED

This section describes water efficiency issues relevant to existing EACs identified in existing studies and expressed by the key informants of this study.

5.1 Commissioning issues

As part of its study, AIRAH consulted with manufacturers and installers of EACs and identified two distinct residential EAC markets – the customer who directly buys a unit for their own home, and the mass builders' market. The mass builders' market is responsible for the greatest number of residential installations. The mass builders' market was identified as a potential problem because they tend to select cheaper models, which are generally less water efficient, and because electricity and/or water may not be connected to the property at the time of installation, so the installer cannot test or commission the unit properly. In addition, generally the installer has no direct contact with the eventual home owner and so there is no advice about operation and maintenance for the homeowner. As reported by one key informant:

> *"In the domestic market, the sub-contractor wants to get the unit installed as quickly as possible. They take it out of the cardboard box, install it and set it to factory requirements and leave. It is rare that someone would return to see if the unit was working properly in the given operating conditions."*

5.2 Servicing and maintenance issues

EACs need to be serviced frequently and regularly to ensure they are operating optimally. Annual servicing is recommended, particularly in areas of poor water quality. Less frequent intervals may be feasible in good water quality areas. Servicing should comprise cleaning the evaporation pads, cleaning out the water reservoir, checking the water quality control system, checking for leaks, checking any drive belts and lubrication as necessary etc.

Overall there is no clear indication of how many households have their systems serviced adequately, especially as so many are installed by builders and the householders may have no direct contact with the installers. Interviews with installation and servicing companies suggest that around 60% of households for whom they directly undertake the installation have their units serviced by the installer at the required interval, usually at the start of the cooling season. However, the number is thought to be much lower for units installed by builders where there was no direct contact between the installing company and the householder. There was a strong indication from other key informants that in many cases EACs are maintained by the householder as the servicing may appear to be a simple task, and often just involves cleaning the pads and draining the system. In Wagga Wagga it is estimated that only about 15% of the households have a routine service by a company, about 60% hose the pads themselves at the start of summer, and the rest do not do any servicing at all (pers. comm. Greg Finlayson).

It was the general perception of the key informants that most of the householders do not fully understand how EACs operate or what the maintenance requirements are for peak efficiency. Servicing companies interviewed thought that most people understood how to use their systems, such as choosing ventilation-only mode when the outdoor air cooled down sufficiently. However, there does not appear to have been any independent assessment undertaken to gauge whether people are using their systems correctly or not.

One problem in Alice Springs, highlighted by a key informant, is that because of the transient nature of the population, newly arrived householders do not know how to use EACs properly. A lot of people run these systems 24 hours a day in the cooling season, which is not necessary. People tend not to do this with refrigerative air conditioning systems as they are more aware of the high running costs (pers comm. Glenn Marshall).

There are therefore probably a large number of EACs that would benefit from servicing by qualified tradespeople. However, interviews with the servicing companies also demonstrated a lack of understanding of correct adjustment of the water quality control systems (i.e. they are often just left at the factory default or adjusted from 'experience' without actually measuring the incoming water quality).

5.3 Retrofitting issues

None of the water utilities contacted have retrofit programs for EACs. For some utilities where EACs water usage is high, this option may be under consideration. However, for others, such as Yarra Valley Water and Central Highlands Water, EACs are not identified as large enough water consumers to be considered a priority in demand management programs.

In addition, as noted by one key informant, retrofitting programs for EACs would be relatively more complex than current retrofitting programs for other appliances such as showerheads. It is technically simpler for the householder to replace a showerhead by swapping it for a more efficient one than it would be to change the settings of the EACs, particularly if it is located on the roof.

Targeting EACs as part of a wider retrofit program (e.g. as part of a residential retrofit program involving efficient showerheads, tap aerators and toilet displacement devices) is likely to be more cost-effective than running a single program just for EACs, particularly in areas where EACs usage is not high. However, it may be the case that when establishing retrofit programs, some utilities are not aware that EACs can be high water users and do not consider EACs when designing their overall demand management programs. This was confirmed by one key informant:

> *"When we established our retrofit program we did not realise that EACs used so much water. If we were to re-establish the program I am sure they would be considered. One of our objectives is to 'do something' about EAC but we are still trying to work out what."*

This highlights the need for greater awareness of EACs as potential big users of water and further studies to determine their share of household water consumption in different regions of Australia, both overall and in terms of peak demand.

5.4 High turnover of tradespeople

The high turnover of tradespeople in regional areas was highlighted as a problem in correct servicing, and a short training course could help with this (pers comm. Glenn Marshall). One installation and service company mentioned they would welcome formal training for their staff as they felt that training in EACs in general is lacking (pers comm. Harrison & Higgins).

5.5 Availability of training for tradespeople

AIRAH has developed a short course in retro-commissioning EACs for water efficiency. The course is available for anyone to run, but it is currently not being formally conducted by any organisation. The course is very comprehensive, and covers issues such as correct procedures for adjusting water quality control devices and retro-fitting conductivity controls to improve water efficiency.

5.6 Accreditation of EACs service personnel

Although the manufacturers generally offer training through their dealer groups, there could be a large number of independent operators who have had no training in how to service and recommission EACs. In addition, in NSW and SA installers do not have to be qualified tradespeople and it is not known how many people servicing EACs do not have appropriate trade training.

5.7 Lack of incentives to manufacturers and tradespeople

It was a common view among key informants that although there may be educational opportunities in the plumbing industry, both manufacturers and tradespeople have no real incentives to adopt and promote EAC water efficiency best practice. As a result, installers tend to be very conservative in setting bleed-off rates. This ensures fewer problems with maintenance and avoids complaints after installation.

5.8 Dissemination of information

One of the manufacturers interviewed was unaware of the work already undertaken by AIRAH and the DMITRE project. In addition, the majority of the interviewees were not aware that AIRAH has developed a training course or the design application publication for EACs.

Other key informants that were aware of these materials emphasised the need for a stronger emphasis in disseminating available information on how to improve EACs' efficiency.

6 MEASURES AND INSTRUMENTS TO PROMOTE WATER AND ENERGY EFFICIENT USE OF EACs

A number of "measures" and "instruments" to improve the water and energy efficiency of existing EACs have been identified as part of this research and through discussions with stakeholders. However, not all offer the same level of success or cost-effectiveness. The measures (i.e. what to do – such as improving water quality controls) and instruments (i.e. how to do it – including economic incentives, regulation or communication/education) are outlined below.

6.1 Measures

Table 4 identifies a number of measures to improve the water and energy efficiency of existing EACs. Of these, a, e and f are targeted at non-evaporative water usage in the bleed-off or dumping system, and b, c, d and g are targeted at evaporative water usage in the cooling process.

AIRAH (2010b) estimates that non-evaporative water consumption represents approximately 20% of the total water usage of EACs. It also estimates that, in Victoria, non-evaporative water usage may be able to be reduced by 90% or more, representing a reduction of nearly 20% in overall water consumption by EACs. However, there has been very limited end use monitoring comparing the amount of water used in the dumping/bleeding system versus the amount of water evaporated in EACs. Thus, it is not possible to rank or evaluate the measures presented in Table 4 according to the amount of water they could potentially save.

Table 4: Measures to improve water and energy efficiency of existing EACs

Technical measures		EACs efficiency improvement	
		Water	**Energy**
a. Water quality controls	Improved bleed valve	x	
	Conductivity controls (TDS monitor)	x	
b. Thermostat		x	x
c. Timer		x	x
d. Reducing cooling loads	House insulation/shading	x	x
	Insulate ducts	x	x
	Ventilate roof spaces	x	x
e. Water treatment		x	
f. Replacing mains water with rainwater		x	

g. Auto shut off vents/dampers		x

As Table 4 shows, there is an interaction between energy and water saving measures. For example insulating ducts are primarily used to save energy. However, they can also save water because the units do not have to run as much.

The following paragraphs describe these measures in more detail and explain why not all offer the same level of success or cost-effectiveness.

Water quality controls

Conductivity controls are the best way to maximise water efficiency. Retrofitting of conductivity controls to existing units would be desirable but probably cost prohibitive for the householder. Seeley International Pty Ltd claims their WaterManager™ conductivity control system can save 9 kL/a compared to a constant bleed rate system. Whilst this represents significant water savings, it is only a cost saving of only around $20 per year. The manufacturer estimates that it costs about $150 to fit a conductivity system to a new unit. The cost of a retrofit, if it is even possible, is therefore likely to be in excess of $500, representing at least a 25 year simple payback for the householder – probably longer than the life of the unit.

There is clearly large potential for recommissioning the water quality control systems in many existing EACs, and ensuring that new units are commissioned properly. This is where the AIRAH reference group believes the greatest potential for water savings could be found. Recommissioning should be done on the basis of actual water supply quality measurements using a TDS meter and providing the service person with a chart or ready reckoner on how to set up the different types of systems correctly. Care would need to be taken in places where water quality can vary due to a changing supply mix, such as locations like Wagga Wagga (pers. comm. Greg Finlayson).

Thermostats and timers

The retrofitting of controls such as thermostats that automatically vary fan speed, put systems into ventilation only mode or shut them off completely could reduce evaporation water use. A wide range of controllers are available for new systems, ranging from simple on/off, high/low, cool/vent controls to sophisticated programmable units with timers, thermostats and control of the water quality system and dumping regime. The feasibility of retrofitting thermostatic controls to existing systems that do not have them would need to be investigated in more depth.

The retrofitting of timers, which could be significantly cheaper than retrofitting thermostats, could help to combat the problem of excessive operating hours of systems.

Reducing cooling loads

Reducing cooling loads through improving the thermal performance of buildings can reduce evaporation use. It was found in Alice Springs that a thermally efficient house could delay turning on the EAC for several hours compared to an inefficient house (pers. comm. Glenn Marshall). EACs are often used in areas with hot summers but cool to cold winters. People often pay more attention to improving winter performance through the installation of bulk insulation and draught sealing than to summer performance, which requires reflective insulation, good shading and the right type of glazing. A house energy retrofit program targeting cooling loads reduction could reduce EAC water use.

Improved insulation of ducting could also lead to lower water and energy use. Roof space temperatures can easily exceed 60°C in summer, so unless ducts are well insulated the cool air from the EAC can pick up significant heat gain on its way through the roof. The

Building Council of Australia (BCA) requires ductwork in new houses to have minimum levels of insulation, but insulating ductwork in older systems could allow systems to be operated at a lower fan speed saving water and energy. Ventilating roof spaces to get rid of hot air would also help reduce duct heat gains.

Cooling loads can also be reduced by closing off unused rooms and opening the windows the correct amount. However, these are behavioural measures, rather than structural issues.

Water treatment

In areas such as Alice Springs the water has high calcium content when compared to other regions of Australia. This requires a higher bleed-off rate to remove the salts from the water and reduce the calcium build-up on the pads. To reduce the water hardness some people add water softeners. However, one key informant has experimented with this and was of the opinion that it is not an effective solution to address EACs water efficiency issues. As the informant explained, these products convert the calcium carbonate ($CaCO_3$) into sodium carbonate (Na_2CO_3); forming a soft powder that can be wiped from the EACs cooling pads surface but unfortunately this is blown inside by the fan if the pads are not wet.

Another option is to use catalytic conditioning, which uses small electrical charges to break up impurities and neutralise the effects of scale as the water recirculates over the pads. It is however, an expensive option and only applicable to new units. One manufacturer offered this as an option several years ago but it has since been dropped due to the very low take up rate. It was claimed that it could reduce the water used for water quality control by up to 45%, but there is no independent verification of that figure.

The view of manufacturers was that water conditioning is too expensive to retrofit to existing systems and would only be justified for new systems in very poor water quality areas. According to GHD (2003), this option is also not recommended due the poor quality of the discharged water.

There may be a case for some water utilities in areas with low quality water to consider treating water to reduce TDS prior to distribution. Location specific costs and benefits would need to be taken into account to determine the cost effectiveness of such an option. The benefits would include savings from EACs and potentially other issues associated with the impact of water quality on hot water systems and copper plumbing which are not well documented.

Replacing mains water with rainwater

Rainwater has lower TDS content than mains water. It can be as low as 2 mg/L, but is usually higher. A study has been undertaken on 35 rainwater tanks in several Australian cities. The TDS of the water samples varied from 9 to 160 mg/L and had a mean value of 33.1 mg/L (Saman et al. 2009).

In Alice Springs some households have been experimenting using rainwater – a source of soft water – to feed the EACs, instead of water from the grid. However, due to the high amount of water required by EACs, an issue remains concerning the availability of enough rainwater to feed these systems, and the need to have a system that is supplied by tap water when rainwater runs out (pers comm. Les Seddon and Richard Bentley). In addition, this would require an automated system to adjust the bleed rate according to the TDS of the water being used. In almost all cases where EACs operate, which generally have low rainfall and a dry season, the volume of roof water would be insufficient to supply an EAC.

6.2 Instruments to promote water efficiency

As identified above not all the measures presented in Table 4 offer the same level of success or cost-effectiveness. Therefore, it is advisable that any options targeted at improving efficiency of EACs focus on promoting well-established and cost-effective measures. Of the measures described in Table 4, these include water quality controls, thermostats and timers, and measures to reduce cooling loads.

The following sections discuss instruments to promote the uptake of well-established and cost-effective measures.

Household education

A major contributor to inefficient use of EACs is the lack of knowledge among householders on how they work.

Household education could be undertaken through the use of a well designed communication campaign encouraging residents to use their EAC in the most efficient and effective way possible. This would involve developing educational materials such as a brochure detailing maintenance steps for managing EACs, including practical cost-effective measures to improve water efficiency and simple actions such as providing adequate ventilation by opening doors and windows at appropriate times. The brochure could be sent to all households with their pre-summer water bill.

The brochure could be sent together with a voucher for a subsidised air conditioner maintenance service visit. The service technicians visiting each household would be trained to use the opportunity to talk to residents about how regular maintenance will save water and cool their houses more effectively.

Educational materials could also be distributed to service personnel to offer to householders when conducting servicing visits.

Other types of educational materials could be 'do it yourself' videos available online on the website of utilities and EAC manufacturers and servicing companies. Access to these videos could also be publicised in the brochures sent with water bills.

Other channels of communication include community events such as markets, radio and the local paper. The WaterSmart program[5], in Alice Springs, has been offering demonstrations of some practical measures to improve the water efficiency of EACs at a local market.

It should be noted that user guidelines both on residential and non-residential EACs have been developed by AIRAH. These were developed under the Smart Water Fund and are available on the website of the DSE of Victoria.[6] These materials could be used by utilities in education and marketing communication activities.

Training of service personnel

As identified previously, although the manufacturers generally offer training through their dealer groups, there could be a large number of independent operators who have had no training in how to service and recommission EACs. In addition, in NSW and SA installers

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[5] The Alice WaterSmart Program is a project led by a consortium of government and community organisations, aimed at promoting more efficient use of water in homes, businesses, parks and gardens. The program includes water home assessments. These are offered for free to community members and include EACs water efficiency assessments. More information about this program is available online on http://www.alicewatersmart.com.au/.

[6] http://www.water.vic.gov.au/saving/home/evaporative-coolers

do not have to be qualified tradespeople and it is not known how many people servicing EACs do not have trade training. However, it was a common view of different key informants that even if educational opportunities in the plumbing industry are provided, both manufacturers and tradespeople have no real incentive to adopt and promote best practice water efficiency in EACs.

An option to address these issues could be to establish, in areas where EACs are prevalent, a requirement that service personnel must undertake appropriate EAC training before participation in a home assessment and retrofitting program.

AIRAH has produced a comprehensive training course on the servicing and recommissioning of EACs. This could be used as the basis for an industry training program.

To encourage the uptake of these courses, they could be adapted to a web-based format. Simple training videos similar to those featured on *Trade Secrets*[7], developed by ISF in collaboration with the Dusseldorp Skills Forum, could also be part of this.

As a complement to these courses, a web-based application to help tradespeople to set the bleed or dump system according to local water conditions could also be developed. This will likely require the involvement of a water chemist.

Some states have a green plumbers network, operating through, for example, the Master Plumbers Association.

Retrofitting and recommissioning programs

A program to recommission water quality control systems and retrofit houses targeting cooling loads reduction could be implemented. These could be designed to be undertaken by properly trained service personnel and implemented after such training is available.

However, a retrofitting or recommissioning program dedicated only to EACs is unlikely to be cost-effective. An option is to incorporate or design these as part of wider water and energy efficiency programs or existing initiatives. For example, any existing maintenance programs for public housing could be reviewed to incorporate servicing of EACs and advice for householders on how to maintain these systems.

6.3 Instruments to promote energy efficiency

As mentioned previously, there are few cost effective opportunities to improve the energy efficiency of existing EACs. Improvements primarily require changes to the technology of the fan, such as direct drive inverter motors, and it is not feasible to retrofit these. These are really only practical for new units.

However, some of the measures to reduce water use, such as improved controls and better thermal performance, will also reduce energy use.

Energy use can be affected indirectly by using auto closing dampers to ensure that the system is closed off to the outside air when not in use. This will greatly reduce energy lost through the system in the heating season.

The same types of options to improve water efficiency of EACs, described in section 7.2, apply to improving the energy efficiency of these systems. Educational programs targeted at householders and service personnel should identify the range of measures presented in Table 4.

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7 See http://tradesecrets.org.au/

In addition, retrofitting programs should target improvement of thermal performance of houses and be conducted by properly trained service personnel. As indicated previously, a retrofit dedicated only to EACs is unlikely to be cost-effective. However, when incorporated or designed as part of wider energy retrofitting programs it is likely to become a more attractive option.

7 FINDINGS AND RECOMMENDATIONS

In line with objectives D and E of stage 1 of this study (refer to section 1.2), this section summarises the study findings, identifies the research gaps found, and provides recommendations on:

- further investigations needed to improve EACs water and energy efficiency, (section 7.1) which drive the need for stage 2 of this study; and
- interim actions that the savewater!® Alliance and the Water Directorate may take (section 7.2), while further research is undertaken during stage 2.

7.1 Research gaps and recommendations for further investigations

1. There is strong evidence that EACs are significant water users. It is estimated that these systems consume up to 10% of the total annual water use in typical Australian households where EACs are used (Saman et al. 2009).

   However, there is very limited water usage data of EACs, which are based on end use monitoring studies. Another major knowledge gap is peak day water demand of these systems and how much they account for when irrigation is also at peak demand. Peak day demand data is particularly relevant for demand management in areas where water treatment costs are high, infrastructure constraints are imminent and for inland cities like Wagga Wagga, which are vulnerable to seasonal and peak demand because they have no major storages and are on a regulated river.

   Further end use monitoring studies are also needed to compare potential savings from non-evaporative water usage versus evaporative water usage. This would assist in enabling the ranking of measures to improve the water use efficiency of existing EACs, identified in this scoping study, according to their potential savings.

   Although stage 1 of this study has identified measures to improve the efficient water and energy use of EACs and associated instruments to promote these, further research is needed to analyse practical aspects of their implementation and cost-effectiveness.

   Recommendation One: *savewater!® Alliance and the Water Directorate (with savewater!® Alliance taking the lead role) to approach the DSEWPaC for funding to further investigate:*

   a) *water usage of residential EACs through end use monitoring studies in different location of Australia; and*

   b) *water–energy trade-offs, costs and benefits of various options and potential programs for implementation targeted at improving water and energy efficiency of existing residential EACs.*

2. There has been very little focus on non-residential EACs, despite these being potential big water users. As highlighted by one key informant, there are fewer of this type of system and fewer people involved in servicing them, and the potential

savings per system are much larger. Thus it would be far more cost effective to initially target non-residential systems than residential systems.

DMITRE of South Australia is currently undertaking a project to investigate the water and energy efficiency of new EACs. Funded in part by WELS, the Ministerial Council on Energy and DMITRE, it aims to revise AS/NZS 2913-2000, leading to a water and energy labelling scheme, and the development of a climate-based decision making tool to inform consumers of air conditioning choices and therefore influence energy and water efficiency into the future. Non-residential EACs are not within the scope of the project.

Recommendation Two: *savewater!® Alliance and the Water Directorate (with savewater!® Alliance taking the lead role) to approach the DSEWPaC for funding to further investigate the following:*

a) *water and energy usage, patterns of use, prevalence as well as commissioning and servicing practices of* ***non-residential*** *EACs systems in Australia;*

b) *water energy trade-offs, costs and benefits of various options and potential programs for implementation targeted at improving water and energy efficiency of non-residential EACs.*

This would be relevant not only to support the efficient operation and maintenance of existing non-residential EACs, but also necessary as a first step to develop appropriate regulatory mechanisms for new non-residential EACs.

3. Stage 1 of this study has found that a number of useful resources such as leaflets, brochures and training courses on how to improve the efficiency of EACs have already been developed by various organisations. However, they are not currently extensively used or coordinated into a central repository.

Recommendation Three: *savewater!® Alliance and the Water Directorate (with savewater!® Alliance taking the lead role) to approach the NWC, WSAA and water utilities of areas where EACs are prevalent, for funding to identify gaps in the existing available materials and begin to fill those gaps and collate the existing materials in a useful way.*

4. Although not very common in residential units and more often used for industrial processes, indirect EACs are effective in regions with moderate/high humidity, where direct EACs are not suitable. The use of indirect systems in the residential sector would allow the geographical range of EACs to be expanded into more humid areas. This has potential benefits in terms of reducing the load of refrigerative systems and their impacts on peak demand and greenhouse gas emissions.

   Seeley, a manufacturer of EACs, is developing an indirect cooler for the residential market.

Recommendation Four: *savewater!® Alliance to approach the DCCEE and the manufacturer (Seeley) for joint funding to review the performance and suitability of direct and indirect EACs in a range of climates as well as to determine its impacts and benefits on energy usage and greenhouse gas emissions, peak demand, and water usage.*

7.2 Recommendations on interim actions

5. It appears that there are no NSW representatives in the industry reference group for the work being undertaken by DMITRE on the water and energy labelling scheme for new residential EACs.

> ***Recommendation Five:*** *Water Directorate (supported by savewater!® Alliance through a letter to that effect) to approach DMITRE about the possibility of having a NSW representative in this reference group. In addition savewater!® Alliance should also approach DMITRE to become a member. This will allow both the Water Directorate and savewater!® Alliance to keep appraised of the progress and outcomes of the group's work in order to ensure that new systems are regulated appropriately, and that the knowledge of both the Water Directorate and savewater!® Alliance is incorporated in that process.*

6. AIRAH has developed a short course in retro-commissioning evaporative coolers for water efficiency. The course is very comprehensive, and covers issues such as correct procedures for adjusting water quality control devices and retro-fitting conductivity controls to improve water efficiency. This course can be used as the basis for an industry training program.

   The development of a training program targeted at service personnel would require funding. A proposal for such funding should include converting AIRAH course materials into a self-study web-based format, as well as the development of a web-based application to help tradespeople to set the bleed or dump system according to local water conditions.

> ***Recommendation Six:*** *savewater!® Alliance to approach AIRAH to ascertain their willingness to publicise their training material and of the possibility of converting their course materials into a self-study web-based format. The possibility of AIRAH delivering the training should also be explored. savewater!® Alliance to approach water utilities, the NWC and WSAA for funding to develop educational programs targeted at service personnel, based on the material developed by AIRAH.*

7. AIRAH has also developed a user guide targeted at householders. These are publicly available.

> ***Recommendation Seven:*** *savewater!® Alliance and the Water Directorate to make water utilities aware of these materials in order to ensure they are used in any future education and marketing communication activities.*

8. It is a clear conclusion of this study that initiatives targeted at changing householders' behaviour cannot rely only in the communication of good practices. In general people need assistance in servicing their EACs, particularly in cases where these are located on the roof.

> ***Recommendation Eight:*** *savewater!® Alliance to take the initiative to encourage water utilities in areas where EACs are prevalent to consider an offer of low cost subsidised servicing as a means of encouraging household improvement of EACs water use.*

9. In NSW and SA installers do not have to be qualified tradespeople and it is not known how many people servicing EACs do not have trade training. However, it was a common view of different key informants that even if educational opportunities in the plumbing industry are provided, neither manufacturers nor tradespeople have any real incentive to adopt and promote best practices water efficiency of EACs. An option to address this issue could be to establish, in areas where EACs are prevalent, a requirement that service personnel must have undertaken appropriate EAC training before participation in a home assessment and retrofitting program.

Recommendation Nine: *It is recommended that savewater!® Alliance takes the initiative to advocate that water utilities and water services associations at the national level, such as WSAA, ensure that the training materials developed by AIRAH are included in any accreditation process of home assessors or retrofitting programs personnel that occur in their jurisdiction.*

10. A retrofitting or recommissioning program dedicated to EACs alone is unlikely to be cost-effective. One option therefore is to incorporate or design these as part of wider water and energy programs or existing initiatives. For example, any existing maintenance programs for public housing could be reviewed to incorporate servicing of EACs and advice on how to maintain these systems.

Recommendation Ten: *savewater!® Alliance to identify opportunities to incorporate EACs servicing visits into existing programs such as retrofit programs and public housing maintenance programs.*

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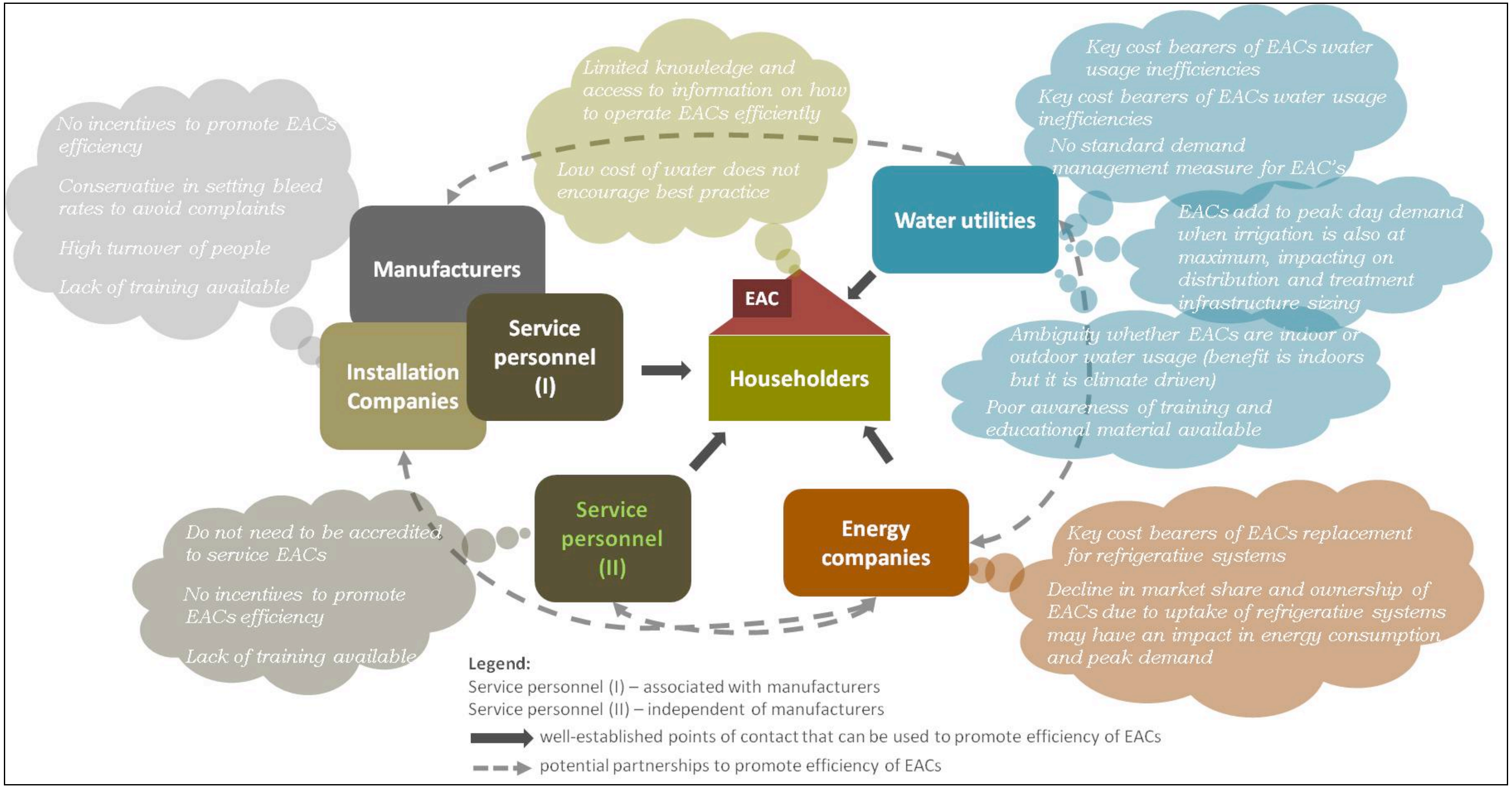
ANNEX: CONCEPTUAL DIAGRAM OF KEY STAKEHOLDERS, ISSUES AND DRIVERS

The diagram below has been developed to inform the generation of potential strategies to promote efficient water and energy usage of EACs. It illustrates some of the key stakeholders associated with the sale, installation and use of EACs, as well as the key challenges, opportunities and drivers and influence points relevant to the efficiency issues of EACs.



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