



UTS: INSTITUTE FOR SUSTAINABLE FUTURES

Assessment of Future Water Efficiency Measures

Final Report



2017

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 wellbeing and social equity. For further information visit: www.isf.uts.edu.au

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CITATION

Please cite as:

Liu, A., Turner, A., and White, S., 2017, Assessment of Future Water Efficiency Measures. Report prepared for City West Water, Yarra Valley Water, South East Water, Melbourne Water, Barwon Water and Department of Environment, Land, Water and Planning by the Institute for Sustainable Futures, University of Technology Sydney.

ACKNOWLEDGEMENTS

The authors wish to thank the water industry practitioners who generously provided advice and shared their knowledge and experience to inform this report. The authors also thank City West Water, Yarra Valley Water, South East Water, Melbourne Water, Barwon Water and the Department of Environment, Land, Water and Planning for funding the project, providing information and giving useful feedback during the review process. All comments and conclusions are those of the authors.

REVIEW

Version	Author	Reviewed by	Date
Draft	AT and AL	AT	06/02/2017
Final draft	AT and AL	AT	12/03/2017
Final draft v2	AT and AL	AT	20/03/2017
Final	AT and AL	AT	14/04/2017
Final v2	AT	AT	27/04/2017

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EXECUTIVE SUMMARY

The Victorian water utilities have been active in the implementation of water efficiency for many years. Similar to other jurisdictions this intensified during the Millennium drought. The approaches employed during the drought involved both individual and joint water utility initiatives, often in collaboration with the Victorian government. These initiatives covered both the residential and non-residential sectors and were supported by the important collaborative research initiated in 2003 under the \$50m Smart Water Fund (now closed).

This research report “*Assessment of Future Water Efficiency Measures*” has been developed by the Institute for Sustainable Futures (ISF), University of Technology Sydney, on behalf of the three Melbourne retailers, Melbourne Water, Barwon Water and the Department of Environment, Land, Water and Planning. The rapid study does not aim to be exhaustive but to begin to gather information to assist in taking stock of the current efficiency situation and to look on the horizon in terms of how efficiency might change. It aims to gather information that will be useful to assist in testing alternative potential scenarios of long term demand forecasts and new potential short and long term efficiency program opportunities that can be actioned when deemed appropriate into the future. There is significant additional conservation potential available as we look to the future in terms of new more efficient appliances and ways to interact with customers by tapping into new technical and behavioural opportunities.

The rapid study has scanned and collated information on the programs undertaken both in Victoria and interstate, and to a limited extent internationally, together with information on the latest innovations in terms of water efficient appliances, behaviour change and digital metering interfaces. The research draws on recent research conducted by ISF, information provided by the funding agencies, information gleaned from ISF’s international network of advisors, and interviews with water efficiency experts, manufacturers and practitioners.

Despite significant gains in water efficiency in Victoria to date, there still appears to be significant conservation potential still available when assessing the programs implemented in Victoria with other jurisdictions, and participation rates to date compared with the overall population sizes of both Melbourne and regional Victoria. Hence, there remains an opportunity to tap into that conservation potential by expanding existing programs and/or introducing additional more targeted programs. Such programs could include for example targeting specific residential sub-sectors, high water users, outdoor watering and maintenance of evaporative air coolers and rainwater tanks and non-residential programs focusing on open space and targeted end uses such as waterless woks and glass washers. Before implementing cost effectiveness analysis, the varying value of water over time and the use of regulations versus efficiency rebate programs will need to be carefully considered. So too will the varying characteristics of Melbourne versus regional Victoria.

The research has revealed trends of development of new appliances with improved efficiency across most end uses, from recycling showers, jet and vacuum toilets, to bead clothes washers and low cost leak detection systems. At the same time, there is a need to keep a watching brief and indeed investigate end uses that could potentially increase water demand per unit and/or overall such as bidet toilets, combined condenser washer-dryers and evaporative air coolers due to factors such as shifts in culture, climate and importantly population.

With the anticipated major population rise both in Melbourne (manifesting as urban densification) and regional areas this will create both major challenges but also enormous opportunities in how we provide water and wastewater services for existing and new future customers.

Consideration of systems thinking will be key including how individual appliances and their efficiency levels fit within the wider system and how we move beyond sustainability towards “restorative”, “regenerative” or “net positive” principles as we transition towards “fourth generation” infrastructure which will need to encompass improved water efficiency, source control and more effective separation of pollutants and recovery of resources. This will mean greater investment in treatment and reuse compared to investment in the transport of water, sewage and stormwater. It will require heightened awareness of the interplay and trade-offs between water and energy and a need to push regulation and building codes to increase efficiency further and lock-in savings.

With the rapid evolution of digital water meters and emergence of the digital era, there will now be significantly increased opportunities for customer interface and behaviour change programs as well as rapid evaluation of savings being achieved. Innovation from other sectors will continue to shape and influence developments in water efficiency such as crowd funding to develop concepts into market-ready water efficient appliances and the use of innovative interaction methods, gamification and alternative incentives.

Despite the emergence of individual digital solutions and home automation, digital metering will be fundamental to water utilities in monitoring and measuring water consumption and providing holistic visibility and control including the ability to more carefully target demand management programs, provide customised water consumption information to users, evaluate the impacts and assist in system optimisation.

The Victorian water agencies will need to take a proactive stance during this time of great change through a suite of research trials and demonstrations of new efficient technology, digital meters and devices and next generation efficiency programs. The report suggests a suite of potential actions and recommendations that could potentially be implemented in Victoria to further improve water efficiency and begin to harness the opportunities provided by the emerging digital era. Fundamental to these actions will be the active formation of a foundation efficiency team, tools and networking within Victoria to retain and build on the vast knowledge gained during the drought.

These are just a few of the opportunities and recommendations that this rapid research study has identified. As we look to the future - efficiency, systems thinking and digital approaches will need to be integral to water and wastewater service provision going forward. Well-directed research, trialling and demonstration of innovative approaches will be essential. The Victorian water service providers and government have showed significant leadership in the water industry with the former Smart Water Fund and have a major opportunity to continue such a leadership role as we embrace the transition to fourth generation infrastructure and the digital era.

Importantly, this research shows that others nationally and internationally are also currently grappling with the same issues and thus collaboration and sharing of information across and between states, nationally and internationally will be key.

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1 INTRODUCTION

BACKGROUND

This research report “**Assessment of future water efficiency measures**” has been developed by the Institute for Sustainable Futures (ISF), University of Technology Sydney. The study has been funded by: the three Melbourne retailers (City West Water-CWW, Yarra Valley Water-YVW, South East Water-SEW), Melbourne Water (MW), Barwon Water (BW) and the Department of Environment, Land, Water and Planning (DELWP).

The Melbourne retailers along with other Victorian water service providers are preparing detailed demand forecasts for the 2017 Urban Water Strategies (UWS) and Melbourne Water System Strategy (MWSS). As part of the preparation of these strategies it has become evident that a deeper understanding of emerging technology and new behaviour change practices are needed, as well as, details of new and as yet underutilised water efficiency programs.

This information will be useful to assist in not only testing alternative potential scenarios of long term demand forecasts but also new potential short and long term efficiency program opportunities that can be actioned when deemed appropriate.

With the rapid urban densification and growth in Melbourne and surrounding regions in Victoria together with climate change this will continue to add pressure on the existing water and wastewater systems. Hence, as identified in the recently released ‘*Water for Victoria*’ (DELWP 2016), water efficiency will need to continue to play an important role going forward.

STUDY AIM

The aim of this study has therefore been to gather information to inform future demand forecasts and strategies and more specifically:

- collate information on past and existing efficiency programs in Victoria and other jurisdictions to determine if there are opportunities remaining;
- assess appliance trends and opportunities; and importantly
- scan efficiency opportunities on the horizon in terms of next generation efficiency technology and appliances, behaviour change activities and digital metering interface systems.

The research does not provide detailed input to the current strategies being finalised but has the potential to inform them at a high level. It provides a rapid appraisal of what might be on the horizon in terms of efficiency and disruption in the future, what we might need to be aware of and what opportunities are available.

The research aims to inform both the Melbourne water service providers and other Victorian water service providers that predominantly rely on Melbourne research for the development of their strategies. The study focuses on the residential sector but does identify non-residential opportunities that have come to light.

A series of recommendations, identified through the research conducted, have been provided. These aim to assist the Melbourne and broader Victorian regional water service providers maintain a focus on water efficiency over the coming years, likely to see some areas of significant change due to new and emerging technologies and behaviour change approaches related to the digital era.

STRUCTURE OF REPORT

The structure of the report includes:

- **Introduction** – overview of the background, aim of the study, report structure and research methods used.
- **Existing efficiency programs in Victoria** - summary of the main efficiency programs used in Melbourne and representative regional areas in Victoria.
- **Efficiency programs in other jurisdictions** - summary of key efficiency programs conducted in Australia, identification of programs not implemented to a significant extent in Victoria, collation of additional examples of international efficiency programs that may be of interest and discussion on opportunities for implementation of programs in Melbourne and regional Victoria highlighting potential differences for regional areas.
- **Appliance efficiency trends & emerging opportunities** - summary of appliance efficiency trends in Victoria and Australia more broadly.
- **Efficiency opportunities on the horizon** - summary of new/next generation efficient technologies/appliances, behaviour change activities and digital metering interface systems (focusing primarily on the residential sector) on the horizon nationally and internationally.
- **Discussion and recommendations** - synthesis, discussion and key recommendations including discussion around issues such as population growth/densification, potential need for system changes, water-energy nexus, regulations versus program timing/cost, short-long term needs and research needs.

RESEARCH METHODS

This study has drawn from several key documents written by ISF including:

- **Urban water futures - trends and potential disruptions – discussion paper** (Turner and White 2017) written for the Water Services Association of Australia (WSAA) which investigated at a preliminary level examples of emerging efficient technology such as showers and clothes washers designed in Europe) as well as digital meters and new emerging technology and sensors associated with the internet of things (IOT).
- **Evaluation of the environmental effects of the Water Efficiency Labelling Standards (WELS) scheme** (Fyfe et al. 2015) written for the federal government. The report collated the most up to date information nationally for WELS appliances (i.e. showers, taps, toilets, urinals, clothes washer-dryers and dishwashers) from market research experts such as GfK for white goods and involved interviews with leading plumbing fixture suppliers such as GWA Group Limited to ascertain current trends in the sales of more efficient devices (i.e. taps, showers and toilets) and any new efficient devices that might be entering the market.
- **Managing drought learning from Australia** (Turner et al. 2016a) written for a US audience, the report collated and summarized the suite of demand management programs used in Australia as part of the Millennium drought and entailed discussion with demand management leaders involved in the drought in Melbourne, Perth, South East Queensland and Sydney.
- **NSW government advisory study on the next generation of water efficiency programs for greater Sydney** (Turner et al. 2013) written for the Metro Water Directorate the study involved assessing the next generation of feasible urban water efficiency programs in Sydney covering residential, non-residential and non revenue water sectors considering the extensive demand management already implemented in Sydney as part of the drought response program.

- **Smart water-use feedback: Options, preferences, impacts and implications for implementation** (Liu 2016) a PhD thesis undertaken by Ariane Liu at ISF that investigated the role of digital water metering and detailed customer water-use feedback in the digital age. This mixed methods research project involved the design, implementation and evaluation of two household water consumption feedback trials in regional NSW to investigate the quantitative and qualitative impacts of online and end use feedback. The research led to a series of published papers, including Liu et al. (2015; 2017), which are also discussed in this report.

The research has also drawn from key information provided by the Melbourne retailers (CWW, YVW, SEW), MW, BW and DELWP, namely:

- Melbourne Joint Water Efficiency Plan 2010/11;
- Joint Water Conservation Plan for Metropolitan Melbourne 2009/10;
- Melbourne Joint Water Conservation Plan Annual Report 2008/09;
- Melbourne Joint Water Conservation Plan Annual Report – June 2007; and
- Victoria rebates data for 2003-15 (annual and summary data in XLS spreadsheets).

The overall approach for this study has involved two stages. Stage 1 mainly involved desktop research including collation of information from existing reports, web searches, and liaison and interviews with ISF's existing network of national and international water efficiency contacts.

The desktop research involved the following tasks:

- summarising existing programs and associated opportunities;
- summarising appliance efficiency trends and associated opportunities; and
- conducting initial national and international scans of new/next generation technologies, appliances, behaviour change activities and digital metering interface approaches.

Around 20 advisors were initially contacted from multiple states and countries to seek advice and insights on potential emerging technologies, behaviour strategies and innovative demand management programs and recommendations on additional contacts to inform the research project.

Stage 2 expanded on the existing research using a 'snowballing' approach to identify additional interesting and or useful participants for liaison and interviews and/or additional desktop research. This stage therefore involved contacting additional experts in water efficiency, leading or emerging appliance/technology providers, and water efficiency program leaders to add further scope and depth to the research project. It also included recommendations from the client advisory group (representatives from MW, CWW, YVW, SEW, BW, DELWP and Central Highlands Water-CHW) on additional areas of interest that should be looked into after review of the study draft report dated 06/02/2017.

Figure 1.1 shows the locations of water efficiency advisors that were contacted to inform the research. They included for example:

- water utilities in Australia, the UK and the US with experience in running innovative water efficiency programs;
- independent not-for-profit organisations and research and advocacy organisations in Australia, the UK and US focusing on sharing knowledge on water efficiency; and
- government departments, industry peak bodies, testing organisations and manufacturers in Australia and the US with detailed knowledge of specific products.

This study report documents the findings and includes a synthesis of the research and recommendations.

Many of the advisors contacted as part of the study expressed significant interest in the project and did not believe such a study had been conducted to any great extent recently. Thus the results would be extremely useful/interesting to those involved in water efficiency more broadly.

Figure 1.1 – World map showing location of water efficiency advisors approached to inform the research¹



¹ Map image is [World - Single Color](#) by [FreeVectorMaps.com](#)

2 EXISTING EFFICIENCY PROGRAMS IN VICTORIA

This section provides a brief overview of the Melbourne and regional context in terms of population serviced. It also provides a summary of the key water efficiency programs implemented in Melbourne and, using BW and Central Highlands Water (CHW) as illustrative examples, regional Victoria. Details on timing, levels of participation and follow-up evaluation are provided where available.

MELBOURNE & REGIONAL VICTORIA CONTEXT

Melbourne has a current population of over 4.5 million², is the fastest growing capital city in Australia³ and is expected to hit a population of 8 million by the middle of the century⁴. Victoria as a whole has a current population of over 6 million⁵, with diverse characteristics ranging from urban centres commuting to Melbourne through to more regional communities relying on key industries such as mining, manufacturing, agriculture and tourism.

MW treats and supplies drinking and recycled water, removes and treats most of Melbourne's sewage, and maintains waterways and major drainage systems across the Port Phillip and Westernport region. The three Melbourne retailers (CWW, YVW, SEW) provide retail water and wastewater services to customers in their defined jurisdictions as shown in Figure 2.1.

Thirteen regional urban water corporations provide water and wastewater services to regional urban customers as illustrated in Figure 2.2. There are four water corporations that provide rural water services, two of these also provide urban water and wastewater services (Lower Murray Water and GWMWater). BW is the largest regional water corporation servicing a population of 300,000, swelling to over 500,000 over the summer holiday period due mainly to tourism⁶. CHW serves a population of over 130,000 people⁷.

² <http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/3218.0Main%20Features252014-15?opendocument&tabname=Summary&prodno=3218.0&issue=2014-15&num=&view=> (accessed 01.02.17)

³ <http://www.abs.gov.au/ausstats/abs@.nsf/lookup/3218.0Media%20Release12014-15#Victoria> (accessed 01.02.17)

⁴ https://www.planning.vic.gov.au/_data/assets/pdf_file/0014/14036/Victoria-in-Future-2016-FINAL-web.pdf (accessed 09.04.17)

⁵ <http://www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0> (accessed 01.02.17)

⁶ <https://www.barwonwater.vic.gov.au/about/about> (accessed 01.02.17)

⁷ <http://www.chw.net.au/about-us/our-organisation> (accessed 09.04.17)

Figure 2.1 – The three Melbourne water retailers (source Gan and Redhead 2013)

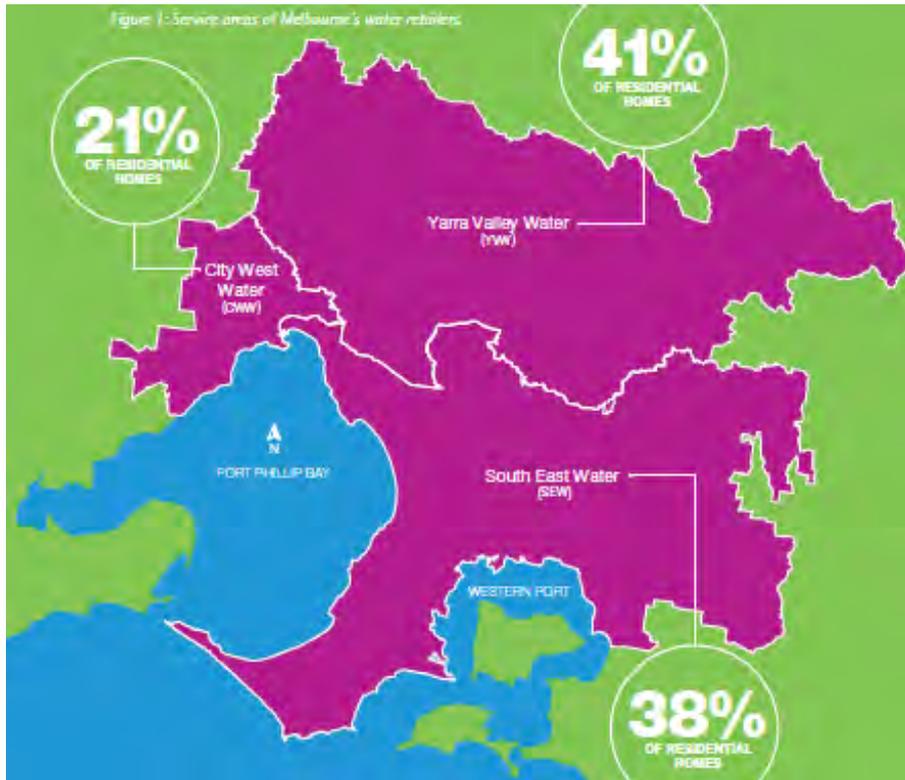


Figure 2.2 – Regional Victoria Urban Water Corporations⁸



⁸ <https://vicwater.org.au/victorian-water-sector/regional-victoria#urban-water-corporations> (accessed 01.02.17)

SUMMARY OF MELBOURNE & REGIONAL EFFICIENCY PROGRAMS

Tables 2.1 to 2.4 summarise the key water efficiency programs implemented in Melbourne by the three Melbourne retailers, BW and CHW (as regional representatives of Victoria) and DELWP (providing support on efficiency programs both in Melbourne and regional Victoria). The summary has been predominantly drawn from the Joint Water Conservation Plans (JWCPS)/Joint Water Efficiency Plans (JWEPS) prepared by MW and the Melbourne retailers, summary spreadsheets and advice provided by DELWP, information from BW and CHW and former reports prepared by ISF.

By focusing in part on BW and CHW the summary aims to be illustrative rather than entirely reflective of programs run in regional Victoria. Some regional utilities have been more active than others. CHW are currently helping to drive the re-establishment of the former Savewater website in collaboration with Smart Approved WaterMark in the form of a Smart Water Advice website specifically for Victoria⁹. This website is now being expanded to other regions such as NSW. Providing a summary of all the Victorian regional efficiency activities was beyond the scope and time available for this study but a collation of such activities and the savings opportunities that still remain would be highly beneficial in terms of how and where individual utilities in the state could tap into efficiency and who they could glean experience and advice from.

Tables 2.1 to 2.4 focus on residential and non-residential programs implemented since the mid 2000s when water efficiency began to gain traction due to concerns over the ongoing drought conditions and associated policy and strategy drivers (Victorian Government 2004; Victorian Government 2006). The tables summarise the range of residential and non-residential programs and provide details on individual programs, periods over which they ran and participation rates, where the information is readily available. Table 2.1 includes details of the Victorian Government's rebates schemes, which ran from 2003 to 2015 and involved the provision of nearly 400,000 rebates over the period.

Details on broader state and national regulations affecting Victoria are summarised in Table 3.1 in Section 3 along with efficiency programs in other jurisdictions.

The combination of restrictions, large water efficiency and behaviour change programs as well as use of source substitution initiatives, price changes and modifications to environmental flows assisted in dramatically driving demand down in Melbourne and curbing the depletion of dam storages as illustrated in Figure 2.3.

⁹ <https://www.smartwatermark.org/Victoria/> (accessed 28.02.17)

Figure 2.3 – Historical Melbourne system storage and demand (source – MW)

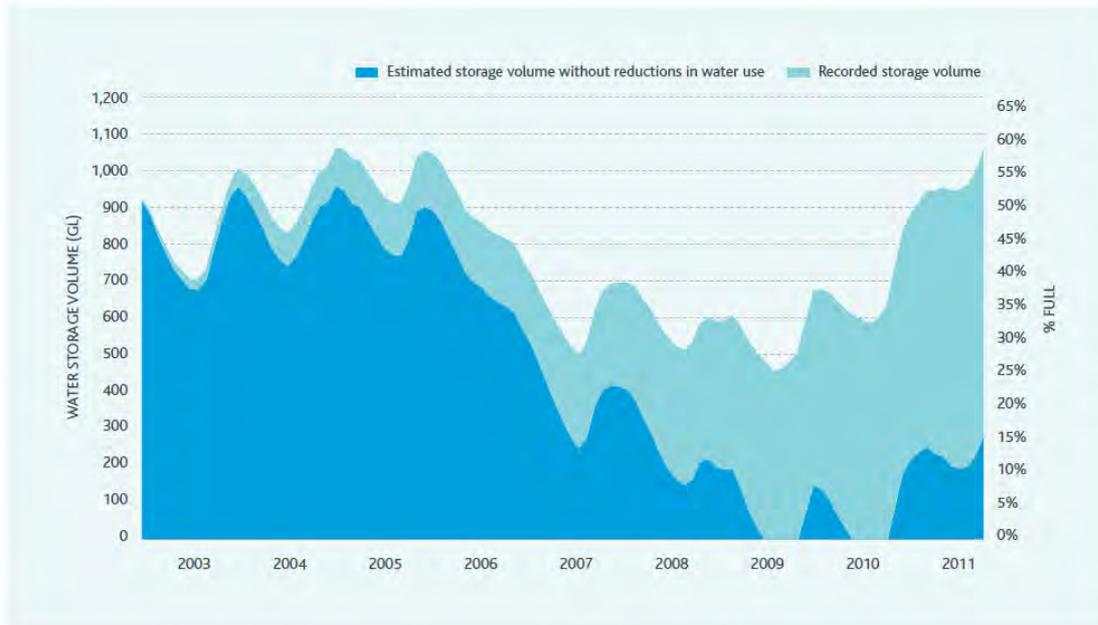


Table 2.1 – Summary of Melbourne & regional Victoria efficiency programs – residential sector rebate programs

Initiative	When	Details	Who/how many Melbourne	Who/how many Regional (e.g. BW/CHW)
Retailer showerhead exchange program	2006/07 to 2010/11	Residential customers exchanged their old showerheads for a free, 3-star water efficient model by bringing in their old showerheads and latest water bill into approved exchange points such as water retailer offices, local government locations, post outlets, hardware stores, and water conservation kiosks in major shopping centres. Some retailers later included free installation of showerheads with energy efficiency equipment. Funded by retailers individually (an assessment of energy savings via the Victorian energy efficiency target assisted the business case). Statistical evaluation conducted with savings ranging from 8.5 to 12.4 kL/household/annum for single residential houses (Fyfe et al 2009a; Fyfe et al 2009b; Fyfe et al 2009c; Turner et al 2014).	461,466 showerheads exchanged (CWW - 101,264; SEW - 185,884; YVW - 174,318) (MJWEP 2010/11)	43,191 showerheads exchanged at the 13 regional water corporations (up to May 2010) of which ~10,000 BW. CHW (program ongoing) exchanged 5,500
	Nov 2013 to present	Currently (Feb 2017) CWW [1], YVW [2], BW [3] and CHW customers can still participate in a showerhead exchange program via local council offices, but SEW does not currently offer this [4]. Funded by retailers. BW using existing showerhead stock purchased at discounted rate from Savewater No additional evaluation conducted yet (ongoing).	(CWW – 1,700) [5] (YVW – 2,800)	BW and CHW ongoing
Retailer toilet replacement program	2009 to 2012	This program offered customers the opportunity to upgrade their old toilet with a new 4-star WELS rated dual flush toilet at a considerably reduced price via a Living Victoria Water rebate. The program was run with key toilet manufacturers and included installation by a qualified plumber and the removal and recycling of old units. Funded by Victoria government and customer contribution. Preliminary evaluation conducted and presented by CWW at AWA conference (Jones and Neilsen)	13,680 toilets replaced (CWW – 6,510) [5]	CHW 735 toilets replaced
	Dec 2015 to present	Currently (Feb 2017), CWW has a new toilet replacement program with prices starting at \$434.50 [6]. Funding – CWW funds marketing of program with customer paying for installation No additional evaluation conducted (ongoing).	229 toilets replaced to date [5]	
Indoor retrofit program	Nov 2006 to Jul 2009	Residential customers in Ballarat and Maryborough were offered a service which included a visit by a plumber to perform a water audit, fit new showerheads, flow controllers, a cistern weight and fix up to 3 minor leaks for a net charge of \$30.		CHW 4,600 retrofits
Victorian government rebate schemes:		Two consecutive rebate schemes provided by the Victorian government led the overall uptake of a total of 382,396 rebates for water efficient appliances and products (Jan 2003 to June 2015). The two schemes are summarised here and the uptake figures (for the combined schemes) are detailed separately below at an appliance / product level.	[TOTAL: 289,348 rebates for Melbourne (Jan 2003 to June 2015)].	[TOTAL: 93,048 rebates for regional VIC of which 30,109 for BW (Jan 2003 to June 2015)]
Water Smart Gardens and Homes Rebate	Oct 2003 to June 2011	This Victorian Government scheme provided rebates through DSE that incentivised customers to purchase water efficient appliances and products including dishwashers, washing machines, shower roses, dual flush toilets, grey water tank systems, high pressure cleaning devices, hot water re-	53,358 rebates for Melbourne across all rebate types (July 2011)	24,208 rebates for regional VIC across all rebate types (July 2011)

Scheme			to June 2015)	to June 2015)
Living Victoria Water Rebate Program (Home & Garden) [7]	July 2011 to June 2015	<p>circulators, rainwater tanks and connections, water conservation audits and a 'basket offer'.</p> <p>This scheme replaced the Victorian Government's earlier scheme (the Water Smart Gardens and Homes Rebate Scheme), and offered similar rebates through DSE to continue to incentivise customers to purchase water efficient appliances and product. (Note: in this later scheme rebates were no longer offered for dishwashers and high pressure cleaning devices).</p> <p>Funding: Victorian Government A review (based on modelled savings of the Living Victoria Water Rebate Program (Home and Garden and Small Business Products)) was conducted in 2016 (Deloitte 2016).</p>	235,990 rebates for Melbourne across all rebate types (Oct 2003 to June 2011)	68,640 rebates in total across all types of which 22,911 BW (Oct 2003 to June 2011)
Clothes washer rebate		A \$150 rebate for AAA rated machine	11,011 machines replaced	3,324 for regional VIC of which 781 for BW (2003 to 2007)
		A \$150 rebate for 5-star WELS water and 4-star energy rated machine replacement.	9,297 machines replaced	1,723 for regional VIC of which 570 for BW (Jul 11 to Jun 2015)
Shower head rebates		A \$10 rebate for at least a 3 star WELS rated showerhead costing \$30-\$100; or a \$20 rebate for min. 3 star WELS rated showerhead costing >\$100.	8,384 showerheads replaced	1,951 showerheads replaced
Dual flush toilet rebate [8]		A \$50 rebate for AAA/ 3-star rated dual-flush toilet replacing an existent less-efficient toilet (2003 to 2007).	15,577 toilets replaced	3,879 toilets replaced
		A \$100 rebate for a 3-star rated or better dual-flush toilet replacing an existent less-efficient toilet.	12,319 toilets replaced	2,684 toilets replaced
Permanent grey water system		A \$500 rebate for a greywater system when connected to subsurface irrigation.	2,367 greywater systems	994 greywater systems
Pool cover with roller/wheel rebate		A \$200 rebate for pool covers with a roller or device to assist with covering/uncovering and be a Smart Approved WaterMark product with a min. thickness of 400 microns and be UV stabilised.	1,932 pool covers	1,451 pool covers
Hot water re-circulator rebate		A \$150 rebate for a hot water re-circulator that diverts cold water from the hot water pipes to household water-supply system.	182 hot water re-circulators	55 hot water re-circulators
Rainwater tank to toilet/laundry connection		A \$200 and later on a \$500 rebate for connecting an existing rainwater tank to a toilet/laundry.	1,985 tanks	468 tanks
Rainwater tank rebates		A range of rainwater tank rebates of \$500 to \$1,500 dependent on size from 1 kl to > 20 kl and connection to indoor end uses such as toilet or laundry (2007 to 2015).	9,904 tanks	7,094 tanks
		Rainwater tank for garden use only with \$150 rebate (2003 to 2011).	20,682 tanks	10,385 tanks
Basket of goods rebate		A \$30 rebate on products worth over \$100, including flow control valves, mulch, wetting agents, compost/mulch bins, moisture/ rain sensors, garden tap timers, trigger nozzles, drip watering systems/weep hoses, temporary grey water diverters, shower timers, rainwater diverters, waterless car cleaners, and toilet flush interrupters (2003 to 2015).	131,544 baskets of goods	42,696 baskets of goods

Water audit		A \$50 rebate for a water conservation audit that assesses water within, or outside, or both within and outside the house and provides information on current use and options to improve water efficiency (2003 to 2015).	11,972 water audits	11,080 water audits
High pressure cleaning devices		Rebate for the purchase of a high pressure cleaning device.	46,015 high pressure cleaning devices	3,891 high pressure cleaning devices
Dishwashers		Rebate for AAA rated dishwashers.	4,516 dishwashers	1,537 dishwashers
Community Rebate Program	2015/16	This Victorian Government program targeted hardship and vulnerable customers identified by water retailers in Victoria that are unable to afford making their homes more water efficient by helping them to install efficient showerheads, dual flush toilets and other eligible water saving products [9]. [Note this program is being extended at least for the rest of 2016/17] Funding: Victorian Government. Evaluation: Internal review conducted prior to extending 2016/17	3,155 rebates	1,236 rebates
Quay Estate Rebate Program (tank to toilet)	2006-present	Rebate for residents on a new housing development in Torquay to connect tanks to their toilets as compensation for a planned dual pipe system for reticulation of reclaimed water that could not proceed for technical reasons. Funding: BW. Evaluation: No.		BW 235 rebates
Rainwater Tank Rebate Program	2007 to 2011	This program involved a licensed plumber visiting the customer's property to provide free advice on rainwater tank size and materials, possible locations, current water use, cost and maintenance. Funding: BW offered eligible customers the opportunity to make quarterly, interest free repayments on their water bills over a 12 month period on any rainwater tanks installed. Evaluation: Yes – no report available.		BW 1,460 rainwater tanks
Water Secure Home Audit	2009 to 2012	This program involved a qualified plumber visiting households to install water efficient devices e.g. efficient showerheads and tap flow regulators, and fixing minor leaks, adjusting single flush toilets and evaporative air conditioners to reduce water consumption. Funding: BW subsidised \$130/visit, with the customer responsible for paying the remaining \$30. Evaluation: Customer feedback surveys, no report available.		BW 6,600 home audits

[1] http://www.citywestwater.com.au/residents/showerhead_exchange.aspx (accessed 01.02.17)

[2] <https://www.yvw.com.au/help-advice/saving-water/water-saving-showerheads> (accessed 02.02.17)

[3] <https://www.barwonwater.vic.gov.au/residential/saving-water-home/exchange> (accessed 01.02.17)

[4] http://mysupport.southeastwater.com.au/articles/FAQ/Can-I-exchange-my-showerhead/?q=how+can+i+keep&l=en_US&fs=Search&pn=1 (accessed 02.02.17).

[5] Pers.comm Ann Forder, CWW (2017).

[6] http://www.citywestwater.com.au/residents/toilet_replacement_program.aspx (accessed 02.02.17).

[7] [https://www.barwonwater.vic.gov.au/vdl/A3385198/Living%20Victoria%20Water%20Rebate%20Program%20\(reticulated%20water%20supply\)%20application%20form%202012-2015.pdf](https://www.barwonwater.vic.gov.au/vdl/A3385198/Living%20Victoria%20Water%20Rebate%20Program%20(reticulated%20water%20supply)%20application%20form%202012-2015.pdf) (accessed 02.02.17).

[8] Note: many but not all the toilets installed under the toilet replacement program would have received a rebate that is included in these numbers.

[9] <http://web.archive.org/web/20160620084326/http://www.delwp.vic.gov.au/water/community-water-rebates-program#sthash.ejJRd3b1.dpuf> (accessed 02.02.17).

Table 2.2 – Summary of Melbourne & regional Victoria efficiency programs – residential sector behaviour change initiatives

Initiative	When	Details	Who/how many Melbourne	Who/how many Regional (eg BW/CHW)
Target 155	2008 to 2011	<p>Introduced as a campaign to encourage residential water users to reduce their consumption to less than 155 lcd. Introduced at the end of 2008, the campaign was built on recognizing customers' efforts to date, informing them about the role of Target 155, and assisting them with knowledge about and access to practical solutions (Fitzgerald 2009).</p> <p>Funding provided by Victorian government with individual actions funded by retailers</p> <p>Evaluation – Siriwardene et al 2011 "How Effective is Target 155 in Melbourne? Insights from Climate Correction Model" estimated savings from Dec 2008 through Aug 2010 at 53 GL</p>	Metropolitan Melbourne	CHW Target 150 in Ballarat
Kiosks		<p>"Set up in shopping centres in the retailer's service areas to provide customers with a forum to access water conservation information and advice and exchange their showerheads" (JWCPMM 2009/10)</p> <p>Funding: retailers</p> <p>Evaluation – n/a - a facilitation channel for other programs</p>	All	
Water Smart Behaviour Change Program	2007 to 2010	<p>This voluntary behaviour change program aimed to help residents to achieve their goals to reduce water use at home by providing advice and ideas for using water more efficiently. Around 110,000 households were invited to participate (DSE 2011)</p> <p>Funding: Retailer internal with Victorian government contribution</p> <p>Evaluation: Yes</p>	>20,000 participant households across Melbourne, Ballarat, Bendigo and Geelong.	
High water users program		<p>This campaign targeted communications with households using >800 L per day via written and face to face communications linked to T155 messaging. (JWCPMM 2009/10)</p>	All	
Fitzroy North Water Saver	2006/07	<p>Behaviour change program targeted to one suburb. Focused on 1000 households in the Fitzroy North area utilising direct marketing techniques to assist customers reduce water use. CWW implemented the program in partnership with the City of Yarra and Vic Government. The program based on the successful Travel Smart program and implemented by consultants, Socialdata Australia.</p> <p>10% savings reported in WCP CWW, 2007.</p>	CWW – Fitzroy North	

Table 2.3 – Summary of Melbourne & regional Victoria efficiency programs – non-residential sector and other initiatives

Initiative	When	Details	Who/how many: Melbourne	Who/how many: Regional eg BW
Commercial				
WaterMAP (Water Action Management Plan)	2006/07 to 2011/12 (BW dates)	<p>During the drought, business and industrial sites using 10 ML/a or more were required to develop and submit to their water utility a “WaterMap”. The program built on and extended the voluntary scheme that had been introduced in 2003, in which Melbourne’s top 200 non-residential consumers developed water management plans in conjunction with their water utility.</p> <p>The program required and provided support to non-residential water customers to: assess their current water use; identify inefficiencies and opportunities for water savings; prepare an action plan to implement water conservation activities; report annually on implementation of those activities (Barron and Liubinas, 2009).</p> <p>Funding: Each water utility resourced the staff to assist customers. Some funding assistance was provided by Victorian Government to assist water utilities to employ a resource.</p> <p>Evaluation: Each water utility was required to submit an annual report to Victorian Government outlining the number of customers and water consumption in each high level industry sector (ANZSIC), and compare this to the previous year.</p>	Victorian Government/Melbourne retailers	130 CHW delivered WaterMaps for all 23 Customers using >10ML/a as part of targeting highest water users for efficiency improvements
Support 155	2008-2010	<p>Businesses could show their support for the Target 155 campaign by signing up to this scheme which could link to workplace audits, retrofits and collateral (JWCPMM 2009/10)</p> <p>Funding: DSE provided collateral. Evaluation: No</p>	Victorian Government/Melbourne retailers	Only used by Western Water as a regional water service provider
Water Saver Garden Centres	2007-2011	<p>Accreditation scheme for garden centres and nurseries offering expert advice for sustaining water wise gardens (MJWEP 2010/11)</p> <p>Funding: Joint funding between retailers and Victorian government</p>	50 garden centres accredited	Limited regional garden participation in the program
Plant Selector Tool	2009 to present	<p>The tool on provides customers with information and guidance on the most appropriate water efficient plant types suited to a particular location. The tool is currently being developed into an app.</p> <p>Funding: Water utilities membership fees</p> <p>BW in partnership with the Gordon Institute obtained a \$37k grant from the Smart Water Fund to develop an interactive Waterwise Plant Selector Tool.</p> <p>Evaluation: Limited to uptake of tool.</p>		BW
Permanent Water Savings Plan	2005 to present	The Victorian Government’s permanent water saving (or use) rules are a set of common-sense rules that reduce demand and ensure efficient water use [1]	All	All
Laundries water efficiency program	Feb 2010- June 2010	<p>This program provided educational resources and tools to communicate water-savings opportunities to public access/on-premises laundries as well as some audits, incentives and grants including for check meters, steam taps, digital metering systems, the replacement of inefficient top-loaders with front-loaders (MJWEP 2010/11).</p> <p>Funding: Victorian Government</p> <p>Evaluation: Yes, final report. The estimated water savings achieved are a reduction of 25% water</p>	1,079 registrants	48

		usage, or 67ML per year across the program. The investment per kilolitre of water saved was estimated at \$1.41 / kL.		
Waterless woks	2011 (BW)	This program was designed to promote behaviour change in Asian restaurants in Melbourne. Programs varied by water utility from funding the replacement of water cooled woks with water-less woks to a providing behaviour change materials and information sessions in multiple languages (JWCPMM 2009/10) Funding: By each water utility. BW funded a waterless wok demo site at a local restaurant Evaluation: An evaluation for BW site. Report not available	Target: SEW - 10 woks; YVW 20-25 woks.	BW 1
Spray rinse valves		This program involved retrofit of spray rinse valves in restaurants / pubs and clubs in Melbourne (JWCPMM 2009/10). Programs were conducted by each water utility. Funding: Water utilities. BW funded a trial at a local hotel Evaluation: CWW, yes. 367 PRSV exchanged, with estimated savings of 23.9 ML/a, 3,129 GJ/a and 160 tonnes CO2-e per year. BW, yes – report not available.	CWW 367 PRSVs Pilot targets: YVW - 50 valves (for 2010/11)	BW 6
Water Secure Business	2006 - 2009	This program provided a range of water saving material for businesses as well as advice from BW efficiency officers. Funding: BW. Evaluation: no		BW
Water Saving Grants Program	2010-2013	This program provided support for business customers and community groups to undertake water-saving projects ranging with grants of either \$5k for smaller projects and \$50k for larger projects. Projects could involve rainwater or stormwater harvesting, wastewater recycling, or improve efficiencies and required at least 50% co-contributions by the applicants. Funding: Victorian Government + utility Evaluation: Yes. Water utilities reported to Victorian Government on how funds were allocated, and estimated water savings.	YVW - 31 grants totalled \$107k plus \$193k provided by participants. Applications assessed using community cost model.	BW CHW delivered 12 grants
Living Victoria Small Business Rebates	2011-2015	This scheme offered a rebate on 50% of expenditure up to a maximum of \$2000 on a mix of water-efficient appliances that included: water data loggers, pre-rinse nozzles, commercial glass washers, waterless wok stoves, laundry systems using ozone technology, condensate recovery systems, waterless or low flow urinals, hand-held rinse sprays, process water reuse, shower-timers/ auto shutoff valves, water efficient combi-steamers. Funding: Victorian Government. A review (based on modelled savings of the Living Victoria Water Rebate Program (Home and Garden and Small Business Products)) was conducted in 2016 (Deloitte 2016). Evaluation: Yes, the Victorian Government evaluated savings based on the information provided in the rebate application form (old vs. new equipment).	2292	1812
Farm Water Saving Grants Program	2012-2016	The Grants were specifically for projects which enabled high water using agricultural customers to make permanent drinking water reductions, through substitution with alternative water including groundwater, surface water or stormwater, as well as on farm efficiency measures. Funding: BW and DELWP. Evaluation: Yes, report not available, water savings 214.5 ML.		BW Colac District 38

On-Farm Leak Detection using Taggle	2012-present	<p>This program uses Taggle technology to assist high water using agricultural (mainly dairy and beef) customers in Colac, detect farm leaks early. Typically leaks are often not detected and repaired until after the water bill arrives, a lag of 2-3 months resulting in the farmer losing money and BW losing water.</p> <p>Funding: BW. Evaluation: Yes, report not available, water savings >65ML.</p>		BW Colac District 73
Water Monitoring for Large Water Users	2009-present	<p>In 2009, BW implemented a data logger program for the top 20 water using business customers in the region. The program used the HydroShare System which was developed by SEW and their partner 'us' (Utility Services).</p> <p>The program enabled customers to monitor and review water consumption, monitor progress on the implementation of WaterMAP actions and identify unexpected water usage that may indicate leaks. The HydroShare loggers were replaced with AEGIS loggers in 2013.</p> <p>Funding: BW. Evaluation: No.</p>		BW 20
Cooling Tower Audits Program	2007-2009	<p>Victorian Government program that was delivered by Australian Institute of Refrigeration, Air-conditioning and Heating (AIRAH) and project managed by CWW. The project has assisted businesses across Victoria to optimise water efficiency in cooling towers. Outcomes include:</p> <ul style="list-style-type: none"> • 469 cooling tower water efficiency assessments (10% of Victoria's cooling tower stock) • AIRAH training courses for system operators • Development of a best practice water efficiency guide added to AIRAH's suite of publications • On-line water efficiency calculator as part of a resource rich website www.mycoolingtower.com.au • 233 check-meters provided to water corporation customers across Victoria to optimise water efficiency in cooling towers. <p>Funding: DSE.(JWCP 2007). Evaluation: Yes, project review report.</p>	<p>469 audits completed across Victoria</p> <p>114 people attended AIRAH training course</p>	BW 12 audits completed
The Top 200 Smart Water Metering Program		<p>Digital water metering initiative for the top 200 commercial consumers using supplier engaged by each water utility (JWCP 2007).</p> <p>Funding: Victorian Government.</p> <p>Evaluation: No.</p>	<p>33 sites installed (2007); targeted roll-out across top 200 sites in Melbourne (MJWCP 2007)</p>	
Tennis courts program	2006/2007	<p>A product and service was trialled to save water applied to en-tous-cas tennis courts.</p>	<p>Targeted up to 200 courts (MJWCP 2007)</p> <p>30 clubs signed up</p> <p>estimated savings based on pilot results 60-80%</p>	
Showerhead Exchange program	2007-current	<p>CWW exchanged inefficient showerheads for water efficient showerheads in businesses including hotels, hospitals, aged care and recreational facilities. 11,500 showerheads exchanged.</p> <ul style="list-style-type: none"> • Estimated savings: • 182 ML water per year • 24,000 GJ gas per year. 	<p>300 CWW business customers participated</p>	<p>CHW targeted accommodation industry with exchange of high-quality showerheads</p>

Clean in Place Efficiency Program	2013	<p>CWW provided assessments to assist businesses to improve water, energy, chemical and production efficiency of Clean In Place (CIP) systems. CIP is a method of cleaning the interior surfaces of pipes, vessels, and associated process equipment, without disassembly. It is common in food, beverage, and pharmaceutical industries.</p> <p>Potential savings identified:</p> <ul style="list-style-type: none"> • 31.9 ML water per year • 30.4 ML trade waste per year • 445 gigajoule gas per year • 29,000 L chemicals per year • 1040 hours downtime per year. 	8 audits
Steam System Efficiency Program	2010-2012	<p>CWW provided audits and training to assist businesses to improve water and energy efficiency of steam systems. CWW is working with customers to implement improvement opportunities.</p> <p>Savings identified:</p> <ul style="list-style-type: none"> • 239 ML water per year • 187,000 gigajoules gas per year • 10,400 tonnes CO2-e per year. 	30 audits
Fire Sprinklers Water Efficiency Project	2009 - 2011	<p>Victorian Government program that was delivered by the Plumbing Industry Commission, and supported by CWW, SEW and YVW. The project has assisted businesses across Victoria to optimise water efficiency in fire sprinkler systems. Outcomes include:</p> <ul style="list-style-type: none"> • A Guide to Fire Sprinkler System Water Saving • Free assessments and pressure setting adjustments <p>The identification of seven main opportunities for reducing water consumption in fire sprinkler systems. Potential water savings estimated to be 500 ML/a across Victoria if all fire sprinkler systems are run at best practice.</p>	<p>CWW, YVW, SEW</p> <p>107 CWW customers participated</p>
Irrigation Efficiency	2015-current	<p>Irrigation of functional open spaces accounts for more than half of the water used by local councils and elite sports venues. Approximately 1.6GL of water is used annually for irrigation in CWW's service area alone. In recognising the value of functional open space, and to assist customers to be as efficient as possible in using water for irrigation, Smart Water Fund and CWW developed the Best Practice Guidelines for Functional Open Space (released in August 2015).</p> <p>A group of 21 water utilities from across Australia are currently working to develop a shared irrigation management tool for irrigation customers. A steering committee is currently assessing if there are any existing tools in the market that meets the water industries' needs.</p> <p>Funding: Smart Water Fund</p>	CWW
Benchmarking (www.watercompare.com.au)		<p>Water suppliers across Australia have collaborated to develop the National Business Water Efficiency Benchmarking project (Water Compare). Water Compare is designed to gather water use information across a wide range of business sectors to enable:</p> <ul style="list-style-type: none"> • Businesses to compare their water use to industry averages and be able to identify their own ways to use water in the most efficient manner and therefore save costs; and 	Approx. 80 visitors per day

		<ul style="list-style-type: none"> Water suppliers to share their experience and pool resources to develop a nationally consistent business customer benchmarking framework. <p>The project was sponsored by the Victorian government, the Smart Water Fund, CWW and water suppliers across Australia.</p>		
Co-funding for Water Efficiency Projects	2007-2014	<p>CWW has co-funded 109 water efficiency projects at customer sites, including:</p> <ul style="list-style-type: none"> Rainwater and stormwater harvesting Amenities upgrades Process modifications Wastewater reuse <p>Providing co-funding which has leveraged customer investment in water efficiency more than 4:1. Total savings across 109 projects is 1.5 billion litres per year water. Total lifetime savings of the projects is 25 billion litres water.</p>	109 CWW customers	CHW co-funded a small number of projects with large customers with large water savings.
Institutional				
Water – Learn it! Live it! (Water-LiLi)	2005-2012	<p>This is a free water education and accreditation program for Melbourne which targets primary and secondary schools and includes a comprehensive resources kit. Accreditation is achieved by completing a number of milestones which include the integration of water education in the curriculum. (JWCP 2010/11).</p> <p>Funded by the Victorian Government (Our Water Our Future Program) via contributions from the three Melbourne retailers and MW.</p>	CWW, YVW, SEW	All regional water corporations had this program available to schools including BW.
SWEP (Schools Water Efficiency Program)	2006 to 2010 and 2012 to present	<p>In 2006, the Victorian Government launched the state-wide SWEP. The program from 2006 to 2010 was based on water audits and retrofit of water efficiency measures (flow control valves, fixing leaks, etc.). 1,737 schools had joined the program state-wide (reported in Low et al. 2015). The original scheme used a 'pay by savings' approach.</p> <p>In 2012 the current SWEP – Data logging program commenced. This innovative and highly successful multi-faceted program used a combination of data loggers on water meters, a website portal, education material and ongoing liaison to help schools to identify leaks, assess their water usage, and promote water efficiency. 900 Victorian schools (about a third of all schools) are now logging their water use on a continuous basis. SWEP is also monitoring electricity use for 125 schools. It is estimated 3 GL of water has been saved, thus saving schools almost \$9 million in water and wastewater charges (May 2012 to Dec 2016). Savings are continuously assessed and longed at the end of each term.</p> <p>In 2016/17 a trial commenced on 15 (later extended to 30) DELWP facility sites across Victoria monitoring water and electricity usage.</p>	Victoria	CHW promoted SWEP to larger schools 2006-09
Other				
Water Infrastructure	Ongoing	This activity involved surveying water mains for leakage across Melbourne (JWCPMM 2009/10). CWW and YVW used specialised service providers via a tender process; SEW's in-house team delivered an	8,278 km surveyed; (CWW - 2,082;	

Losses Program	acoustic leak detection service (JWCP 2010/11) Multiple approaches used from active leakage detection and zone metering to metering improvements and pressure reduction.	SEW - 2,399; YVW - 3,797 km)
Research programs	<p>A variety of research programs including:</p> <ul style="list-style-type: none"> • The Joint Residential End Use Measurement Study which collected high resolution, appliance use data • National Business Water Efficiency Benchmarking Project • Evaluation of costs and benefits of water conservation initiatives • Leak detection trials of fixed noise loggers • Smart garden watering online communities <p>(MJWEP 2010/11). Since 2002, \$50m has been invested in research relating to climate change and water scarcity through the Victorian Smart Water Fund by MW, the three Melbourne retailers and the Victorian Government. A recent report [3] provides a summary of the activities including many that focus specifically on water efficiency research. The Clear Water website contains further details of individual projects funded under the Smart Water Fund [4], some 230 projects.</p>	

[1] <http://delwp.vic.gov.au/water/using-water-wisely/permanent-water-saving-rules> (last updated Dec 2011)

[2] <http://watercompare.com.au/About-WaterCompare/Overview.aspx> (accessed 03.02.17)

[3] <https://www.clearwater.asn.au/resource-library/publications-and-reports/water-efficiency-research-summary.php> (accessed 28.02.17)

[4] <https://www.clearwater.asn.au/resource-library/smart-water-fund-projects/> (accessed 28.02.17)

Since the end of the drought and the overall reduction in investment in water efficiency programs, total and per capita water demand in Melbourne has remained relatively low considering population rise as illustrated in Figures 2.4 and 2.5¹⁰. This indicates, in combination with other factors, that both structural/technical and behavioural water efficiency changes have assisted in reducing water demand and minimising bounce back.

Figure 2.4 – Total water use in Melbourne

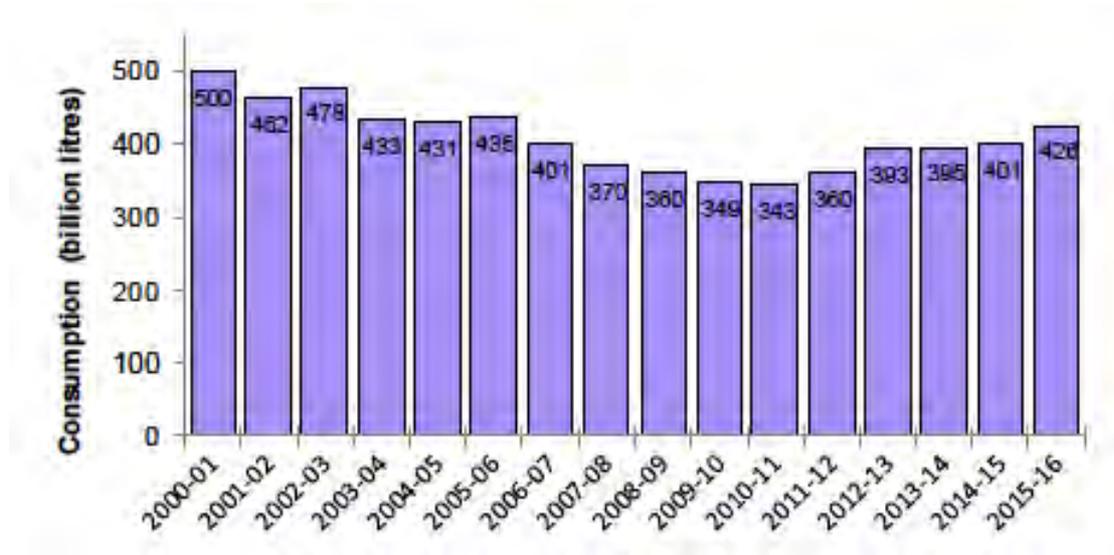
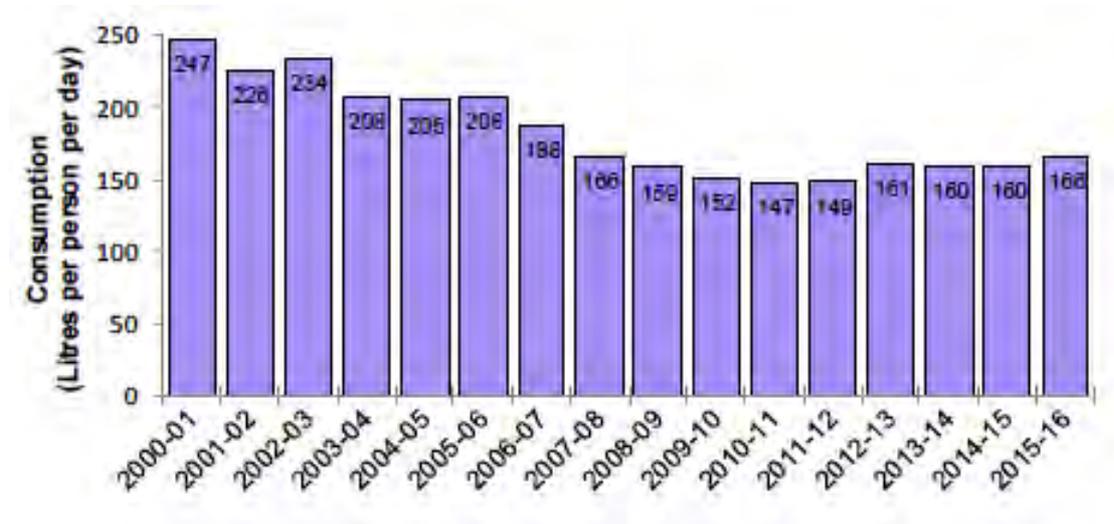


Figure 2.5 – Per capita residential water use in Melbourne



¹⁰ CWW, MW, SEW and YVW, 2016, Water Outlook for Melbourne. Report prepared by City West Water, Melbourne Water, South East Water and Yarra Valley Water. Available at: <https://www.melbournewater.com.au/getinvolved/saveandreusewater/Documents/Water-outlook-Melbourne2016.PDF> (accessed 01.02.17).

3 EFFICIENCY PROGRAMS IN OTHER JURISDICTIONS

This section summarises key programs implemented around Australia and a few examples from overseas. These are predominantly drawn from recent research documented in “*Managing drought: learning from Australia*” (Turner et al. 2016a) and primary research conducted as part of this study.

Reflecting on programs already implemented in Melbourne and regional Victoria (summarised in Section 2), and those implemented in other regions (summarised here in Section 3), enables opportunities for future potential water efficiency programs to be observed.

DEMAND MANAGEMENT AROUND AUSTRALIA

Due predominantly to the Millennium drought, water efficiency programs in Australia advanced rapidly during the 2000s both in terms of the breadth of end uses and sectors and the scale of programs (Turner et al. 2016a). For some end uses this means that large-scale roll out of low cost efficiency programs is now more difficult, for example the showerhead exchange programs, due to saturation of the market. In many cases, greater consideration of the conservation potential and cost effectiveness will be needed including how regulations can be better used to drive efficiency over the longer term and how more sophisticated program design can be used to tap into more difficult and specific sub sectors through customer segmentation (Turner et al. 2013).

To consider the opportunities for program intervention in Victoria it is useful to look firstly at other jurisdictions in Australia to ascertain if any particular programs either not implemented in Victoria, or only implemented to a lesser extent, could be considered and adapted.

Table 3.1 summarises key programs implemented around Australia predominantly during the Millennium drought. Much of the information has been drawn from Turner et al. (2016a). Lessons and additional details on many of the programs can be found in Chong et al. (2009); Turner et al. (2013); Turner et al. (2014); Fyfe et al. (2015); Turner et al. (2016a).

Table 3.1 – Demand management programs

Types of programs	Description	Examples	Comment/Potential for Melbourne and regional Victoria
Regulations			
Standards/labelling	<p>Efficiency labelling, originally instigated in Victoria, was taken over by WSAA in 1999 and became mandatory in 2005 under the federal government's Water Efficiency Labelling and Standards scheme (WELS). Appliances and fixtures, most domestic water using equipment, require a label showing their relative efficiency under standardized tests, and in some cases need to meet minimum standards to be sold (i.e. toilets and clothes washers). During the drought the scheme provided an essential consistent terminology for water efficiency products, such as showerheads, toilets, taps, clothes washers, dishwashers and urinals, for water utilities and government agencies to use when communicating with customers and when highlighting the products they advocated as part of their efficiency programs. A database listing all registered products can be found at the WELS website (http://www.waterrating.gov.au) together with a recent review of the program (Fyfe et al. 2015).</p>	National (Water efficiency labelling and standards – WELS – scheme)	Opportunity for Victorian utilities and DELWP to drive greater levels of water efficiency in appliances and fixtures and advocate minimum performance standards for specific end uses and expansion of WELS to additional end uses (i.e. coolers, combination washer-dryers) that are likely to increase demand.
Regulations and codes on buildings	<p>Building codes and regulations can have a significant influence on the efficiency of properties by recommending/mandating the use of efficient products. In the 1980s the national plumbing code mandated the use of dual flush toilets in new and renovated dwellings sparking a dramatic shift in toilet efficiency. In NSW the Building Sustainability Index (BASIX) came into effect in 2004 mandating minimum water and energy (GHG) standards for new and renovated dwellings, through building certification processes (varying across the state for different climate conditions).</p> <p>As part of the broader Victorian Star Building Standard (ASCB 2005), a system was introduced in July 2005 requiring new homes to: achieve a 5 star energy rating for the building fabric structure, adhere to maximum flow rates for showerheads and taps, and have a maximum water pressure of 73 psi (500kPa). In addition, new houses must install either (1) a rainwater tank with a capacity of at least 2 kl for toilet flushing serviced by a 50m² roof area, (2) a solar hot water system, or (3) be connected to a reticulated recycled water system where available (ASCB 2005). 6 star energy ratings have been required since 2011.</p>	Sydney/NSW (BASIX) Victorian Star Building Standard	There is significant opportunity for the current Victorian Star Building Standards in Melbourne and regional Victoria to incorporate further mandatory water saving devices in new and renovated properties especially considering the current and anticipated level of population growth.
Voluntary			
Standards/labelling	<p>Smart Approved WaterMark (SAWM), launched in 2006, originally provided standards and a simple labelling scheme predominantly for outdoor products. During the drought the scheme gained momentum and additional products were gradually added, including products for the non-residential sector (i.e. commercial glass washers) (SAWM 2011). In 2015 SAWM set up a partnership in Europe with Waterwise UK under which products approved by SAWM can now use the same label in Europe. The Smart Water Mark website (https://www.smartwatermark.org/home/) now hosts details of water efficiency products and advisory services and the materials from the former Savewater website active during the drought (now at https://www.smartwatermark.org/Victoria/ and being gradually released in other states such as NSW).</p>	National (Smart Approved WaterMark - SAWM)	Victorian utilities and DELWP actively engaged in supporting SAWM and the Smart Water Advice website (former Savewater website) to assist in general efficiency awareness across the state.

Types of programs	Description	Examples	Comment/Potential for Melbourne and regional Victoria
Residential measures			
Restrictions	A core option used during the drought, mainly targeting outdoor water uses in the residential sector (i.e. garden watering, car washing, cleaning hard surfaces, swimming pools) and some non-residential sectors (i.e. irrigation of parks and sports fields, nurseries and market gardens, swimming pools, commercial car washes and building activities). In many areas permanent water savings measures/sensible watering practices have become standard. Additional details are provided in Turner et al. (2016a) and https://opus.lib.uts.edu.au/bitstream/10453/20462/1/Chongetal2009waterrestrictions.pdf and https://opus.lib.uts.edu.au/bitstream/10453/20462/2/Chongetal2009waterrestrictionsappendix.pdf	Most major capital cities and many regional towns adopted various levels during the drought.	Extensively used by Melbourne and regional Victoria.
Residential home audits	Audit programs have been implemented at various scales since the 1990s and have varied to some extent but typically involve, for a small fee, a qualified plumber going to a participating house and installing, where appropriate, a new 3 star (<9 l/s) water efficient showerhead, tap flow regulators/aerators on kitchen and bathroom sink taps, and a toilet cistern flush arrestor in single flush toilets. Minor leaks are often checked and, where feasible, repaired and additional showerheads offered for an extra fee. Advice and educational materials are also often provided to customers by the plumber and in some programs advice on other programs the participant could benefit from (e.g. clothes washer rebates, rain water tank rebates and garden audits). Household audit data is often collated to assist in subsequent analysis and evaluation of savings. Evaluations in Sydney identified an average saving of 21 kL/household/a based on single residential dwellings (Turner et al 2005). Energy savings from hot water were also identified (Turner et al 2014). Various implementation models have been used ranging from the use of a utility's own staff for audits and bulk buying of products to reduce costs, to tenders with local plumbing service providers, to contracting out the entire service to niche contractors. Typically programs cost approximately \$180 per service with the customer paying only around \$20. In recent years utilities have used a full cost recovery approach but this has tended to dramatically reduce participation rates (Turner et al 2016a).	SWC - WaterFix - 485,000 homes (1999 – 2011) Peak - 80,000 audits/year SEQ – Home WaterWise Service – 228,000 homes (2006 - 2008) Peak – 3,000 audits/week	Audits have been used in Melbourne and regional Victoria, although, to a much lesser extent than Sydney and SEQ. Due to the high participation in the showerhead exchange program an audit program would provide less savings if rolled out broadly. However, a well designed, funded and advertised targeted audit program which links indoor and outdoor usage together with rebates available could yield significant savings especially in regional areas with larger families and gardens thereby increasing cost effectiveness. Also, a targeted program focusing on multi-residential units in Melbourne (similar to new SWC Multi-res WaterFix program (see below) could provide savings).
DIY water saving kits	Kits containing regulators and aerators for showers and taps provided free of charge in public places such as shopping malls. The largest example of such a program was in Sydney, which was provided as an alternative to the WaterFix audit program (i.e. different customer market segment).	SWC – > 211,000 kits (2004 – 2011)	Some potential for this program but likely low savings if rolled out broadly due to the already successful showerhead exchange program.
Showerhead swap	Participants typically exchange up to two inefficient showerheads for free efficient devices obtained from various outlets, such as shopping malls, local council offices and hardware stores after providing details of their latest water bill. Early statistical evaluation of the Melbourne program identified savings of between 8.5 to 12.4 kl/household/a depending on which jurisdiction implemented (Turner et al 2014).	Melbourne retailers- >460,000 showerheads (2006 – 2011) Perth - 124,000	Melbourne retailers developed and led this program nationally. Modified program still running for some areas. Showerheads are the largest per capita water user according to Melbourne

Types of programs	Description	Examples	Comment/Potential for Melbourne and regional Victoria
		showerheads (2011-2013)	research (Gan and Redhead 2013). Hence there is still likely to be an opportunity for savings but it would need to be through a targeted program. JWEF 2011 noted difficulties penetrating certain demographic segments (i.e. tenanted, high income and elderly).
Toilet replacement programs	Typically, the program involves a qualified plumber replacing up to two single flush toilets with new efficient 4 star dual flush toilets often linked to a rebate from a state government. The toilets are typically removed and recycled. Many utilities formed a partnership with Select Solutions using Caroma products to streamline the program and reduce costs. Documented savings range between 20 and 31 kl/household/a depending on the jurisdiction and how implemented (Turner et al, 2014).	Sydney - 28,000 toilets (2008–2011) Melbourne – Retailers replacements 13,680 toilets (2009-2012) DELWP rebates 27,600 (2011-2015)	Whilst Melbourne and regional utilities have implemented such programs, with the assistance of the DELWP rebates, significant savings are potentially available through programs that can target higher occupancy households to increase the cost effectiveness.
Clothes washer rebate programs	Rebates, typically \$150, were provided towards the purchase of a machine at point of sale for those machines with a specified minimum efficiency level (initially 4 star but in some jurisdictions rebates eventually only permitted 5 stars to increase savings). Measured savings between 18 and 23 kL/household/a (Turner et al 2014).	Sydney - 186,000 machines (2006-2010) Melbourne 19,214 machines (2011-2015) Perth - 210,000 machines (2003-2009) Qld >188,000 machines (2006-2008)	The clothes washer rebate programs implemented by Perth, Sydney and Qld have assisted in shifting the market towards more efficient machines. The Victoria program participation rates are an order of magnitude less than Sydney, Perth and Qld. According to Melbourne research (Gan and Redhead 2013) clothes washers are the third highest water using end use per capita, 55% of clothes washers in Melbourne are still top loaders (typically less efficient) and only 36% of machines are 4-star or better. This end use therefore still provides opportunities for savings Hence further regulation and/or targeted rebates could provide significant savings.

Types of programs	Description	Examples	Comment/Potential for Melbourne and regional Victoria
Garden programs	<p>Outdoor water usage has traditionally been the highest end use in single residential dwellings in Australia, varying significantly depending on climate conditions and lot size. Many jurisdictions have implemented multi-pronged programs that aim to assist customers in reducing their water usage in the garden. Perth led the way in developing strong industry linkages, training, and certification arrangements with garden centers and irrigation specialists, replicated by other utilities. Many jurisdictions have provided thousands of dollars worth of rebates with baskets of goods containing rain sensors, catch cups, tap timers, soil wetting agents, mulch and money off irrigation systems. Others have provided garden workshops. Many have linked their messaging to the Smart Water Mark website.</p> <p>A few utilities/government agencies have provided assistance in the home with a garden audit including the DELWP indoor and outdoor water audits. The largest program provided has been in Sydney, Love Your Garden, which targeted households with high outdoor water use. It provided them with the chance to have a qualified horticulturalist review the water demand in their garden. A detailed watering plan was developed for each garden's needs and an array of tools offered (i.e. tap timers, rain gauges and tap tags) with the service, valued at AUD 180, provided to householders for only AUD 33.</p>	<p>Sydney - Love Your Garden program - 23,500 home garden visits (2003 – 2010) DELWP Water Audits (indoors and outdoor) – 11,967 homes (2011-2015)</p>	<p>According to Gan and Redhead 2013 outdoor irrigation is still one of the largest per person water demands. This is likely to be even more pronounced in regional areas where lot sizes are larger. Whilst some outdoor audits have taken place in Melbourne and BW it would appear that there is still significant opportunity to ramp up outdoor water programs and link them to for example, the Smart Water Mark website.</p>
Rainwater tank rebates	<p>Rainwater tank rebates have been very popular in Australia with all the major cities and many regional areas providing incentives. Typical programs involved scaled rebates for participants buying tanks ranging from 1 kl to 10 kl. Additional rebates were generally available to incentivise connection to indoor end uses such as toilets and clothes washers to optimize savings.</p>	<p>Sydney - 58,941 (2002 -2011) SEQ >239,000 (2006-2008) Perth – 15,648 (2003 – 2009) Melbourne 30,393 (2011–2015)</p>	<p>Over 31% of dwellings in Melbourne and 56% of dwellings in the rest of regional Victoria have rainwater tanks in properties suitable for rainwater tanks (ABS 2013). Hence there is still scope for regulation and/or rebates for tanks although care needs to be taken as in some jurisdictions tanks have not provided the savings anticipated and have not been cost effective (Turner et al. 2016a). If tanks are not saving as anticipated in Victoria (Moglia et al, 2015) a rainwater tank servicing and optimisation program could be beneficial involving auditing and a suite of measures from owner education and connection to indoor end uses through to pressure vessel installation to improve savings.</p>
General rebate schemes	<p>All the major cities have provided large rebate schemes providing millions of dollars of incentives for customer to purchase efficient showerheads, toilets, clothes washers, rainwater tanks (with indoor connections) and garden products as indicated above.</p> <p>Other rebates have included items such as tap flow regulators, hot water recirculators, dishwashers, toilet</p>	<p>Perth rebates 383,597 2003-2009 Melbourne</p>	<p>The savings for many of these additional rebates is not publically reported. Further research and collaboration is required between water utilities across Australia to</p>

Types of programs	Description	Examples	Comment/Potential for Melbourne and regional Victoria
	flush interrupters, pool covers, high pressure cleaning systems, waterless car cleaners, rainwater diverters, garden bores (in WA), greywater systems and aerobic treatment units. Participation rates and savings for such products have varied significantly.	286,732 Qld 465,000 2006-2008	identify if such rebates are cost effective and if so how savings and participation rates can be improved.
Targeting high residential water users	The largest example of the high water users program was in SEQ in 2007, the One to One program (Turner et al 2010). The program was initiated in combination with Level 5 restrictions and the Target 140 campaign. It involved identifying high water-using households (>800 l/household/day), and providing a survey form of >50 questions to 80,000 households to find out why each household was using so much water. The survey received a 92% response rate. A follow-up One to One personalised Water Savings Plan was provided to those households using >140 lcd to advise on how to save water (linked to the rebate scheme at that time). The associated High Water Users Program was a restriction requirement that could result in an infringement or installation of a flow restriction device if the occupier could not advise why their demand was high (e.g. number of people, home business, medical condition). The One to One program was a voluntary program.	SEQ High Water Users and One to One program (70,000 homes involved in survey + follow-up personalised plans)	Melbourne retailers have taken part in such a program but to a far lesser extent than the SEQ example. This program was highly successful in engaging participants with water saving awareness and rebates available. Since 2007 interface opportunities have improved and there are now faster lower cost methods available to further improve the program.
Target 140/155 (residential lcd)	Innovative, multi-media, multi-strategy communication campaigns to encourage reduction in household water use to 140 or 155 lcd in SEQ and Melbourne respectively across all uses. In SEQ, where Target 140 was first implemented, restrictions were tightened to Level 5 in 2007, breaking new ground in terms of the extent of behaviour change expected of the community. While moving to Level 5, the Target 140 campaign was introduced encouraging individuals to reduce household water demand to less than 140 lcd from pre-drought levels of 300 lcd. With severe outdoor restrictions already in place, voluntary indoor water savings were seen as an opportunity. Other targeted programs such as the One to One water savings program (detailed above in targeting high residential water users) were introduced at the same time to specifically curb the demand of the top 10% of high water users.	SEQ – Target 140 Melbourne - Target 155	SEQ now have target 150 to 100 lcd incorporated as part of their drought planning (SEQWater, 2015). Melbourne has recently reintroduced the Target 155 campaign and a regional version - Target your water use – that takes into consideration how regional areas are likely to have higher water demand than Melbourne due to larger gardens, larger families and varying climate factors etc. There are major opportunities to link these programs to a Victorian statewide equivalent of the SEQ One to One program focusing on the top 10% of residential water users in both Melbourne and individual regional areas.
Non-residential measures			
Waterless woks	A targeted non-residential end use program initially established in Sydney and later adopted to a lesser extent in Melbourne. The program focused on the installation of waterless woks to replace high water using wok burners, extensively used in Asian commercial kitchens, typically using 2.5 to 3.5 kL/d per stove and up to 75% of the water use in an Asian restaurant (Sydney Water 2007). The alternative waterless woks saved up to 90% of the water used by traditional wok stoves. The program established in Sydney in 2003/04,	Sydney (>270 restaurants) & Melbourne (100 waterless wok products)	This program has been implemented in Melbourne and trialed by BW but to a lesser extent than in Sydney. Whilst the program did not save as much as originally anticipated it was highly successful in

Types of programs	Description	Examples	Comment/Potential for Melbourne and regional Victoria
	<p>which identified a payback period of only one year, initially had limited uptake until the Saving Water in Asian Restaurants Project, run by the Ethnic Communities Council of NSW, began in 2006. With assistance from state government funds, participating restaurants could receive up to AUD 2,000 towards replacement of an existing conventional wok stove or a AUD 2,000 grant plus the same amount as an interest-free loan (payable after a year). A combination of subsidies, qualified multi lingual environmental educators, Chinese and other language educational brochures and DVDs, case studies and a website were developed.</p>	<p>administered (Deloitte 2016)</p>	<p>Sydney (assessed through evaluation). Cost effective opportunities for savings are likely still be available in Melbourne.</p>
Glass washers	<p>In 2009 Sydney Water commissioned research into the water usage of commercial dishwashers and glasswashers (NPC 2009). The study found that the food service sector is very water intensive with dishwashing and glasswashing being two of the highest water using processes. Whilst there was opportunity for water savings in dishwashers, a sector wide program wasn't warranted. Glasswashers on the other hand represented far greater savings potential and a combination of a rebate program and water and energy ratings scheme could provide significant savings in the sector. Testing indicated savings of 50 kL/a could be made buy replacing an old wash and dump unit with a more efficient recirculating type with over AUD 1,000 per annum savings in water, energy and detergent¹¹. Several efficient machines are now certified under the Smart Approved WaterMark scheme¹². The program received limited exposure in Sydney except in best practice guidelines¹³</p>	<p>In Melbourne 470 glasswasher products were administered under the Living Victoria Water Rebate Program (Deloitte 2016)</p>	<p>According to an internal review (Deloitte 2016) the glasswasher program in Melbourne was not considered cost effective. However, this review did not take into consideration the significant energy savings. Whilst the program has gained good take up between 2011 to 2015 under the Living Victoria Water Rebate Program, the program warrants further investigation into potential uptake and water, energy and detergent savings.</p>
Business water efficiency management plans/ water saving action plans	<p>Water efficient management plans (WEMP) or action plans were used to target high non-residential water users in many major cities across Australia during the drought. In Perth the WEMP program commenced in 2007 and targeted all businesses and government agencies using > 20 ML/a, requiring them to conduct a water management assessment and submit annual water efficiency management plans to the Water Corporation of WA on progress in reducing consumption. In SEQ the WEMP program targeted business customers using >10 ML/a together with nurseries, public swimming pools, buildings with cooling towers and areas using potable water to irrigate >500m². Under such plans customers were required to demonstrate savings of >25% or best practice. In Sydney several business programs were implemented. The business customer program ran from 1999 to 2013 and encompassed several programs including supporting large water-using business customers in the industrial, commercial and institutional sectors to achieve water and cost savings, by applying industry best practice and efficient management practices in day-to-day operations. Numerous best practice guides were developed as part of the program for sectors such as hotels, clubs and commercial laundries. The BizFix program ran from 2009 to 2011 assisting business</p>	<p>Perth, SEQ, Sydney and Melbourne</p>	<p>Melbourne utilities have been extremely active in non-residential water efficiency both during and after the drought with CWW being particularly active due to non-residential demand being such a large component of their water demand. There is potential to increase non-residential customer engagement through higher co-funding incentives if deemed cost effective and to provide greater assistance to regional areas including expansion of Water Compare to additional sectors more aligned to regional areas.</p>

¹¹ <http://www.hospitalitymagazine.com.au/food/news/winterhalter-is-first-to-get-water-saving-certific> (accessed 09.04.2017)

¹² <https://www.smartwatermark.org/products/?category=8&waterid=54> (accessed 09.04.2017)

¹³ https://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mdq1/~edisp/dd_045254.pdf (09.04.2017)

Types of programs	Description	Examples	Comment/Potential for Melbourne and regional Victoria
	<p>customers to retrofit water efficient fittings in bathrooms and kitchenettes. 50:50 co-funding was provided. The program assisted 327 business sites to identify water savings. (Turner et al 2017). In Melbourne during the drought all business and industrial customers were required to develop and submit to their water utility a “WaterMap” for each site using >10 ML/a. This Victorian Government program built on and extended the voluntary scheme introduced in 2003, in which Melbourne’s top 200 non-residential consumers developed water management plans with their water utility. The program has been voluntary since the end of the drought with CWW leading the WaterMAPs¹⁴ advisory program due to their high non-residential demand (40% of water supplied). They have also helped develop the NBweb program now called Water Compare, a benchmarking tool for various business sectors, with WSAA and many utilities across Australia.¹⁵</p>		
Schools programs	<p>Most regions across Australia have engaged in some form of water efficiency program for schools for many years. Such programs have ranged from developing education materials for children, assisting schools to find leaks through sub-metering and smart meters, assisting schools to upgrade inefficient appliances around the school premises and advising on irrigation equipment and practices. During audits of schools, significant water losses and wastage have been found, providing significant opportunities in this sector. The implementation processes used are broad, differing in each location and over time but typically include the utility working closely with government education departments and individual public and private schools. The Victorian Government have developed one of the most successful programs in Australia – the Schools Water Efficiency Program (SWEP)¹⁶. The program has been conducted in several stages after first being conceived in 2005/06 during the drought. Audits and retrofits were conducted from 2006 to 2010. After an initial voluntary phase the program became mandatory for public schools, leading to 1,739 participants of which over 1,600 were public. In 2012, the program progressed to the use of data logging and smart meter usage providing schools with the opportunity to access subsidized data loggers, web technology, specialist advice and curriculum materials for managing and monitoring water use and leaks (Walker et al. 2014, Walker et al. 2015). Approximately 900 Victorian schools (about a third of all schools) are now logging their water use on a continuous basis. SWEP is also monitoring electricity use for 125 schools. In 2016/17 a trial commenced on 15 (extended to 30) DELWP facility sites across Victoria monitoring water and electricity usage.</p>	<p>Most major urban centres including Sydney, Perth, Hunter, Canberra and Melbourne/ Victoria</p>	<p>Victoria is currently seen as a leader in this sector. Opportunities remain in further expanding the program across the state.</p>

¹⁴ <http://www.citywestwater.com.au/business/waterMAP.aspx> (accessed 09.04.2017)

¹⁵ <http://www.watercompare.com.au> (accessed 09.04.2017)

¹⁶ <http://www.myswep.com.au> (accessed 09.04.2017)

Types of programs	Description	Examples	Comment/Potential for Melbourne and regional Victoria
Public open space irrigation programs	Sydney Water assisted the Hawkesbury-Nepean River Recovery Program (HNRRP) funded by the Australian Government in the implementation of the Irrigation and Landscape Efficiency Project (ILEP) with the aim of improving water efficiency and turf and soil management for Greater Sydney’s open spaces (i.e. parks and sporting facilities). Savings were achieved by using improved technology and a range of land and site management practices for over 33 sites. The sites were owned by 23 partner organisations including councils, golf courses and sporting fields. ILEP concluded in September 2011. The knowledge gained was used developed the ‘Best practice guidelines for holistic open space turf management in Sydney’ ¹⁷ .	Sydney HNRRP 33 sites & Sydney Water development of best practice guidelines	In 2015 CWW developed Best Practice Guidelines for Functional Open Space under the Smart Water Fund and are currently involved with 21 other water utilities across Australia in developing a shared irrigation management tool for irrigation customers. Scope to work with individual sites to achieve potential savings.

¹⁷ https://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mdq1/~edisp/dd_045253.pdf (accessed 09.04.2017)

DEMAND MANAGEMENT OPPORTUNITIES

Scanning the programs in Tables 2.1 to 2.3 and in this section Table 3.1 it would appear many of the key end uses in the residential sector (i.e. showers, toilets, clothes washers) and a significant spectrum of the non-residential sectors (i.e. commercial, institutional and industrial) and sub-sectors (i.e. schools) have been covered by the water efficiency programs implemented in Melbourne (and Victoria more broadly) so far.

However, considering the participation rates and the population size of Melbourne and regional Victoria there still appears to be water conservation potential available. This could be in the form of programs that could be pushed harder in terms of uptake and programs that may not have been tried at all.

To actually determine which programs to take forward will need:

- detailed analysis on the water usage and conservation potential in each specific region by sector, sub-sector and where feasible end use;
- detailed market segmentation of customers to better understand how to develop more sophisticated tailored demand management programs going forward;
- collation of evaluation information on savings, implementation techniques and costs of existing programs implemented so far to maximise learning;
- cost effectiveness analysis of demand-side options compared to supply-side options and alternative options including consideration of whole of society costs and benefits to the multiple stakeholders involved; and
- analysis of short and long term needs in terms of availability and “value” of water including the consideration of regulations versus incentive programs and timing needs.

The analysis should include dialogue between the Melbourne retailers, regional demand management teams and experts from other jurisdictions in the form of local workshops and linkage to national communities of practice meetings chaired by WSAA to help share knowledge and ideas and discuss opportunities and barriers to a new generation of water efficiency programs. Extension of this research study to collate the latest international examples of demand management programs and set-up an associated shared database would be highly beneficial. In addition active formation, as a minimum, of a core state based foundation efficiency team, tools and networking together with foundation level investment in water efficiency is needed. This would assist in retaining and building on the vast knowledge gained during the drought ready for water scarcity/droughts as they emerge in the future and better integration of efficiency in “fourth generation”¹⁸ infrastructure.

This retention and sharing of knowledge would link to many of the steps and recommendations identified in the recently released WSAA paper “**Urban Water Futures: Trends and Potential Disruptions – Discussion Paper**” (Turner and White 2017) that identifies the need for a national conversation, pool of knowledge, identification of knowledge gaps and cross sectoral databases, models and tools to aid water efficiency and water planning and management during the current rapid transition phase now occurring in part due to the emergence of the digital era.

¹⁸ Fourth generation infrastructure – Using the principles of integrated resource planning and encompassing improved water efficiency, source control and more effective separation of pollutants and recovery of resources. Improved management and control of flows in the system requiring greater investment in treatment and reuse compared to investment in the transport of water, sewage and stormwater, and the recovery of energy, carbon and nutrients. (Turner and White 2017).

PRELIMINARY ASSESSMENT OF DEMAND MANAGEMENT OPPORTUNITIES

Even without the detailed analysis and dialogue recommended above a preliminary assessment of programs implemented in Australia during the drought versus those in Melbourne and Victoria more broadly suggest that some of the key programs that could be pushed, tried or adapted include for example:

Regulations

- **Standards/labelling and regulations and codes on buildings** – whilst Victorian utilities have been active in these areas - due to the population growth in the area there is significant scope to advocate minimum performance standards and greater regulation on end uses such as evaporative coolers and combination condenser washer-dryers and to refine building codes to help push mandatory use of water efficient appliances in new and refurbished buildings similar to BASIX in NSW. In addition, depending on the outcomes of evaluation it may be beneficial to adjust regulations and building codes to require greater use of efficient appliances and the use of source substitution at a household level (e.g. rainwater tanks plumbed to indoor end uses) in regional areas, ensuring adequate ongoing maintenance.

Residential measures

- **Residential home audits** – implemented extensively in many jurisdictions across Australia such as SEQ and Sydney but only to a limited extent in Melbourne and regional Victoria. Opportunity for targeted audits for specific sub-sectors. Also potential to tap into low Showerhead Swap uptake groups (i.e. tenanted, high income and elderly) and higher occupancy households which could link to the toilet replacement programs to increase savings and cost effectiveness.
- **Clothes washing machine rebates** – implemented extensively in many jurisdictions and to a lesser extent in Victoria where identified as the third highest end use per capita. Opportunity to capture savings through gradual turnover as part of current minimum performance standards or ramp up savings during times of drought through rebates.
- **Love Your Garden audits** - implemented by SWC. Significant opportunities available especially in regional areas where there are typically larger lot sizes/gardens and interest in gardening activities. Due to the lifting of long term restrictions in Victoria after the drought and recent re-establishment of the former Savewater website in collaboration with Smart Approved WaterMark in the form of a Smart Water Advice website specifically for Victoria¹⁹ there is significant opportunity to reduce water use in this end use.
- **Evaporative cooler maintenance programs** – despite evaporative coolers being of concern in terms of their water usage there have been no extensive programs conducted in Australia on managing this end use. This provides an opportunity for regional Victorian utilities to lead the way in developing a much needed cooler audit and maintenance program that could be replicated across regional Victoria (and metropolitan Melbourne to a lesser extent) and other jurisdictions such as South Australia, regional NSW, central NT and much of WA.

¹⁹ <https://www.smartwatermark.org/Victoria/> (accessed 28.02.17)

- **Rainwater tank programs** – implemented extensively in Victoria through both regulations (Victorian Star Building Standard) and rebate programs. Rainwater tanks are popular in Australian culture. However, there are concerns over the installation and performance of existing rainwater tanks already installed that is likely impacting on their performance and savings potential (Moglia et al, 2015). In addition, large numbers of tanks are not connected to indoor end uses therefore reducing their savings potential. Hence, there is an opportunity to implement a tank servicing and optimisation program to assist in improving savings in infrastructure already in properties and improving customer knowledge of the systems. This program could be linked to household home audit and/or garden programs to improve cost effectiveness.
- **The High Water Users and One to One water saving programs** - implemented in SEQ in 2007 and only to a limited extent in Melbourne. Opportunity for both metro Melbourne and regional areas to tap into high water using households and assist them to save water and energy through a previously well designed, tested and implemented program.

Non-residential

- **The waterless wok program** - first implemented in Sydney and then in Melbourne to a lesser extent. Opportunity for large savings in small sub-sector from a well-tested and proven program with a relatively short pay back period for customers.
- **Glasswasher program** – researched in Sydney towards the end of the drought and implemented at a small scale in Sydney and Melbourne. Opportunity for large water savings in small sub-sector from a reasonably well-tested and proven program with a relatively short pay back period for customers when water, energy and detergent savings are considered.
- **Public open space program** – implemented in Sydney for both Council public open space and numerous Council and private run sports facilities, this program provides an example of a well designed program with significant opportunity in Victoria.

NEW EXAMPLES

Since the end of the Millennium drought many water utilities in Australia have rolled back their water efficiency programs. However, in some areas research and smaller scale programs are still being investigated or implemented.

Examples of Australian and international programs that have emerged as a result of the research from this study and which could apply to the Melbourne and regional Victoria context include the following.

Sydney - Multi-unit dwellings (MUDs)/High-rise Waterfix

This program being investigated by Sydney Water Corporation (SWC) is a Waterfix program tailored to MUDs/strata properties. Most of the older MUDs in Sydney have a single meter for which the strata body receives the water bill. According to SWC research >85% of the water is used by individual units. Because the water using fixtures/appliances are privately owned the strata cannot legally fund their repair/replacement and due to the pooled water costs there is little incentive for individual unit owners to repair plumbing faults or improve water efficiency. To date, WaterFix has been implemented in 25% of single dwelling properties in Sydney, a significant participation rate, but in only 10% of MUDs.

To increase the MUDs uptake, SWC have introduced a dedicated ***Hi-rise WaterFix program***, which includes a benchmark (L/bedroom/day) as a proxy for water use/person. Those properties high on the benchmark (i.e. >500 L/bedroom/day) compared to those considered more efficient (<300 L/bedroom/day) are approached for a performance contract. The performance contract together with a voted resolution by the Strata Executive Committee (at an AGM) enables the community funds to pay for private improvements (i.e. WaterFix), which enables the costs of the WaterFix program to be recouped via the water bill in arrears by adding a WaterFix surcharge to subsequent water bills that is less than the value of saved water. This continues until the WaterFix debt is paid off. Strata bodies appear to be highly engaged with the program. Before the program the MUDs uptake of WaterFix was only 50/month. It is now reaching 500/month (pers. comm. Andre Boerema, SWC 2017).

Whilst MUDs in Victoria have been metered individually since the early 1990s there is still scope to implement a similar scheme for older MUDs and to consider using the funding mechanism outlined to incentivise MUD properties with a high proportion of tenancy/rental units.

Valencia, North of LA, US – Water SMART

Looking further afield internationally, the California drought has pushed water utilities to find new ways to approach their customers and help them reduce demand. An interesting example from one of the smaller progressive private utilities north of LA in the US, Valencia Water²⁰, with a customer base of just over 30,000, has used an in-house designed Water SMART Workshop program²¹, where SMART means “saving money and resources today” (but more recently has been modified to “together”). The online tool enables customers to receive a USD20 credit on their water bill by completing a 45-60 minute workshop. During the workshop customers learn about the drought, how to use their water bill to measure and verify their water efficiency, how to check for leaks and save water both indoors and outdoors. Once they finish the workshop they obtain a personalised Water SMART report that ranks their use from platinum to bronze, their level of efficiency and advises on programs, rebates and incentives available to them. An automated response is then generated 2 days, 2 weeks and 2 months after participation in the workshop as a reminder to implement their personalised water saving opportunities. Valencia Water originally held live/in-person workshops but after the on-line version was set up participation increased four-fold (pers comm. Matt Dickens, Valencia Water 2017).

Valencia, North of LA, US – Water SMART Allocation Program²²

Since 2009, Valencia Water has used a water allocation system, whereby individual residential customers are advised of their water usage allowance or quota based on an assumed 4 person household (i.e. calculation of an indoor water usage allowance) and other factors such as their outdoor watering area. Detailed analytics draw on multiple data sources to assess the outdoor component of each property and its daily water requirements. Households can apply for a variance to their allocation under certain circumstances (i.e. medical reasons, households with greater than 4 people etc.). In 2011, a tiered rates system was introduced to support the allocation system. In 2012, non-residential dedicated irrigation customers were added to the program.

Whilst the system relies on an automatic meter reading (AMR) system to provide monthly bills to customers that advises on their water usage it demonstrates a useful approach which considers both indoor and outdoor factors affecting demand. Customer bills describe each household as super efficient, efficient, inefficient, excessive or wasteful when compared against their specific allocation and charged according to the tiered system, where customers

²⁰ <http://www.valenciawater.com> (accessed 10.03.17)

²¹ <https://www.watersmartworkshop.com/Index.asp> (accessed 10.03.17)

²² <http://www.valenciawater.com/conservation/watersmart.asp> (accessed 10.03.17)

using less than their quota are charged at a lower rate and vice versa. The utility website provides advice, surveys, rebates, programs and landscape classes to assist customers to reduce demand. This framework has proved invaluable to the utility during the recent drought conditions, enabling them to intensify savings and dialogue with their customers about reducing demand.

Thames Water, London, UK – Clearwater Court bathroom trial²³

In June 2015, Thames Water started a water efficiency trial at their Clearwater Court head office in Reading with the aim of developing a best practice case study for business customers. The trial involved the replacement of five existing dual flush toilets with Propelair models using 1.5 L/flush (see Table 5.1 for details). In addition, existing taps were replaced with Cistermiser sensor taps set with 3.5 L/min flow rate of an 8 second duration and existing urinal sensors were replaced with Cistermiser sensors set a 0.5 L/flush, and 6 flushes per hour, seven days a week. To record consumption before and after the trial, water meters were installed on all hot and cold pipes. Overall, the bathroom refurbishment achieved water savings of 83% (11,636 L/person/day, equivalent to 606,000 L/annum). The Propelair toilets reduced water consumption by 80%, the sensor taps by 59%, and the urinal sensors by 90%. These savings were calculated to equate to an average of over 3,000 L/person over the course of a year. In addition, it was estimated that by replacing all of Clearwater Court's bathrooms using Propelair toilets, sensor taps and urinal sensors, total savings of 4.8 million L/annum could be achieved which would yield cost savings of £9,950 per annum. Following the success of the trial, Thames Water proceeded to retrofit Propelair toilets in all its bathrooms at Clearwater Court, and at Walnut Court (Thames Water's Revenue Contact Centre) and Spencer House (Thames Water's laboratory for conducting its sampling and testing).²⁴ These refurbishments led to a 50% reduction in overall building water consumption at Clearwater Court and a 66% reduction at Walnut Court.

Interestingly, the study noted that the previous bathroom fittings were already considered water efficient, so the refurbishment demonstrated a vast improvement upon pre-existing concepts of water efficiency.

Digital metering and behaviour change

The examples provided above are just a few of the efficiency program opportunities still available to Victorian water utilities. Some of these particular examples show how data gathering and manipulation and web-assisted tools can assist in targeting and engaging customers. Additional examples of web assisted tools are provided in Section 5 that rely on more advanced digital metering technology.

REGIONAL CONSIDERATIONS

As indicated in Section 2, whilst the main population (4.5 million) is centred in Melbourne, the remaining 1.5 million population is spread across the rest of Victoria and serviced by the 13 regional urban water corporations. The characteristics of these regional areas varies significantly from urban suburbs on the outskirts of Melbourne through to communities relying on mining, manufacturing, agriculture and tourism.

BW and CHW were used as examples of how regional Victorian water utilities have implemented efficiency programs so far and are good examples of the diverse characteristics of water using customers in the residential and non-residential sectors. However, the complexity and diversity of regional Victoria cannot be underestimated.

²³ <http://www.propelair.com/case/thames-water-head-office-clearwater-court/> (accessed 09.03.17)

²⁴ <https://www.thameswater.co.uk/sitecore/content/corporate/corporate/careers/working-for-us/our-key-sites> (accessed 17.03.17).

“Target Your Water Use” is a program established for regional Victoria. It is similar to Target 155 used in Melbourne but does not set specific targets for each area because it is recognised that there is significant variation of water use across Victoria, especially in the hotter northern region. This recognition of variation in water usage demonstrates the need to tailor demand management programs for regional areas. As previously indicated some areas rely more or less on industries such as mining, manufacturing, agriculture and tourism and thus need to specifically target such sectors in terms of demand management programs.

In terms of residential demand, water usage varies across the state due to factors such as:

- climate which differs from southern coastal areas to hotter northern inland areas;
- type and age of property where regional areas have a higher proportion of separate detached dwellings compared to Melbourne with this point of difference likely to increase further with Melbourne urban densification predominantly relying on an increase in multi-residential flats/MUDs;
- lot size and associated size of garden with regional areas typically having larger lot sizes and gardens compared with Melbourne;
- occupancy ratio and household demographics;
- socio demographics;
- prevalence of animal husbandry;
- connection to rainwater and potentially bore water;
- reliance on evaporative air coolers (EACs);
- prevalence of tourism/holiday homes affecting resident population; and
- population growth and rate of urban densification

to name but a few.

For example, the use of EACs in regional areas of the state, especially to the north, is more common and there is anecdotal evidence that the use of EACs in such areas may be on the increase in new developments because they are relatively cheap to install (pers com Brendon Clarke, CHW 2017). See Section 5 for more details on EACs.

EACs can use significant volumes of water, especially if they are not well maintained (Murta et al, 2012). Hence efficiency programs need to be carefully tailored to the specific regional context which is why careful end use and sector based analysis is required to feed into both the demand forecasting and options analysis for each regional area. Many regions will of course share similarities in terms of end uses (toilets, showers, clothes washers, dishwashers) but there are likely to be more unusual characteristics that need to be considered differently (e.g. prevalence of EACs, holiday homes on the coast or in the mountains, areas with a high proportion of low-income households or renters, army bases for which individuals may or may not pay household water bills).

Looking at both BW and CHW, both regional utilities have been active in water efficiency programs over the last decade. However, similar to the Melbourne retailers there is still opportunity to increase participation levels in programs above those currently attained. As indicated earlier programs that regional areas could therefore focus on include for example:

- **Residential home audits** – where in regional areas a suit of complementary programs could be linked to lower overall program costs (e.g. toilet rebates and evaporative coolers and rainwater tank maintenance programs as indicated below).
- **Clothes washing machine rebates** – likely more cost effective in regional areas with higher household occupancy rates and larger families.

- **Love your garden audits** – particularly important in regional areas due to the larger gardens causing higher outdoor and seasonal water demand and generally greater interest in outdoor gardening in regional areas.
- **Evaporative cooler maintenance programs** – potential for education and maintenance programs linked to residential home audits (as indicated above to reduce costs) as important to many regional areas but particularly northern inland areas where such coolers are more prevalent.
- **Rainwater tank savings optimisation programs** – where in regional areas rainwater tanks are seen as symbolic of saving water, still popular and an important way to engage the community who want to “do the right thing” (pers. comm. Brendon Clarke, CHW 2017). Education and servicing of existing tanks would be important to regional areas where well over half of houses already have rainwater tanks which could potentially be used more efficiently including connection to indoor end uses.
- **The High Water Users and One to One water saving programs** – significant potential to adapt such programs to regional areas that often have wide variation in use with a segment of very high residential water users that could be assisted to save water.

Other programs focusing on the residential sector in the regional areas could involve general awareness raising of efficiency, including leakage and potentially maintenance advice programs for older style homes.

From the previous list programs less relevant would be the non-residential Waterless Woks and Glasswasher programs, although useful as smaller niche programs. However, Public Open Space programs would likely reap valuable savings. Residential and non-residential programs focusing on specific sectors such as holiday homes and hotels would also likely provide major savings although again these would need to be assessed for each urban centre in terms of relevance. In addition, programs, as conducted during the drought, focussing on working with top non-residential business customers in each regional centre and where feasible incentivising through rebates on audits is again likely to reap on going savings. Tools that can assist will be those such as Water Compare²⁵, although this benchmarking tool may need to be gradually augmented with additional non-residential customer types of more relevance to regional areas.

Another regional factor that needs to be taken into consideration is the “community spirit” that can be tapped into and harnessed in regional areas compared to the sometimes more difficult anonymous characteristics of larger cities (pers. comm. Brendon Clarke, CHW 2017). Many of the original demand management programs conducted in Australia demonstrated high participation rates, for example Kalgoorlie Boulder, in which well over half the households took up available initiatives (White 1998). With the emergence of more sophisticated programs that tap into web based tools and market segmentation there is more opportunity to trial some of these more innovative programs in regional areas.

A program in the UK that is targeting community spirit is the Southern Water “Water Efficiency Grant Scheme”²⁶, where, if community groups save water the water utility provides funds for community infrastructure and projects. Whilst currently a relatively small program the concept is interesting for regional utilities that service several towns and may find specific constraints in one or two, as the approach could provide interesting opportunities. Further extension of the concept could involve gamification were several community groups or even whole communities could sign up to a competition to save water and pit against each other to win tiered prizes.

²⁵ <http://www.watercompare.com.au/About-WaterCompare/Overview.aspx> (accessed 12.04.17)

²⁶ <https://www.southernwater.co.uk/water-efficiency-grant-scheme> (accessed 17.03.17).

A key issue for regional areas will be the need to retain and share knowledge, expertise and resources. Hence as discussed previously the need to form, as a minimum, a core state based foundation efficiency team, tools and network together with foundation level investment in water efficiency that the regional areas can use.

OTHER CONSIDERATIONS

A key consideration in the future will be how to develop programs that tap into customer sectors with significant conservation potential still available (e.g. large families), identify programs that provide multiple benefits (e.g. reduction in both water and energy usage that maximise incentives for participation) and to design programs that are cost effective both during 'normal' and 'drought conditions' and that can be dialled up or down by utilities/government as needed, refer to Section 6 for more on this.

With the evolution of digital water meters and the emergence of the digital era there will now also be significant increased opportunities for customer interface and behaviour change programs. These along with emerging technology advances on the horizon are considered in the following Sections. Such advances are likely to significantly change the way we collate and analyse data on customers and our ability to improve water efficiency programs and customer engagement.

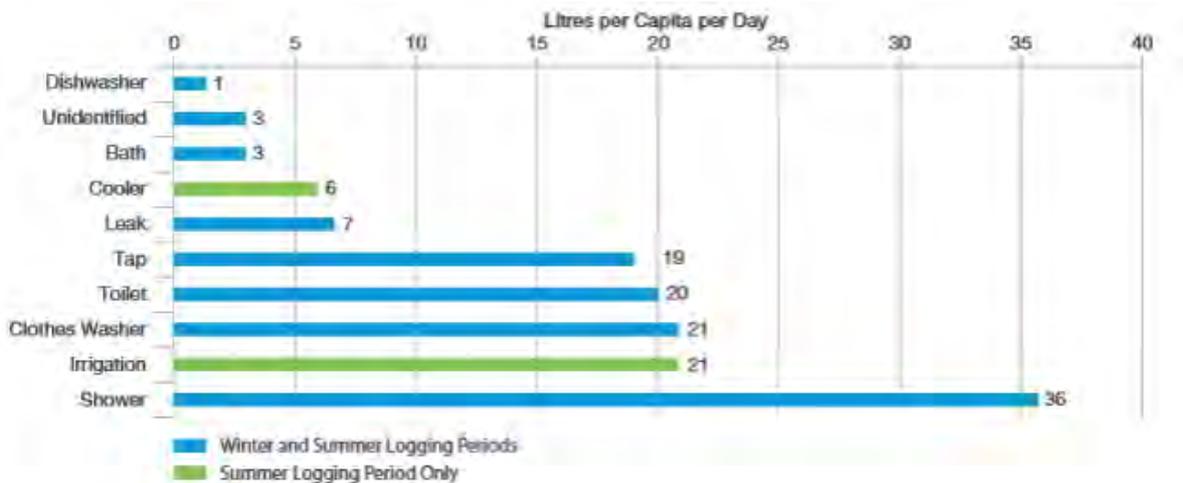
4 APPLIANCE EFFICIENCY TRENDS & EMERGING OPPORTUNITIES

This section looks at how appliance efficiency trends have changed in recent years in Australia more broadly.

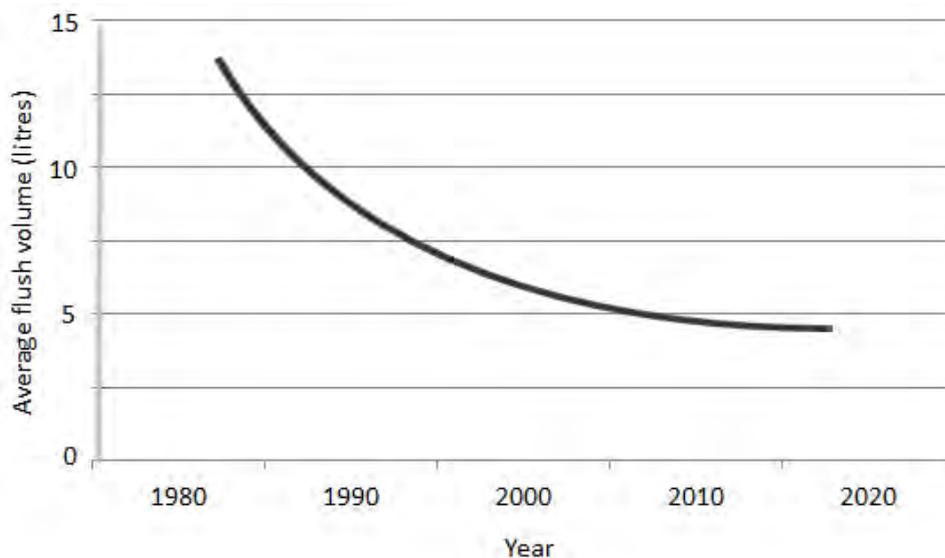
APPLIANCE EFFICIENCY TRENDS

A comprehensive list of end uses from the Melbourne based study by Gan and Redhead (2013), Figure 4.1, assists in reflection of the magnitude of individual end uses and past and potential future trends. Surprisingly, even after the extensive retailer showerhead exchange program, which introduced over 450,000 3-star water efficient showerheads into the Melbourne region, shower usage still dominates residential per capita daily demand.

Figure 4.1 – Daily per capita end uses for combined summer and winter periods (source – Gan and Redhead, 2013)



For almost all water-using appliances, a downward trend in demand per appliance (i.e. litres per wash for dishwashers and clothes washers) has already occurred across Australia and is expected to continue. Although, in many cases the reduction is likely to taper off, as illustrated in Figure 4.2 for toilets, as significant gains have already been achieved. To achieve a step change in toilet water usage for example the use of non-conventional systems (i.e. vacuum systems) would be necessary as further discussed in Section 6.

Figure 4.2 Average toilet flush volumes

In end uses such as dishwashers and clothes washers, significant efficiency gains have been made in recent years. Figure 4.3 shows the cumulative distribution function of products registered within the national WELS database for (a) dishwashers and (b) clothes washers over recent years. For dishwashers the trend has been towards greater efficiency across the entire range of models. In 2006, less than 25% of models registered used less than 14 litres/wash. By 2013 around 90% of models did. For clothes washers, shown in Figure 4.3 (b), a different trend can be seen. Where once clothes washing machines typically used 140 litres/wash, 5-star machines are now available using for example 50 litres/wash. However, this shift in efficiency has predominantly been in the mid to high-end consumption end. For example, in 2006, 60% of clothes washing machines registered on the market used 100 litres/wash or less. Less than 10 years later, by 2013, this had increased to 90%. However, the share of machines available using 60 litres/wash or less had hardly changed. The increased shift in the availability of more efficient machines, especially front loaders, has been observed in sales data with a marked increase in 4.5 star front loading machines since 2007 (Fyfe et al, 2015). The most efficient machines are currently WELS 5 star. There are minimum water efficiency standards for clothes washers (i.e. models cannot be supplied that are less than 3 stars (>5 kg machine) or less than 2.5 stars (<5kg) capacity)²⁷.

Various leading manufacturers of 5-star washing machines were contacted as part of this research to investigate when and if 5.5 and 6-star washing machines could potentially be expected, however, the representatives contacted were unable to provide this information. Reflection on these conversations did nevertheless serve as an important reminder that there are a variety of factors that shape the purchasing decision of consumers beyond water efficiency ratings alone, including convenience, capacity, size, speed, range of functions and energy efficiency. The development of new clothes washers will therefore be shaped by consumer needs and expectations.

To further increase the range and penetration of the more efficient clothes washers stronger regulations will be required as discussed in Section 6.

²⁷ <http://www.waterrating.gov.au/about-wels> (accessed: 08.03.17)

Figure 4.3 Cumulative distribution function for (a) dishwashers and (b) clothes washers

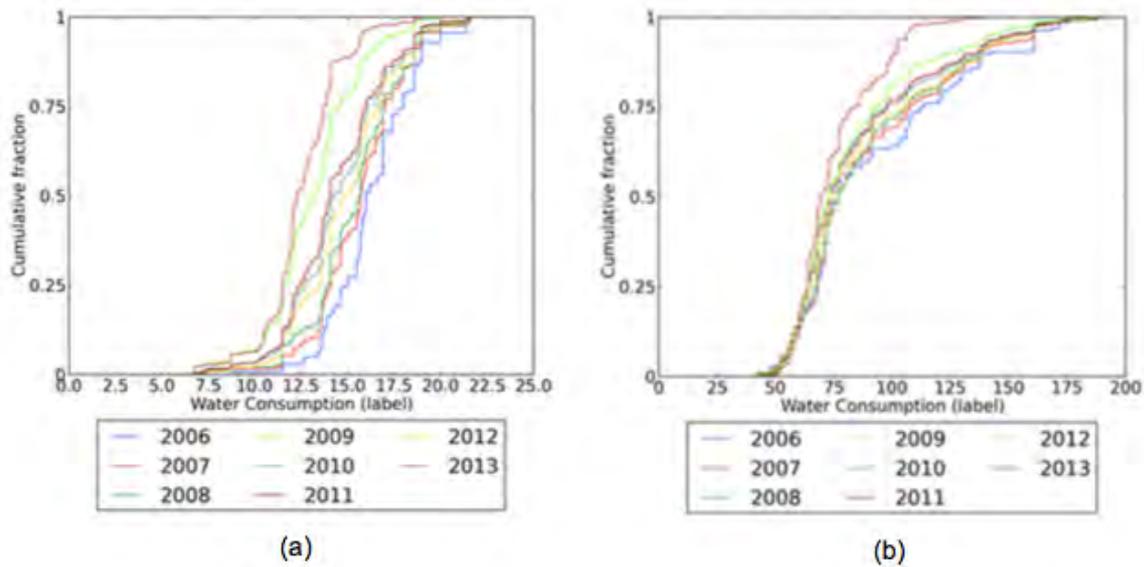


Table 4.1 provides an overview of our assessment of expected changes in water demand at the end use level from the highest to lowest end use reported in Gan and Redhead (2013). New technologies mentioned are discussed further in Section 5.

Table 4.1 Analysis of end use water demand per unit

End use	Our assessment	Water demand
Shower	A general increase in water efficiency per unit is expected due to improvements in devices but this is likely to stop at the recently approved WELS 4-star (6.5 L/min) point until new technology is tested and approved. Innovative more efficient showering systems are coming to the market internationally including recycling / purification systems and atomizer systems.	
Irrigation	Overall demand is likely to fall due to urban form changes and a shift towards MUDs and higher urban density as well as automated systems. This is likely to reduce demand on a per property basis and drive improved water efficiency.	
Clothes washer	A general increase in water efficiency per unit is expected. Currently, the highest washer rating registered in Australia is WELS 5 star, with water use around 7 L/kg (i.e. 50 L/wash for a 7kg unit). Low water use bead technology and waterless clothes washers are on the horizon.	
(combined condenser washer-dryer)	Overall demand may grow for this end use with the shift to MUDs due to increased urban density. The dryer component typically uses water. This is currently not rated but is registered in the WELS database, which shows significant variation in water usage between machines ranging from 1 to 148 L per load for the dryer component. ²⁸	
Toilet	A general increase in water efficiency is expected per unit. The increased availability of alternatives to conventional toilets (e.g. composting toilets / waterless toilets / vacuum toilets) is noted together with a drive by their manufacturers to address aesthetics and sound to overcome cultural barriers to uptake.	

²⁸ <http://www.waterrating.gov.au/> (accessed 07.03.17).

End use	Our assessment	Water demand
(bidet toilet)	The market for bidet toilets / bidet toilet seats is currently low but may grow with cultural shifts in Australia. Current water usage per unit of such devices is relatively low but varies significantly from 0.6 – 1.2 L/min while dependant on duration of each usage (typically 1-2 mins). ²⁹ Whilst only a relatively small end use in terms of potential water use it has been covered here to demonstrate an emerging end use.	
Tap	Improvements in efficiency per unit are expected predominantly through increased usage of flow regulators and aerators. Smart taps that target more informed user behaviours are also on the horizon with the potential to contribute towards improved water efficiency (see Section 5).	
Leak	Continued reductions in water loss are expected through improvements in leak detection via digital metering as well as pressure management.	
Cooler	The outlook for Evaporative air coolers (EACs) is unclear. New units are becoming more efficient but usage is still strongly linked to behavioural practices and maintenance of the equipment. Over recent years there has been a gradual downward trend in such appliances because of the increase in reverse cycle systems (Murta et al 2012), although due to their low capital and operating cost they are still popular. New indirect systems are coming to market to stem the decline and expand the area of operation.	
Bath	Baths and particularly spas are generally going out of fashion and usage, especially with the increases in urban densification and smaller MUDs.	
Dishwasher	These are generally already efficient but likely to increase further in water efficiency per unit.	

Most end use appliances will likely increase in water efficiency. These along with advancements in behaviour interfaces and digital meters are discussed in Section 5. However, three water-using appliances identified above that may lead to increases in consumption are bidet toilets, combined condenser washer-dryers and EACs. These are discussed in turn below.

Bidet toilets

A growing market for bidet toilets and bidet seats (which can be fitted to conventional toilets) may lead to increased water consumption associated with toilet usage. There are various trends which could contribute towards increased uptake in Australia. At the same time, there are cultural barriers to overcome if bidet toilets and seats are to achieve more significant inroads into the Australian market. As indicated in Table 4.1 the water usage per unit is relatively low compared to other end uses and as such even if significant penetration of this end use was to eventuate it would be amongst the lowest in terms of daily per capita demand. Nonetheless it helps demonstrate an emerging disruptive technology that requires further observation.

²⁹ <http://www.manybidets.com/bidet-seat-comparison-chart/> (accessed 07.03.17).

Toto, Japan's market leader in sanitary ware, has been reporting rapid growth in sales of its 'washlet' bidet seat – see Figure 4.4 – in overseas markets including a 2.5-fold increase between 2012-2016 (Toto 2016). While traditionally more popular in Europe, Asia and the Middle East, the bidet toilet may emerge as an increasingly popular appliance in Australia over the coming years.

Kohler, the US's biggest manufacturer of bidet toilets suggests the availability of the latest 'intelligent toilets' which combine 'user experience and superior hygiene' could lead Australia to follow the overseas trend in demand for bidet toilets (Kohler 2016). Apart from reported growth in uptake from the elderly and those with mobility restrictions³⁰, companies such as Toto are targeting the high end of the market including condominiums as well as hotels as a luxury item. Australia's multi-culturalism and the influx of tourists including those from the Middle East and South East Asia are suggested to carry expectations for such products (Kohler 2016), while one bidet retailer we interviewed suggested bidet toilets in homes are also increasingly an expectation of the 'well-travelled'.

In order for bidet suppliers to achieve more significant increases in uptake in Australia, a cultural shift is likely to be required to more broadly change mind sets towards bidets. According to Kawahara and Narikawa (2015), an important contributor to Toto's success in Japan is attributed to its efforts in promotion, including the use of advertising and publicity to counter consumers' tendency to reject new products.

Returning to bidet toilets' water usage, one retailer (pers. comm, retailer 2017) that we interviewed advised that the variety in flow rates does not necessarily reflect water efficiency, since the bidets with higher flow rates tend to offer a superior clean in a shorter time. Therefore, the impact on water demand of any increase in uptake in bidet toilets and bidet seats will, as with other water using appliances, be shaped by both patterns of behaviour and technical specifications. One supplier also advised that bidets and their usage is a topic most people feel uncomfortable talking about. These insights suggest the impact of bidets on water demand may be less well known than with other appliances and may be an area requiring further investigation to understand the potential impacts within the Australian market.



Figure 4.4 Toto Washlet electronic toilet seat with an integrated water-cleansing system for personal hygiene)

³⁰ Interestingly, the prototype of the Toto Washlet was originally invented in the US as 'medical equipment', which Toto later remodelled as a consumer product and created its own market for in Japan, where bidet seats are now considered indispensable by most Japanese (Kawahara and Narikawa 2015).

Combined condenser washer-dryers

There may also be growth in overall water demand through continued uptake of combined condenser washer-dryers, which require additional consumption of water during the drying cycle. Traditionally seen more in Europe, such appliances are likely to grow in demand in Australia as urban density intensifies and the proportion of MUDs with reduced floor space increases. Our interview with a leading manufacturer/supplier of combined condenser washer-dryers in Australia confirmed that the demand for these appliances comes from consumers with space restrictions, primarily apartments and one-bedroom homes. However, if space is not an issue, consumers will still almost always prefer to install a separate dedicated washer and dedicated dryer, on the grounds that together they usually cost about the same and they generally have a larger capacity for both washing and drying (such as 8 kg loads instead of 5.5 kg loads) (pers. comm, manufacturer 2017).

Other evidence from interviews (pers. comm, advisor 2017) suggests that when using combination condenser washer-dryers there is a variation in the capacity of the washing machine versus the dryer component, with the dryer component typically having a capacity of around 2/3rd of the washing component. Among current WELS registered machines the capacity of the dryer component is between 45-80% of the capacity of the washing component. Figure 4.6a shows washing and drying capacity loads for combined condenser washer-dryers in the WELS database. This leads to further water efficiency issues such as the risk that full loads of washing are not conducted to accommodate the smaller drying component of the washer-dryer process and therefore the washing component of the combination machines is less water efficient in practice than that labelled (pers. comm, advisor 2017).

The water and energy consumption for the wash cycles is covered by the WELS rating scheme, however, the water consumption of the drying cycle has until recently not been reported except when applying for energy registration and is not covered by regulation (Szann 2008). According to Fyfe et al (2015) in 2015 combination washer-dryers that use water in the drying process make up around 10% of registered products. The WELS database does not provide details on actual sales for this end use.

From the current WELS database there appears to be significant variation in water usage of the drying component of combination condenser washer-dryers ranging from as little as 1 to as high as 148 L per load.³¹ This variation is shown in Figure 4.6b which plots washer consumption per wash load against dryer water consumption per drying load using data from the WELS database for currently registered combined washer-dryers. This variation in water usage is significant.

There are signs that this water using end use is likely to increase with growing urban densification and increase in smaller MUDs, that the lower volume of the drying component is leading to less water efficient behaviour for the washing component of such machines and that the water usage of the drying component is highly variable. Hence this end use warrants further investigation and consideration of how the water using elements can be effectively controlled by regulation.

³¹ <http://www.waterrating.gov.au/> (accessed 07.03.17).



Figure 4.5 LG combination condenser washer-dryer

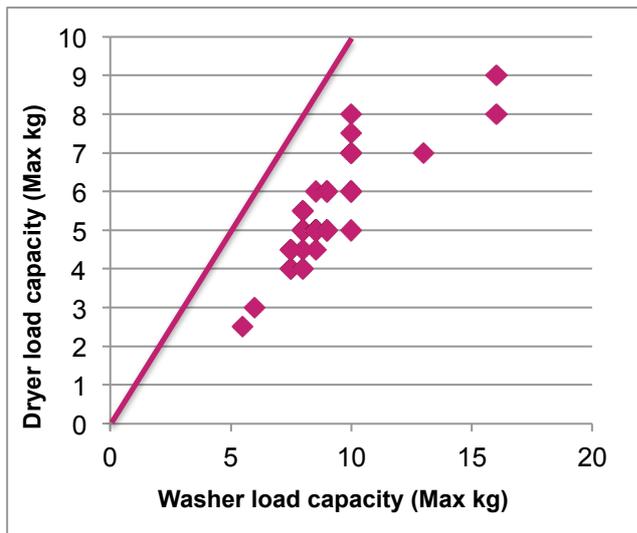
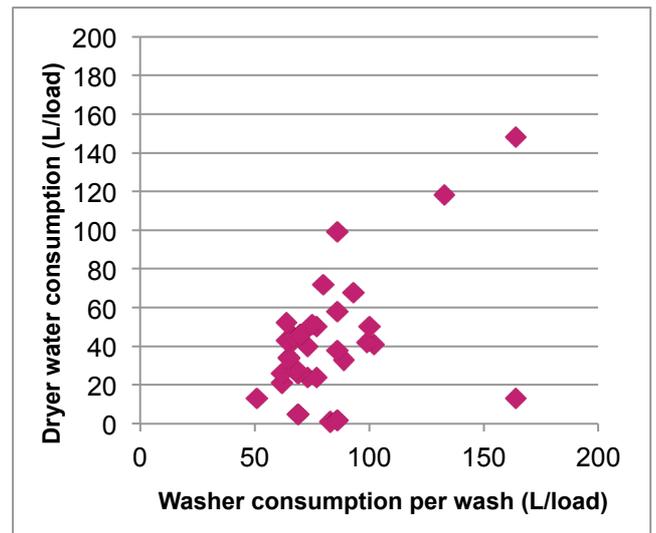


Figure 4.6a – Washing and drying capacity loads for combined washer-dryers.



Coolers

In Australia evaporative air coolers (EACs) are used in both the residential and commercial sectors. They are used extensively in drier coastal and inland regions of Australia where they work best due to lower humidity. EACs use a combination of water and electricity. Despite being so prevalent in major cities such as Adelaide and Perth and to a lesser extent Melbourne and Sydney, there is still a limited on the ground understanding of their water and energy usage, especially in the non-residential sector (Murta et al. 2012). In addition, due to the Millennium drought breaking there has been little focus on this end use in recent years since the release of the AIRAH best practice guides³² (pers. comm Phil Wilkinson, AIRAH).

There is evidence that large amounts of water are being used in EACs and there is scope to reduce this. A study conducted in Victoria indicated that 2.5 GL (17% of EAC residential water usage) could be saved each year through improved efficiency (AIRAH 2010a; Wilkinson 2011). Another study for the non-residential sector in Victoria estimated that 1.8 GL (35% of non-residential EAC water usage) could be saved each year through best practice operation (AIRAH 2010b; Wilkinson 2011). There are significant opportunities for improvements in the technical and behavioural practices of such units that could significantly reduce both water and energy demand (Murta et al. 2012).

According to Gan and Redhead (2013) EACs are one of the lower per capita end uses (refer to Fig 4.1) in Melbourne, predominantly used in the summer months. Of the sample used for the end use study 28% used an EAC during the summer period analysed. Usage varied but on average across the retailers was 4 days a week, for 4 hours a day, using 17 L/hr of operation. See Table 4.2 below.

Table 4.2 – Evaporative air cooler usage in Melbourne (Source Gan and Redhead 2013)

Evaporative Coolers	CWW	SEW	YVW	MEL
Average frequency of use (days per week)	3.4	4.4	4.2	4.1
Average duration (hours per day)	1.1	3.4	5.1	3.8
Average volume (L per operational hour)	25.3	13.4	18.1	17.1

However, water usage varies significantly depending on the unit used (continuous bleed or dump) and how it is set and maintained. In research conducted in Alice Springs some EAC bleed off rates were set as high as 30 L/hr, whilst manufacturers at the time, recommended lower levels, e.g. 10 L/hr, indicating that operational usage may potentially be far in excess of theoretical (Turner et al. 2003). More modern units have moved away from continuous bleed and towards more efficient dumping systems with the use of more sophisticated total dissolved solids (TDS) sensors, which dump a proportion of the water used to reduce TDS in the system (pers. comm. manufacturer).

³² http://www.airah.org.au/Content_Files/TechnicalPublications/AIRAH_residential_evap_cooling_bpg.pdf (accessed 17.03.17)

http://www.airah.org.au/Content_Files/TechnicalPublications/Non-residential_evaporative_air_cooling_systems-BPG.pdf (accessed 17.03.17)

Discussions with AIRAH, as part of this current study, indicate that little if any research has been conducted in recent years for the residential or non-residential sector since the end of the drought (pers. comm. Phil Wilkinson, AIHRA) even though in some areas EACs remain a relatively high water using end use. In recent years there has been a surge in the installation of split reverse cycle systems that do not use water but use energy and significantly contribute to peak energy usage. Hence the EAC market has been in decline. However, due to the low capital and operating costs of EACs (typically \$1/day for EAC versus \$4 - 5/day for refrigerative systems to cool a home) EACs remain popular (pers. comm. manufacturer).

In more regional areas such as Wagga Wagga in NSW EACs appear to remain prominent including in new homes where it has been estimated that 90% of new homes are installing EACs (Murta et al. 2012). This prominence and potential growth is also the case in more northern areas of Victoria where in new houses the relatively low cost of EACs appears to remain attractive (pers. comm. Brendon Clarke, CHW). More detailed assessment of the current stock, potential growth and actual usage of EACs in regional areas of Victoria is warranted.

From discussion with a leading manufacturer, the usage of EACs varies significantly across Victoria, with Melbourne at around 30%, coastal areas such as Portland very low, Ballarat similar or slightly lower than Melbourne but in the northern areas of Shepparton closer to 50% of houses. Going forward with electricity prices increasing and climate change EACs will remain in the market and potentially even gain popularity (pers. comm. manufacturer).

In addition further extension of evaporative cooling is being observed in both the residential and non-residential sectors (i.e. in hospitals and large blocks of residential flats evaporative cooling is being used to pre-cool chillers). With the growth in flats in Melbourne this application of evaporative cooling could therefore grow (pers. comm. manufacturer).

Further, research in indirect EACs has also shown the potential for growth and the opportunity to increase the range of geographical areas in Australia where EACs can function optimally, creating the opportunity to reduce both water and energy demand. Whilst products such as the Seeley Climate Wizard have won awards for such units (Seeley), further research is needed to demonstrate the extent of the opportunity for their use in the residential and non-residential sectors, as the results of field trials have been mixed, in part due to the operation of the technology (SSE 2012; SWC 2012; WCEC, 2015b). Whilst indirect systems have been in the market for over a decade in the non-residential sector, the Seeley Residential Climate Wizard Indirect EACs have just come to the end of the field testing stage, with units expected to be launched in 2017 (pers. comm. Seeley).

5 EFFICIENCY OPPORTUNITIES ON THE HORIZON

This section summarises some of the latest national and international developments in terms of innovative water using appliances and related technologies including monitoring systems and customer behaviour interfaces, providing a broad overview of some of the emerging efficiency opportunities that could shape the demand for water both in the near future and the next few decades to come.

EFFICIENT APPLIANCES ON THE HORIZON

A national and international scan of the latest water using appliances and prototypes that are coming to market or are under development shows that continuous innovation is currently underway, with new and emerging opportunities for household water efficiency across all end uses of water.

Table 5.1 presents some of the most interesting new and emerging appliances and fixtures. These products have either recently entered the Australian market, or are currently available in specific overseas markets where development has been led (e.g. typically in the US or northern Europe). Examples of some of the latest ideas that are still in either a conceptual or development stage have also been included in order to provide insight into some of the opportunities that could to some extent shape the design of water efficient appliances of the future. Details are provided on what the devices are/their basic design principles, water-savings (as advertised by the manufacturer/retailer), availability in terms of markets, and indicative costs of purchase (and delivery if applicable) where possible.

Further detailed investigation will be required for any of the devices to be taken further in terms of their actual water and energy usage as some of the high efficiency claims of overseas products are likely to be based on a higher water usage and/or flow rate compared to those now used in Australia. All cost information has been converted into Australian dollars if quoted in other currencies. Many of the products listed currently have relatively high costs (i.e. some of the recycling showers). However, many of these products could come down in price if a larger market was available or they moved away from the early adoption phase.

Increasingly, new innovations such as those in Table 5.1 will begin to challenge the water industry's and consumers' existing concepts of water efficiency for appliances.

The products provide a preliminary list for Victorian utilities to turn to and explore in terms of products they may recommend to their customers or test and pilot as part of future efficiency programs.

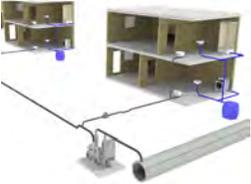
Table 5.1 Summary of new and emerging end use appliances and fixtures

End use/summary	Details	Examples	References
Showers			
A range of innovative water-efficient showers are hitting the market that potentially offer significant water-savings as well as associated energy savings.	<p>Recycling / purification systems that filter, purify and recycle water during shower usage.</p> <ul style="list-style-type: none"> • Claims of up to 90% water savings. • Some might be available in Australia later in 2017. • Currently sold to C&I environments, but also targeting residential customers. • Cost: \$3,600 - \$7,525 (with claims to an overall positive ROI). 	<ul style="list-style-type: none"> • Orbital systems • Hamwells e-shower 	<p>https://orbital-systems.com</p> <p>https://www.hamwells.com/e-shower</p>
	<p>Conventional short shower (2 mins) followed by the use of a recycling system with filtering and reheating.</p> <ul style="list-style-type: none"> • Claims of ~80% water savings. Consumes 9L/min in step 1 and a maximum of 4L in step 2. • Claims a cost differential of less than 50c per day if amortised over the duration of the average home loan. 	<ul style="list-style-type: none"> • Quench shower 	<p>http://quenchshowers.com</p>
	<p>Atomiser type showers</p> <ul style="list-style-type: none"> • Atomises water into millions of tiny droplets. • Claims savings of 70% (assuming <3 L/min in regular mode) • Some include multiple outlets. • Two-year payback. • Available for pre-order with shipping later in 2017. • Cost: \$530 plus \$130 for shipping. 	<ul style="list-style-type: none"> • Nebia 	<p>https://nebia.com</p>
Other relatively low cost water-efficient shower products are readily available via retailers and online shopping including: shower shorteners, timers, displays and	<p>LED shower head</p> <ul style="list-style-type: none"> • LEDs light up the shower head and spray with different colours according to the amount of water used 	<ul style="list-style-type: none"> • HYDRAO First 	<p>https://www.hydrao.fr/en/hydrao-first/</p>

End use/summary	Details	Examples	References
alarms which target reducing shower length; and aerators that focus on reducing flow rate.	<ul style="list-style-type: none"> • LEDs are powered by the water flow, so no energy is required. • 9 L/min flow rate • Comes with the HYDRA Smart Shower app used to set the four desired thresholds (volumes and colours); and to visualise consumption, costs and savings. • Cost: \$112 • Currently available for shipping within Europe. 		
	<p>Shower shorteners</p> <ul style="list-style-type: none"> • Rely on pre-selection of a desired shower duration e.g. between 3-11 mins, with countdown displays and flow restriction after the set time. • \$99-\$149 	<ul style="list-style-type: none"> • Davinda • Shower Manager 	<p>http://davinda.com.au/index.php/shower-shortener/ http://www.showermanager.com/conservation-store/shower-timer-home.shtml</p>
	<p>Shower timers / displays / alarms</p> <ul style="list-style-type: none"> • Devices which can be used to pre-set a desired shower duration with digital displays and/or audio/visual (LED) alarms. • Cost: \$11 (available via Ebay stores) • Some models also come with a radio or work as a speaker. 	<ul style="list-style-type: none"> • Ecosavers • Efergy 	<p>http://www.ecosavers.nl/?page_id=146 http://efergy.com/eu/products/showertime</p>
	<p>Aerator type shower devices</p> <ul style="list-style-type: none"> • Can be fitted to an existing conventional shower head to draw air into the water flow and make droplets hollow • Claims water-savings of up to 50%. • Available via retailers in ANZ e.g. Bunnings Warehouse. • RRP: \$28 	<ul style="list-style-type: none"> • Felton Oxijet 	<p>http://www.felton.co.nz/oxijet</p>

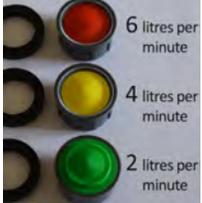
End use/summary	Details	Examples	References
<p>Irrigation</p> <p>Water-efficient outdoor devices include digital tap flow meters and tap timers, which target more efficient behavioural usage, and more advance smart irrigation controllers to programmatically optimise watering. The latest irrigation controllers particularly include digital user interfaces for monitoring and control.</p>	<p>Smart irrigation controllers:</p> <ul style="list-style-type: none"> • Can track evapo-transpiration (temperature, wind, solar radiation and humidity) to fine-tune irrigation and provide visibility and control via a web interface or smartphone app. • Reported water-savings of between 16-59% with WeatherTrak and 50% with Banyan and Hunter Hydrawise. • Mostly commercial applications. 	<ul style="list-style-type: none"> • WeatherTRAK • Banyan Water • Hunter Hydrawise 	<p>https://www.hydropoint.com/products-and-services/smart-irrigation/</p> <p>http://www.banyanwater.com/smart-irrigation-controller/</p> <p>https://www.hydrawise.com/</p>
	<p>Digital tap flow meters (outdoor usage)</p> <ul style="list-style-type: none"> • Measure water usage – both the volume per watering session and accumulated usage. • Cost: \$24 	<ul style="list-style-type: none"> • Hoselink 	<p>https://www.hoselink.com.au/buy/tap-flow-meter-gauge/5815</p>
	<p>Digital tap timers (outdoors usage)</p> <ul style="list-style-type: none"> • Enable programing of watering schedules e.g. with watering up to 4 times per day; with individual day selections; and with watering duration selections from 1 min and longer. • Cost: from \$60 (Ebay store price) 	<ul style="list-style-type: none"> • Holman Industries 	<p>https://www.holmanindustries.com.au/products/automatic-digital-tap-timer-co1605/</p>
	<p>Labelling scheme:</p> <ul style="list-style-type: none"> • Smart Approved WaterMark provides details on a suite of garden mulches and soil wetting agents; irrigation systems and sensors; grey water systems; rain water harvesting systems; pool covers; waterless car wash products; plumbing services etc. 	<ul style="list-style-type: none"> • Smart Approved WaterMark 	<p>https://www.smartwatermark.org/</p>

End use/summary	Details	Examples	References
Clothes washers			
There are now several highly efficient clothes washers available with 5-star WELs ratings. Some integrate intelligent sensors to weigh the load and adjust water consumption accordingly.	<p>Top conventional washers</p> <ul style="list-style-type: none"> • SensiSave technology adjusts the water level and time of wash to match the load • 5-star WELs and 5-star energy ratings • \$1699-\$1899 • 50 L / wash based on 7kg capacity. • Available via retailers. 	<ul style="list-style-type: none"> • ASKO W6564 SensiSave Washer • ASKO W6884 ECO Washer 	<p>http://www.asko.com.au/products/laundry-appliances/washing-machines/front-loading/w6564</p> <p>http://www.asko.com.au/products/laundry-appliances/washing-machines/front-loading/w6884eco</p>
In the commercial sector, nylon bead washers are now in use which consume up to 80% less water; and waterless supercritical machines are being conceptualised.	<p>Nylon bead washers</p> <ul style="list-style-type: none"> • Use small nylon beads that eliminate stains by locking them into the molecular structure of the polymer. • Up to 80% water savings. • Available in UK and US currently as either lease or outright purchase. 	<ul style="list-style-type: none"> • Xeros 	<p>http://www.xeroscleaning.com/the-xeros-machine</p>
Supercritical washing machines are being conceptualised that use zero water consumption.	<p>Supercritical washing machines</p> <ul style="list-style-type: none"> • Waterless • CO2 or NO2 • Conceptual phase 	<ul style="list-style-type: none"> • Supercritical 	<p>http://red-dot-21.com/design/supercritical/</p> <p>http://e3tnw.org/ItemDetail.aspx?id=512</p>
New steaming wardrobes are now also on offer as an alternative to conventional washing.	<p>Steaming wardrobes</p> <ul style="list-style-type: none"> • Freshens clothes reducing the need for washing or dry cleaning, effectively extending the period clothes can be worn between washes by steaming and deodorizing. • Uses clean tap water but does not require a water connection. • Available in US via retailers (\$3845). 	<ul style="list-style-type: none"> • LG Styler 	<p>http://www.lg.com/us/lgstyler</p>

End use/summary	Details	Examples	References
	<ul style="list-style-type: none"> Not currently available in Australia. 		
Toilets			
<p>The latest market offerings for conventional toilets include 4.5 / 3 L dual flush, as well as ultra low flush toilets with a 3 / 2 L flush and 6-star WELS rating.</p>	<p>Water-efficient dual flush conventional toilets</p> <ul style="list-style-type: none"> 4.5 / 3 L flush with 4 star WELS rating Available via retailers. 	<ul style="list-style-type: none"> Caroma 	<p>https://www.caroma.com.au/bathrooms/toilet-suites/profile/profile-4-easy-height-connector-toilet-suite</p>
	<ul style="list-style-type: none"> 3 / 2 L flush toilet with 6 star WELS rating. Available via retailers. 	<ul style="list-style-type: none"> Azzurra 	<p>http://www.azzurra.com.au/wp-content/uploads/TechSpecs/Cal%20Eco%20pedestal.pdf</p>
<p>Alternative toilets include water less or almost water less composting toilets and vacuum toilets – both of which have moved forwards in terms of overcoming potential barriers to their uptake.</p>	<p>Modern vacuum toilets</p> <ul style="list-style-type: none"> Look and feel like conventional toilets. A small diameter pipe connects the toilet to an in-line vacuum pump. When flushed, a strong vacuum is created inside the pipe (which connects the toilet to an in-line vacuum pump) and pulls the waste out of the toilet for carriage using air instead of water. Waste passes through the pump and is discharged to the chosen collection or treatment point. <1 L/flush (single flush) used to hygienically rinse the toilet bowl. Claims water-savings of 90%. 	<ul style="list-style-type: none"> JETS 	<p>http://www.vacuumtoiletsaustralia.com.au/operation.html</p>
	<p>Low flush toilets with an air jet</p> <ul style="list-style-type: none"> Uses 1.5 L/flush (when flushed, 0.5 L of water washes the pan, followed by a 	<ul style="list-style-type: none"> Propelair 	<p>http://www.propelair.com</p>

End use/summary	Details	Examples	References
	<p>high velocity jet of air to flush away the waste, before the system is refilled)</p> <ul style="list-style-type: none"> • Requires a small amount of power by mains or battery. • Claims water-savings of 84% and energy savings of 80% related to processing the water and waste. • Payback period: 1-3 years • Commercial and industrial customers include local authorities. Healthcare providers, universities, offices and managers of public buildings. • Can be installed on existing pipes. • Cost approximately \$1,300 (£800) 		
	<p>Waterless composting toilets with ventilation system and composting chambers</p> <ul style="list-style-type: none"> • The ventilation system ensures fresh oxygen is always moving through for optimal composting and minimal odour. • Some models are self-contained and can sit on the bathroom floor while others require under floor space. Additional composting chambers can be used to increase capacity • Some models require zero water use; others use a 0.5L flush. • Costs: range from \$800-\$2549. 	<ul style="list-style-type: none"> • Ecoflo Wastewater Management 	<ul style="list-style-type: none"> • http://ecoflo.net.au
	<p>Toilet suites (with an integrated hand basin)</p> <ul style="list-style-type: none"> • Features a cistern with a dual-flush push button and spout combination, which allows the fresh water used to wash hands to be recycled for flushing. • 5 star WELS rating • Cost: \$681 • Available at retailers e.g. Bunnings Warehouse. • Demand derives mostly from residential 	<ul style="list-style-type: none"> • Caroma Profil 5 toilet suite deluxe 	<ul style="list-style-type: none"> • https://www.caroma.com.au/bathrooms/toilet-suites/profile/profile-5-toilet-suite-deluxe-with-integrated-hand-basin

End use/summary	Details	Examples	References
	customers interested in more sustainable solutions (pers. comm. Caroma).		
Toilets that may actually increase water usage are bidet toilets / seats	<p>Bidet toilets / seats</p> <ul style="list-style-type: none"> • Electric toilet seats with a water spray wand for personal hygiene • Available via retailers. • Prices for new items on Ebay stores range from ~\$450-\$2100. 	<ul style="list-style-type: none"> • Toto Washlet 	http://asia.toto.com/washlet/
Taps			
The latest water-efficient taps and devices for indoor usage include sensor taps and smart taps with digital displays/ flow meters. Other efficiency devices include tap aerators as well as atomiser type nozzles.	<p>Sensor taps</p> <ul style="list-style-type: none"> • Use infra-red to provide a touch-free controlled flow of water that responds automatically to movement. • The sensor can either be integrated within the tap or mounted on the basin or wall. • 6 star WELS rating. • 3.5L/min • Water stops after 2 seconds when hands removed • Cost: \$500+ 	<ul style="list-style-type: none"> • ABL taps 	http://www.abltilecentre.com.au/zip-deck-mounted-sensor-tap-battery-powered/
	<p>Electronic control smart taps</p> <ul style="list-style-type: none"> • Can now include a variety of features such as a digital thermostat, a high temperature limit (49 degrees Celsius) and adjustable temperature and water flow rate settings, a countdown timer plus on/off – all operated via a touch LCD control panel. • Cost: ~\$355 + \$55 for shipping to Australia. 	<ul style="list-style-type: none"> • Smart taps 	https://www.aliexpress.com/item/Water-saving-Themostatic-Sensor-Faucet-Smart-Intelligent-Faucet-Basin/1989319683.html?spm=2114.40010308.4
	<p>Tap aerators</p> <ul style="list-style-type: none"> • Tap aerator inserts / flow restrictors can reduce the flow to 2, 4, 6 or 9L/min. • Water savings of up to 70%. 	<ul style="list-style-type: none"> • Reduction revolution 	https://reductionrevolution.com.au/products/low-less-tap-aerator

End use/summary	Details	Examples	References
	<ul style="list-style-type: none"> Cost: \$4.95 	 <p>6 litres per minute 4 litres per minute 2 litres per minute</p>	
	<p>Atomiser type tap nozzles</p> <ul style="list-style-type: none"> Atomise water Are Installed onto an existing tap Can achieve water-savings of 98% water; or 75% by switching to the nozzles' regular saving mode. 	<ul style="list-style-type: none"> Altered:Nozzle – “the world’s most extreme water saving nozzle” 	<p>https://www.kickstarter.com/projects/621008351/alterd-nozzle-same-tap-98-less-water</p>
Leaks			
<p>Recent innovations are making leak detection much simpler and faster leading to significant water-savings. Some devices can be used to communicate leaks and allow users to remotely shut off the flow of water.</p>	<p>Digital metering systems</p> <ul style="list-style-type: none"> Enable (near) real-time monitoring of household water consumption which through the use of leak detection algorithms can be used to alert the supplier or customer to possible leaks. 		
	<p>Leak detection with remote control</p> <ul style="list-style-type: none"> The Water Hero app allows users to see usage data and to program their leak detection preferences (trigger settings) from their smartphone, and to remotely control the shutoff valve e.g. in the case of a burst pipe. Cost: \$400-\$900. 	<ul style="list-style-type: none"> Water Hero 	<p>http://www.waterheroinc.com/home/</p>
	<p>Leak detection with water sensors</p> <ul style="list-style-type: none"> To be placed around the home, e.g. near a washing machine, sink, bath or refrigerator. D-Link Wi-Fi Water Sensor was reviewed as the best smart water sensor currently on the market (see: 	<ul style="list-style-type: none"> D-Link 	<p>http://us.dlink.com/products/connected-home/wi-fi-water-sensor/</p>

End use/summary	Details	Examples	References
	<p>http://thewirecutter.com/reviews/the-best-smart-leak-detector/</p> <ul style="list-style-type: none"> It is one of the few options that does not require a smart-home hub and can work with an existing Wi-Fi network. Monitoring via a smartphone app. Amazon price: \$75 each. 		
Coolers			
<p>Coolers can use between zero and significant amounts of water depending on the types installed.</p>	<p>Cooling</p> <ul style="list-style-type: none"> Seeley International offers cooling either for one room via: Portable evaporative cooling (\$50-\$1200); Portable refrigerated air conditioning (\$150-\$1200); or Split system refrigerated air conditioning (\$600-\$3000); Or for a whole home via: Ducted evaporative air conditioning (\$4000-\$15000); or Ducted reverse cycle refrigerated air conditioning (\$4000-\$20000). Portable units use up to 4L/hour while central systems may use up to 25L/hour Refrigerative systems use no water during operation 	<ul style="list-style-type: none"> Seeley 	<p>https://www.seeleyinternational.com/ http://www.sustainability.vic.gov.au/services-and-advice/households/energy-efficiency/at-home/cooling/evaporative-coolers. http://www.airah.org.au/Content_Files/TechnicalPublications/AIRAH_residential_evap_cooling_bpg.pdf.</p>
Baths			
<p>Baths could use less water in future with some clever re-designing.</p>	<p>Multi-functional bath tub</p> <ul style="list-style-type: none"> Has a tilt function that saves water depending on how the bath is used and how much it is tilted. Water savings of 80% for a foot bath, 60% for a half-body and 40% for a full-body bath. Conceptual phase 	<ul style="list-style-type: none"> Multi-functional bath: 	<p>http://www.yankodesign.com/2013/03/22/water-saving-body-wash/</p>

End use/summary	Details	Examples	References
<p>Dishwashers</p> <p>Highly water-efficient dishwashers are available on the market using less than 10L/wash.</p>	<p>Water-efficient dishwashers:</p> <ul style="list-style-type: none"> • 6 star WELS ratings • 15 place settings; 9.6L/wash or 0.64L per place setting (Smeg) • 14 place settings; 9.5L/wash or 0.68L per place setting (V-Zug). • 13 place settings; 6.5L/wash or 0.5L per place setting (Neff). 	<ul style="list-style-type: none"> • Smeg • Neff • V-Zug 	

USER BEHAVIOUR

An important issue to bear in mind when considering the potential contribution of new and emerging water efficient appliances, fixtures and customer interfaces to reductions in water demand is the role of **human interactions** with each product. New technologies may offer hopeful promises, however, the interactive behaviours of users need to also be recognised as influential in determining the ultimate impacts on household water consumption (Beal et al. 2013; Stewart et al. 2013). Returning to Table 5.1, some examples can be used to better illustrate the important interplay between technology and behaviours. With some of the latest products, there is still considerable room for a behavioural component to water consumption. However, for others, the effect of human behaviour – choice or decision-making – on how the appliances are used and therefore how much water is ultimately used can be significantly decreased. For example, with the shower shorteners, the user can still pre-select a shower duration varying from what is widely considered short (i.e. 3 or 4 mins depending on the particular brand and model) to what would be considered as long (up to 11 mins with the ‘Shower Manager’). The Davinda shower shortener also allows the user to extend the duration of the shower by an additional minute, when the pre-selected shower duration is coming to an end. Therefore, while the devices present the opportunities for users to save water, there is a certain degree of control for the user to ‘override’ the target usage amounts. For appliances such as clothes washers, it is important to ensure that machines have a default so consumers can easily recognise ‘normal’ efficient cycles for which the machines are rated as efficient and do not inadvertently use less efficient cycles. For end uses such as irrigation, there are now greater opportunities to partially remove or reduce the ‘behavioural’ component of the water using practice. This offers the potential to more closely align the needs of plants by taking into consideration meteorological conditions and substantially reducing overwatering caused by behavioural practices. Although in Victoria, the adoption of such efficient irrigation systems may take some time due to consumers preferences to use handheld hoses brought about in part by the Millennium drought.

Another issue to consider is the **‘time factor’**, whereby the water savings actually achieved in association with any specific water efficient device may vary over time. This issue is discussed in Liu et al. (2017) with reference to the Technology Acceptance Model (Davis 1986) and the related distinction drawn by Martinez-Torres et al. (2008) between *initial* and then *continued use* of a technology. The discussion in Liu et al. (2017) (which concerns the case of an online water consumption portal) highlights the role of householders’ acceptance of technology and how this acceptance may vary over time, as might the behavioural responses to a technology (as reflected in actual water demand). Other literature from the household energy sector has for example reported devices ‘fading into the background’ with loss of interest and enthusiasm over time (Faruqui et al. 2010). There is always a risk that consumers that do purchase the most innovative devices lose interest in their usage once the novelty factor has passed, with behaviours not in line with how the products are intended to be used to achieve the advertised water savings.

Another note of caution concerns **how realistic are the advertised savings**. For example the Altered: nozzle tap suggests major water savings of up to 98% by atomising water drops and even 75% when used in its regular mode. Other products would require significant behavioural changes in order to realise the advertised water savings. The Quench shower advertises up to 80% water savings and involves a conventional short shower (which consumes 9L/min in the first step) followed by the use of a recycling system with filtering and reheating in a second step (which consumes a total maximum of 4L). The manufacturers recommend users to wash themselves and carry out personal maintenance within the first two minutes, which is when water is going down the drain and “to develop ways to shower more efficiently” to achieve this. Here, user expectations such as with regards to comfort may need to be challenged. The baseline measurement to which advertised savings are being

compared is also important. Many times, how projected savings were calculated by suppliers is not entirely transparent – and calculations may draw on particularly high or inefficient usage patterns as a point of reference to maximise the perceived benefits of their products and appliances.

A further consideration when evaluating innovative and emerging water appliances and technologies is to understand their possible **markets**. In some cases, for example with the latest showers by e-Hamwells and Orbital Systems, which involve a few thousand dollar outlays, these products are likely to largely only attract commercial customers and only the highest end of the residential market. With some water saving appliances, there may be opportunities for incentivising their uptake if the return on investment can be justified. Research will continue to play an important role and the willingness of water utilities to actively identify, and trial and pilot new and untested innovations will remain helpful in better understanding the real opportunities that specific emerging innovations present. Research into customer preferences and perceptions of the importance of water efficiency in relation to other factors such as convenience and comfort that influence the adoption of alternative water using appliances can also improve the water industry's understanding of the opportunities and barriers to uptake of new and existing water efficient options.

OTHER TRENDS DRIVING INNOVATION

Crowd funding

An interesting observation made in conducting this research was the use of crowd funding platforms in order to further develop innovations from concepts and prototypes of water efficient appliances to market-ready products. The crowd funding business model presents an innovative way for designers and inventors to pitch their ideas for products widely via the internet, secure 'backers' who either pre-order the finished product or provide investment into the proposed product, and then use the funds raised in order to realise the product. Some examples of crowd funded innovations and developments are provided below to illustrate the opportunities that this model presents.

Hamwells e-Shower³³

In December 2016, through the use of CollinCrowdfund's crowdfunding platform, Hamwells were able to secure an additional €300,000 of funds for their e-Shower within just 1 hour from a total of 327 investors. The funds will be used to support large scale market introduction and international market expansion, including to dry areas such as in the US, Australia and the Middle East and investment in manufacturing moulds, showroom models, investment in international certification and working capital to fund marketing and sales efforts. As part of the call for funding, Hamwells offered investors investing €500/1,000 an equivalent discount voucher of €500/1,000—on the e-Shower HomeSpa (the luxury version of the e-shower with a screen) (see also Table 5.1).

Waterdrop foldable watering can³⁴

The crowdfunding platform Kickstarter is also being used to secure backers for other innovations in water efficiency. One recent example is Esferic's foldable watering can (see Figure 5.1) which can be used to collect cold water while waiting for the shower or bath water to become hot. The project was brought to life through the pledges of 314 backers totalling €16,680. The funds will be used to professionalise production processes, conduct further

³³ <https://www.collincrowdfund.nl/hamwells/> (accessed 10.03.17)

³⁴ <https://www.kickstarter.com/projects/614674700/water-drop> (accessed 10.03.17)

research, explore partnerships, and build a water-saving community by creating a smartphone app to advise users how much water they and all other users save each day and share practical advice. Pledges started from €12, to secure one bag with the app once produced.



Figure 5.1a – WaterDrop foldable watering can

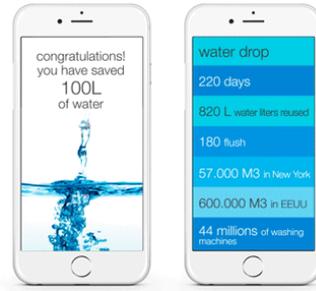


Figure 5.1b – WaterDrop app

Drumi foot powered washing machine^{35,36}

YiREGO also secured enough backers via the Indiegogo crowdfunding platform to support the launch of Drumi (Figure 5.2), a foot powered washing machine which uses just 5-10 L of water per load and no electricity. The portable machine has a capacity of 5 pounds (just over 2 kg), which is enough to wash 6 T-shirts, and takes only about 5 minutes to operate. Adopting the crowdfunding approach helped YiREGO to secure around US \$275,000 in January 2016 through pre-orders placed by backers who are now expecting delivery of the washers in July 2017.



Figure 5.2 – Drumi foot-powered washing machine

While each of the above appliances/devices may only attract certain niche customer segments (including in Victoria), they serve as cases in point that crowd funding presents new and unexpected opportunities for new innovations to come to market with implications for water consumption and efficiency of usage.

³⁵ <https://www.indiegogo.com/projects/drumi-the-foot-powered-washing-machine-design-green#/> (accessed 10.03.17).

³⁶ <http://www.digitaltrends.com/home/the-drumi-is-a-foot-powered-washing-machine/> (accessed 10.03.17).

Innovation from other sectors: Greenredeem^{37,38}

An innovative incentive scheme from the recycling sector, called Greenredeem, has led to a cross-application for Thames Water, London, UK, to promote residential water efficiency.

For several years, Greenredeem has already been partnering with local authorities to increase residential recycling rates and promote behavioural change. The recycling incentive program was reported to have led to recycling rates growing at three times the national average including by 31% in the Royal Borough of Windsor & Maidenhead between 2010-2013. Greenredeem works by rewarding people for taking ‘everyday green actions’ as well as making green pledges and taking part in quizzes. Members collect points which can be redeemed for personal rewards or donated towards cash grants for the funding of pre-selected community projects. Residents can also engage with the program via the Greenredeem web platform or smartphone app.

Thames Water has recently teamed up with Greenredeem to pilot a scheme with up to 3,000 households that form the smart-metered fixed area network in Reading. The scheme promotes water savings by rewarding residents with points for engaging with the web platform (see Figure 5.3) and for saving water. Points collected can then be used to claim a range of rewards from free coffees, discounts at local attractions, and offers at local restaurants, to prize draw entries and opportunities to donate points to charities. The customised web platform uniquely combines information about the household’s weekly water use together with the user’s activity in terms of points collected and redeemed, and alerts to new activities/rewards that are available. The platform thus targets regular and interactive engagement by householders with their water consumption.

If the pilot that will run until the end of 2017 proves successful, Thames Water may roll the scheme out on a wider basis to other digitally metered homes.



Figure 5.3 – Thames Water Greenredeem web platform

³⁷ <https://www.greenredeem.co.uk/cp8.php> (accessed 09.03.17).

³⁸ <https://www.greenredeem.co.uk/thameswater> (accessed 09.03.17).

THE FUTURE OF MONITORING, FEEDBACK AND CONTROL

Water service providers will continue to play an important role in measurement and monitoring of residential water consumption and in shaping demand and developments that foster the sustainable use of water resources. The general progression that is being seen with measurement and monitoring and that is set to continue into the future is illustrated in Figure 5.4.

This shows the continued penetration of metering and especially the growth of sub-metering (i.e. for MUDs); a gradual shift away from conventional metering towards digital water metering; and the parallel emergence of digital solutions (for individual appliances and fixtures) and integrated systems for household water measurement, monitoring and ultimately control. These trends are discussed in turn below together with a discussion of the opportunities for water efficiency these developments present, while highlighting things to keep an eye on.

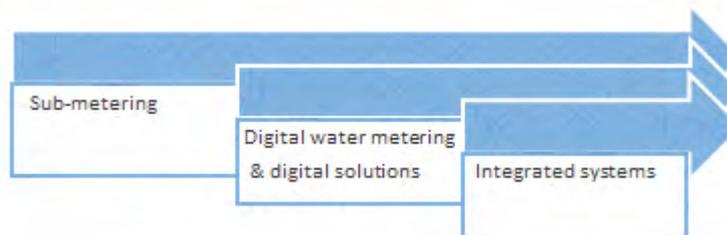


Figure 5.4 – Progression in monitoring, feedback and control

Sub-metering

Important opportunities to improve water efficiency can be harnessed through the increased penetration of metering. Sub-metering involves the installation of metering devices downstream of a water utility large customer meter, and enables the measurement and billing of water consumption of individual units rather than of an entire MUD, which may have anywhere from a handful of sub dwellings to several hundred. The installation of sub-meters, either in new or older MUDs, can significantly influence patterns and volumes of water usage and facilitates the important principle of user pays pricing. A study by Aquacraft and the East Bay Municipal Utility showed water-savings of up to 15% through the introduction of sub-metering and volumetric billing in MUDs (Mayer et al. 2004).

New technologies are emerging that make the process of sub-metering easier, potentially including those for older MUDs, which may be of interest to the Victorian utilities that have had sub-metering for MUDs since the early 1990s, and for non-residential commercial properties. For the residential sector as the stock of sub-metering gradually increases through the requirement for new MUDs to have sub-metering in many jurisdictions, proxy estimates based on the number of bedrooms are starting to be used in locations such as Sydney to assist in reducing demand through targeted programs as discussed previously in Section 3.

Our review of available research found there is a significant lack of recent published studies regarding the impacts of sub-metering on water consumption. This presents an opportunity for further research to improve and disseminate knowledge on this issue for both the residential and non-residential sectors.

Digital water metering

Digital water metering is enabling the water industry to enter the digital age and to embrace new levels of water usage measurement and monitoring and experiment with new opportunities for analysis and communication. The information derived from digital metering can specifically be used to:

- aid demand forecasting;
- guide the design of demand management programs and interventions;
- facilitate evaluations of specific programs;
- identify leaks and
- enable the provision of detailed water consumption feedback to end users;

all of which can contribute to a continual progress in water demand and systems management which can help meet demand, defer capital expenditure on infrastructure and reduce operating costs (Turner and White 2017; Liu 2016).

Implementation of digital meters have been advancing steadily both nationally and internationally, however, access to more detailed water consumption feedback is slowly starting to reach householders (Liu 2016). Various studies have helped to demonstrate important potential for residential water savings. For example, the provision of leak notification letters (Britton et al. 2013), feedback postcards (Fielding et al. 2013), in-home displays (Doolan 2010; Wetherall 2008) and online portals (Erickson et al. 2012; Joo et al. 2014) have each reported a positive impact of between 5-10% water savings.

More recent research conducted at ISF (Liu 2016) investigated the opportunity for more detailed consumption information feedback for householders by implementing two digital metering trials. The research showed significant householder interest and measurable impacts including water savings. An important finding was the variety found in householder preferences for and responses to feedback, which was interpreted to signal that greater customisation could further elevate the value of feedback to customers and improve engagement with the opportunities presented by digital metering. However, it remains to be proven whether more user-driven, bottom-up approaches could offer opportunities to improve customer engagement (Liu 2016).

A review of the current market situation shows that a growing number of digital meters are being developed for the water sector together with an ever-increasing number of managed service providers offering various kinds of customer interfaces in the form of web portals and smart phone apps (e.g. see Figure 5.5a). Standard features now include:

- consumption feedback at varying time intervals (e.g. daily, hourly, or down to minutes depending on the frequency of data logging);
- high usage alerts and leak alerts (sent via SMS or email);
- comparative feedback e.g. based on the household size (number of occupants) or water efficient benchmarks;
- water savings recommendations that are either customised or generic;
- regular reports sent via email.

Some systems are incorporating additional information beyond water use (e.g. weather data as well as interactive features). However, most current offerings in terms of online interfaces are remarkably similar across the market, so opportunities exist for the development of new and innovative approaches to customisation and engagement (Liu 2016).

Recent research trials, including those at ISF, have also been investigating opportunities for the provision of end use feedback (i.e. breakdown of household water consumption between, for example, usage by shower, toilet, taps, clothes washer, outdoors and leaks). In our customer preferences survey and evaluation of households provided with end use reports, end use feedback was found to be widely appealing among household customers that expressed value in the ability to see an overview of where water is being used in the home (Liu et al. 2015) (See Figure 5.5b). Current technologies for end use disaggregation are still, however, immature in terms of both speed and accuracy, so ongoing research is investigating the opportunities for automated end use pattern recognition (e.g. Nguyen et al. 2013; Current ARC Linkage project between CWW, SEW, YVW, Griffith and UTS).

A research project in Europe, WISDOM, has also been investigating the opportunity to provide both real time and end use feedback via an online platform, however, the results of the trial have yet to be announced.³⁹ Interestingly, the research has brought together a consortium of 11 project partners from the UK, Italy, Spain, Ireland and France comprising water utilities, local authorities, universities, engineering consulting and ICT companies, demonstrating a collaborative approach that brings together water and technology experts to drive innovations in efficient water management.⁴⁰



Figure 5.5a – Mackay Regional Council’s MyH2O online water consumption portal accessible via computers or a smartphone app.

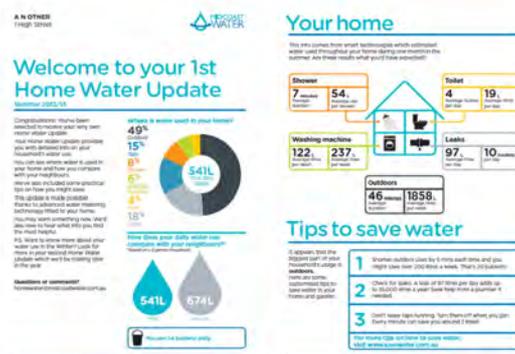


Figure 5.5b – Home Water Update report used to provide study households with end use water consumption feedback (Liu et al. 2015).

Water-efficiency experts contacted around the world for this study confirmed there is ongoing excitement internationally with the use of digital metering for customer-side leak detection and for the collection and provision of detailed consumption feedback to end users, both measures which can lead to reductions in household water demand through increased awareness, efficient appliances and more conservative water-using behaviours. These positive impacts have been demonstrated in a number of analyses of research trials as well as through headline figures reported for roll-outs. However a number of key challenges remain. Wider user uptake and ongoing engagement remain key challenges to address⁴¹, which will require additional research into customer needs and drivers in order to suitably adapt and shape approaches to the utility-customer interface (Liu 2017). In addition, the cost-

³⁹ <https://www.youtube.com/watch?v=6SJVXBVc8N4> (published 18.01.17)

⁴⁰ <https://www.youtube.com/watch?v=6SJVXBVc8N4> (published 18.01.17)

⁴¹ See Liu et al (2017) which discusses online portal uptake which has been around the 30% mark for first time users; with fewer return users.

effectiveness of alternative approaches to customer engagement within a utility digital strategy also requires investigation.

Integrated solutions – home monitoring and automation

For the future of water efficiency, previously unlinked “things” will soon become connected. Traditionally, water-using appliances such as toilets and showers only consumed water. However, we are approaching the cusp of a technology revolution with the onset of home monitoring and automation.

New digital solutions, notably, digital displays are already available in the market for individual appliances / fixtures – currently showers and taps, with some examples for taps and showers having been presented in Table 5.1. Nevertheless, these products are not well tested/researched; and it is unclear how long it will take for such devices to conquer even a small share of the residential market, or whether this will only attract a niche segment with an interest in sustainable solutions.

If we look to the developments taking place in the home energy market, an increasing number of applications have been emerging for measuring and monitoring consumption, as well as controlling electricity demand with two-way controls. Various platforms have been developed e.g. Apple HomeKit⁴², Google Nest⁴³, and Samsung SmartThings Hub⁴⁴, to name but a few, and the list of smart home products is also growing and includes smart lightbulbs, door controllers, window blind controllers, heating and cooling controllers, motion sensors and smoke detectors etc. Figures 5.6 a and b provide examples of the wider status of home automation, while Figure 5.6 c provides a specific system for household leak detection using sensors.

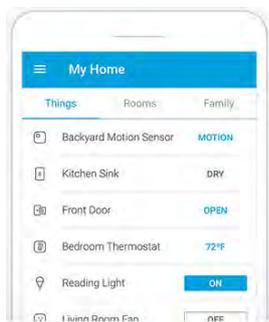


Figure 5.6 a – Example of smart devices monitored and controlled via the Samsung mobile phone app and Samsung SmartThings Hub



Figure 5.6 b – The Samsung SmartThings Hub which communicates with a wide range of connected devices currently retails at US\$99 in the US and Canada (Samsung 2017).

⁴² <http://www.apple.com/shop/accessories/all-accessories/homekit> (accessed 10.03.17)

⁴³ <https://nest.com/#> (accessed 10.03.17)

⁴⁴ <https://www.smarthings.com/> (accessed 10.03.17)



Figure 5.6c – Example system linked by Dlink^{45,46}

It is highly likely that further applications will gradually begin to emerge for monitoring and controlling household water using appliances. However, this is also likely to take some time. A future possibility will be for integrated smart household energy and water management. The ability to control water using appliances will have implications for the demand of water as well as for time of use profiles and opportunities for peak lopping which will provide significant opportunities for water system optimisation and the associated opportunities for the reduction of capital and operating costs in the system.

Implications of the digital age for water providers

While individual digital solutions and home automation will emerge slowly, digital water metering will be fundamental for measuring and monitoring for the foreseeable future. It will provide water utilities with the holistic visibility and control required for effective water provision in cities of the future that includes the ability to carefully target demand management programs, provide customised household water consumption feedback and to evaluate the impacts of programs, all of which will be critical when facing scarcity (e.g. future drought).

To embrace the digital age, water utilities can take a pro-active stance in shaping the digital transformation. In order to do this, an active approach to further research trials is particularly recommended. Regarding customer interfaces, research is required that includes both larger scale evaluations and investigation into the opportunities for more user-driven customisation approaches. Such research can contribute towards a fuller understanding of the associated opportunities and impacts of digital opportunities for customers at scale that importantly go beyond the prevalence of small-scale research pilots which have been implemented with limited flexibility in terms of adapting the approaches tested and with a lack of consideration of scalability to an entire customer base.

⁴⁵ <http://us.dlink.com/products/connected-home/wi-fi-water-sensor/> (accessed 10.03.17)

⁴⁶ <https://www.youtube.com/embed/UR9SDvnu7C1?autoplay=1> (accessed 10.03.17)

6 DISCUSSION AND RECOMMENDATIONS

This section discusses additional key issues that need to be considered as Melbourne and regional water service providers look to the future. These include for example:

- population growth and densification;
- the need for systems thinking;
- water-energy nexus interactions;
- the importance of regulations;
- consideration of program intervention timing and costs and short-versus long term needs;
- the emergence of the digital era;
- the need for futures thinking; and
- identification of research needs.

Some of the concepts are drawn from a discussion paper recently written by ISF for WSAA “*Urban Water Futures: Trends and potential disruptions*” (Turner and White 2017).

DISCUSSION

Population growth/densification

As identified in Section 2, Melbourne is the fastest growing capital city in Australia and is expected to hit a population of 8 million by the middle of the century⁴⁷. This creates both major challenges but also enormous opportunities in how we provide water and wastewater services for existing and future customers.

To accommodate the growing population the current trend is towards urban densification within the city. This will put significant strain on the existing services and traditional methods of service delivery. In regional areas growth is predominantly in the form of single dwellings with the need to extend existing services to new areas and/or create more decentralised systems which rely less on transportation of water and wastewater but more on localised sources, treatment, use and reuse - “fourth generation” infrastructure (Turner and White 2017).

The importance of systems thinking

Going forward a more systems based approach will be required both within Melbourne and the regional areas now before it is too late. Such a systems approach will provide the opportunity to make a step change in how we provide water and wastewater services and the associated levels of efficiency attainable. It will enable us to move beyond sustainability and towards “restorative”, “regenerative” or “net positive” principles as we transition towards “fourth generation” infrastructure which will need to encompass improved water efficiency, improved source control and more effective separation of pollutants and recovery of resources. It will also encompass improved management and control of flows in the system

⁴⁷ https://www.planning.vic.gov.au/_data/assets/pdf_file/0014/14036/Victoria-in-Future-2016-FINAL-web.pdf (accessed 09.04.17)

requiring a greater investment in treatment and reuse compared to investment in the transport of water, sewage and stormwater, and the recovery of energy, carbon and nutrients. (Turner and White 2017).

Due to the influence of the Millennium drought we have to a certain extent, already pushed the limits of water efficiency of individual conventional water-using appliances. However, this does not mean that the limits of water efficiency have been reached, but rather that a broader, systems thinking approach is required in the future to push efficiency further, provide the ability for a step change in efficiency and to avoid any negative impacts arising from improved efficiency.

For the future of water efficiency, changes will be required in the wider systems of which individual water-using appliances are just one component. For example, the water efficiency of toilets needs to be viewed beyond the toilet pedestal and cistern and the flush volumes towards a more systemic view, which incorporates, for example, the ability of the drainage system to take away waste with less water, as well as factors such as the composition of toilet paper, including the current trends in the use of wet wipes.

Concerns have arisen recently regarding the ability of wastewater plumbing to handle the more premium types of toilet paper since the reduced flows from low flush toilets can result in such paper sticking to the walls of pipes, particularly at joints (pers. comm. Steve Cummings GWA 2017). There has also been significant concern raised over the increased use of flushable wet wipes in recent years. Such wet wipes are now recognised as a major cause of sewer blockages costing the water industry globally millions of dollars per annum to rectify (Patrick Hatch 2016; Choice 2016; Sydney Water 2017)⁴⁸.

In addition, 'dead legs' and stagnant water in water supply pipes have given rise to personal health and safety concerns. In the US, reduced flows are being blamed for emerging pathogen growth issues such as legionella (pers. comm. John Koeller 2017).

To avoid these issues and enable further reductions in water use such as toilet flush volumes, changes in building plumbing codes may be required for drainage gradients and the reconfiguration of household drainage systems to aid bathroom and household drainage and flushing. Developments, marketing approaches and the quality, labelling and regulation of products such as toilet paper, wet wipes and plumbing systems should no longer be considered in isolation and the convergence of water and waste products carefully monitored as we go forward (Fam et al, 2017).

In order to achieve a step change in water usage associated with end uses such as toilets a deliberate shift away from traditional gravity fed hydraulic systems to vacuum systems will be necessary to enable flows of 0.8 L/flush or less to be achieved. These could work well in new MUDs being developed as part of the urban densification of Melbourne but also in regional areas where vacuum systems have been more prevalent traditionally because of their use in difficult terrain.

⁴⁸ According to a CHOICE study in 2016, clearing blockages costs Australia's water providers \$15 million p.a. which are largely attributed to wet wipes. See <https://www.choice.com.au/health-and-body/beauty-and-personal-care/skin-care-and-cosmetics/articles/flushable-wipes>. According to Sydney Water, 75% of sewer blockages involve wet wipes, which do not break down as quickly as toilet paper. Estimates suggest 1 in 4 people in Sydney are flushing wipes. See: <https://www.sydneywatertalk.com.au/wet-wipes/faqs> (accessed 18.01.2017). In December 2016, the Australian Competition and Consumer Commission (ACCC) announced impending court action against makers Kimberly-Clark Australia and Pental for making false or misleading claims that their 'flushable wipes' disintegrate as well as toilet paper. See <https://www.choice.com.au/health-and-body/beauty-and-personal-care/skin-care-and-cosmetics/articles/flushable-wipes>. According to reports by the Age, New York City has spent over \$23 million over the last 5 years dealing with issues associated with wet wipes whilst Thames Water in the UK spends \$23 million p.a. in London. See <http://www.theage.com.au/victoria/wet-wipes-causing-havoc-in-australias-sewage-and-water-systems-20150316-1m04am.html>.

On the other hand, a watching brief will also be necessary to manage the potential growing emphasis on health and safety which could lead to a “switch in focus away from further ratcheting down the water consumption rates of fixtures and appliances” (pers. comm. John Koeller 2017).

Hence, greater emphasis will be required on trialling and learning from pilots such as the Pixel Building in Melbourne and Central Park in Sydney where systems thinking, closing the loop and moving towards regeneration are key if we are to have any hope of shifting to new water and wastewater service configurations before it is too late (Turner and White 2017).

In addition, new and adaptive engineering assumptions will need to be drafted for both the water and wastewater systems taking into consideration the significant average and peak lopping due to efficiency and how this translates to urban densification and new areas being developed.

Water energy nexus

As part of the water industry’s response to the Millennium drought, a significant investment was made to diversify water sources including desalination, major recycling, alternative sources and water efficiency. In many cities this has increased the energy intensity of water service provision (Kenway et al. 2008; Cook et al. 2012; Kenway and Lant 2015). In terms of water efficiency measures these tend to provide significant energy reduction benefits such as in the case of showerheads reducing hot water demand (Turner et al. 2014). Such benefits provide further incentives to residential and non-residential customers that go beyond just saving water.

However, care is needed as we go forward that energy usage does not increase as we drive water efficiency down especially for new emerging appliances such as combination condenser washer-dryers and end uses in transition such as EACs. In such circumstances regulations will need to play an important role in balancing water and energy usage and efficiency and ensuring negative consequences don’t arise as was seen in the emergence of rainwater tanks where energy usage increased due to poor configuration of system components (Retamal and Turner 2010; Ferguson 2011).

The need for appropriate regulation

One important cautionary piece of advice concerns the importance of regulation and standards – not only for water and energy efficiency but also with regard to the quality of water fixtures and fittings.

For the future of water efficiency, it will be critical to maintain strong consistency of standards in Australia. It will be important for DELWP and the water utilities to play a strong role in ‘holding the line’ and in continually pushing standards forwards, particularly as newer products are developed (e.g. bidet toilets and combined condenser washer-dryers). This will need to include ensuring that the efficiency setting of a product is effectively the default, thereby helping customers use products efficiently and not inadvertently use more water and/or energy than expected. It will also be imperative to capture water saving opportunities as the region grows and insist on pushing minimum performance standards for appliances thereby locking out poor performers in the market.

In addition, insisting on ensuring the building regulations in new and altered residential and non-residential buildings use the most efficient water fixtures and fittings will be imperative considering the impact this will have on water demand going forward over the coming decades. This will be essential in both Melbourne and regional areas where urban sprawl and the propensity for single residential homes on smaller blocks are emerging. In regional areas strong regulations on the use and maintenance of source substitution measures such as rainwater tanks will be important.

Regulation on the configuration of the proximity of hot water systems to hot water using end uses will also need to be considered to minimise the water (and heat) lost while waiting for hot water to arrive and potentially the incorporation of dual piping in new homes to encourage fit for purpose water use in the future.

The durability of water fixtures and fittings is also a genuine concern, since it will be highly detrimental to the water industry if products are initially rated as highly water efficient at the point of import, yet deteriorate rapidly and leak thereby needing unexpectedly premature replacement.

During the drought both garden products and rainwater tank equipment demonstrated instances of poorer quality products on the market initially and in the case of rainwater tanks in some instances manufacturers going out of business due to significant competition. As Victoria and other major cities head towards large population growth/influx over the coming years lessons need to be drawn from these experiences.

Important lessons are to be learnt from recent negative experiences in Australia from within the building industry which include the breakout of a fire due to the quality of cladding material used in the Lacrosse building in Docklands, VIC⁴⁹; and asbestos findings in roof panels of the new Perth Children's Hospital to which 20 workers were exposed⁵⁰. While standards do not currently generally appear to be a problem with water saving appliances this could become an issue in future and a proactive approach to the ongoing development of standards will avoid a need to have to 'play catch-up' in the future.

Efficiency program intervention

Efficiency program intervention, timing and costs in the short versus long term and their relationship to regulations and the temporal "value" of water will be important to consider going forward.

The key question around the "value" of water and how this may change over time needs specific consideration, especially as this has been a major issue of concern for initiatives such as efficiency and source substitution (e.g. rainwater tanks and larger recycled water projects) post drought where significant investment has been made in higher cost options and questions subsequently asked on the justification of such expenditure (Turner et al. 2017; Turner et al. 2016b).

In the case of Sydney, dam trigger levels identify when restrictions and major infrastructure should be used to slow the depletion of water reserves and increase supply as indicated in the Metropolitan Water Plan 2010 (NSW DPI 2010). Analysis conducted more recently, "*Advisory Study on the Next Generation of Water Efficiency Programs for Greater Sydney*" (Turner et al. 2013), explored modifying the dam trigger levels for Sydney to incorporate demand-side measures at various trigger points representing various levels of efficiency option intensity sparked by lowering dam levels and/or increasing per capita demand. These trigger levels would vary from an essential "foundation" level (i.e. the minimum demand management team, research and efficiency program expenditure needed to keep efficiency in the consciousness of customers, maintain customer relationships and importantly minimise savings erosion), to "tier 1" and "tier 2" levels with varying levels of efficiency option intensity and expenditure dependent on how close and how much the next more expensive supply-side option is. If tier 2 were to be triggered this would allow higher cost demand-side options to be implemented because the value of water would be higher at that point in time. The Sydney Metropolitan Water Plan is currently under review and will be released in 2017.

⁴⁹ <http://www.theage.com.au/victoria/docklands-apartment-tower-fire-fuelled-by-material-in-buildings-walls-says-mfb-20150427-1mukhx.html> (accessed 25.01.17).

⁵⁰ <http://www.abc.net.au/news/2016-07-14/asbestos-found-in-perth-childrens-hospital-roof-panels/7628108> (accessed 25.01.17).

The revised version of the Metropolitan Water Plan is likely to have some consideration of these additional demand-side triggers.

Other recent investigations into the relationship of water efficiency with the value of water have been conducted by SWC. As part of the ongoing review of Sydney Water's licence the Independent Pricing and Regulatory Tribunal (IPART) set a new requirement, after consultation, that requires SWC to move towards a water conservation assessment methodology and away from a prescriptive approach. The methodology, the Economic Level of Water Conservation (ELWC), aims to help SWC work out the most effective water conservation projects and the most appropriate levels of investment in water efficiency, recycling and leak reduction programs. The methodology, developed and approved by IPART, will then allow SWC to develop a new five-year water conservation program in 2017.

The digital revolution

With the rapid evolution of digital water meters and emergence of the digital era, there will now be significantly increased opportunities for customer interface and behaviour change programs. In many cases, particularly with the introduction of the internet of things, it is currently difficult to imagine the wide array of devices, processes and data that will emerge and help revolutionise the water industry.

While individual digital solutions and home automation will emerge slowly, digital water metering will be fundamental for measuring and monitoring for the foreseeable future. Digital metering will equip water providers with the holistic visibility and control required for effective water provision in cities of the future that includes the ability to carefully target demand management programs, provide customised household water consumption feedback and to evaluate the impacts of programs, all of which will be critical when facing scarcity (e.g. future drought) (Turner and White 2017; Liu 2016).

Water providers can importantly take a pro-active stance to inform and shape the digital transformation through the implementation of research trials and projects that investigate new and emerging opportunities, and prove the costs and benefits of efficient digital technologies and services to ultimately enable their most beneficial utilisation among customers. In this regard, the Melbourne utilities' Digital Metering Joint Program⁵¹ which is exploring digital metering with a view to making a decision in late 2017 on whether to upgrade a combined network of 2 million meters to digital, represents an important strategy that can contribute towards understanding and harnessing these possibilities in terms of customer engagement, metering and communication technologies, and business case development.

In terms of customer engagement in the digital age, untapped opportunities particularly exist to explore more user-driven customisation of the digital metering customer interface. More research is required to understand both how to enhance customer engagement with the monitoring and managing of their water use, and how to achieve more significant impacts from large scale roll-outs of digital metering and behavioural strategies that go beyond the confines of small scale pilots.

Finally, in facing the digital revolution, water providers can importantly further advocate the sustainable use of water resources by using demand management programs that harness digital data and also promote the use of innovative and water efficient devices to foster water efficiency among their consumers.

⁵¹ <https://media.yvw.com.au/inline-files/Digital%20Metering%20Joint%20Program%20Factsheet%20-%20Nov%202016.pdf> (accessed 09.02.17)

Futures thinking

There are significant disruptions in the water industry on the horizon. Instead of allowing the current trends and disruptions in the water and related industries to take us to an unknown destiny, the water industry should take control, innovate, advocate and drive in the desired direction. To do this will require a futures thinking approach, which requires participants to look to the desired future and identify the paths necessary to get there (Turner and White, 2017). As recognised leaders in water and wastewater planning, demand forecasting and end use measurement, the Melbourne retailers should help lead the water industry in starting this futures thinking discussion. These discussions need to highlight specific areas of research and piloting required to fill in current knowledge gaps.

Research needs

During the drought Australia led the world in terms of driving knowledge on water efficiency, demand management program design, implementation and evaluation. Since the end of the drought the drivers for efficiency appear to have somewhat evaporated in the consciousness of decision makers. However, utility customers have not lost this knowledge or inherent need to save water in the driest inhabited continent in the world.

With the dams relatively full and desalination plants available in the wings it is time to take stock of the significant knowledge we have on water planning and management and specifically water efficiency and with a futures thinking frame take stock of where we are at, what knowledge gaps still remain and what research needs to be conducted to help drive us in the desired direction that helps us live within the resources we have while the population rises and begin to move towards “fourth generation” infrastructure and “restorative”, “regenerative” or “net positive” principles.

Efficiency and digital approaches will need to be at the centre of such an approach. Hence well-directed research, trialling and demonstration of innovative approaches will be essential.

RECOMMENDATIONS

A number of recommendations at both a broad and detailed level have been drawn from the research conducted for this study.

From a broad perspective the Melbourne and regional water utilities would benefit from:

- Leading the water industry, as a minimum, in a Victoria wide systems and futures thinking approach to water service provision, considering in a workshop forum what the desired future should look like and the steps necessary to get there including creating a research, piloting, demonstration and evaluation strategy.
- Implementing such a strategy linked to past research activities (i.e. the Smart Water Fund) and current activities focusing on creating a digital strategy.
- Expanding this research study to include a comprehensive summary of all residential and commercial initiatives and particularly regional residential and commercial efficiency programs conducted beyond those identified for BW and CHW.
- Also expanding this research to collate a comprehensive database of leading edge international technology, behaviour, digital metering and program design, which could be developed collaboratively through organisations such as the US Alliance for Water Efficiency, US Water Research Foundation, UK Waterwise, and WSAA.
- Setting up a regular knowledge-sharing forum and data information-sharing platform (similar to the Clearwater site and beyond the current scope of the Smart Water Advice site) specifically aimed at sharing water efficiency knowledge and resources, which could be expanded to feed into the WSAA networks/communities of practice.

- Conducting detailed conservation potential analysis (using end use and sector/sub sector analysis) for Melbourne and the regional areas to determine the opportunities that still remain. Some sectors of particular interest could include tourism, mining, small farms and growth areas (urban sprawl).
- Conducting detailed market segmentation of customers to better understand how to develop more sophisticated tailored programs.
- Collating and distributing evaluation information on actual savings and costs of existing programs implemented to date to maximise learning.
- Creating a suite of existing and next generation water efficiency options for Melbourne and the regional areas, drawing on new emerging international examples especially in digital metering that can be used to turn to as required.
- Conducting cost effectiveness analysis of demand-side options compared to supply-side options and alternative options including consideration of whole of society costs and benefits to the multiple stakeholders involved in a broad suite of options that could be utilised into the future.
- Conducting analysis of short and long term needs in terms of availability and “value” of water including the consideration of regulations versus incentive programs and timing needs.
- Determining how to set up, as a minimum, a core state based efficiency team and base level investment in water efficiency to ensure efficiency skills and knowledge are shared and retained in the region and available to respond to water scarcity/droughts as they emerge.
- Conducting analysis of the short and long run marginal cost of water in the region and modifying system trigger levels to incorporate efficiency triggers for system depletion and per capita water increase.
- Strengthening current regulations and building codes to better incorporate water efficiency, the incorporation of minimum water efficiency performance standards and source substitution/fit for purpose.
- Further investigating specific end uses of potential concern such as bidet toilets, combination condenser washer-dryers and evaporative coolers.
- Reviewing emerging water saving technologies and appliances of interest to identify specific innovations, which warrant obtaining further supplier information with a view to conducting customer trials and research.
- Conducting research into the methods used to calculate advertised water savings for specific technologies to establish best practice approaches and guidelines (e.g. with regards to baseline measures and for a range of patterns and frequencies of usage) that allow greater transparency and comparability of new products.
- Conducting customer research into the factors that shape decision making between alternative water using appliances and the role that water efficiency plays in relation to other factors such as convenience and comfort to understand opportunities and barriers to uptake of water efficient options.
- Conducting research into the range and comparability of different analytical methods that have been used to calculate water savings through behavioural changes using digital metering customer interfaces.
- Conducting analysis of the scalability of water savings achieved through digital metering and behavioural change when upscaling from small scale pilots up to full scale roll-outs.

- Conducting detailed customer research to understand the potential for more bottom-up approaches to digital customer interface design and opportunities that enable user-driven customisation.
- Conducting customer research and trials to understand opportunities for combining water consumption feedback with other sources of information (e.g. energy consumption feedback etc.) and novel ways of motivating engagement and water-saving behaviours (such as rewards, and gamification strategies).
- Conducting research into the opportunities that home automation presents for household water management with a view to understanding the combined future trajectory for both individual digital solutions (i.e. smart taps and showers etc.) and for household digital metering and the overall customer consumption interface.
- Conducting research into the feasibility of new services that could be provided by water utilities in the light of digital metering and monitoring that are enabling improved visibility of opportunities for targeted water savings (beyond leaks, to other end uses and appliances) and means for communicating these opportunities to consumers and incentivising action.

At a more detailed level the Melbourne and regional water utilities would benefit from exploring in the shorter-term options that may not have been previously used or utilised to the same degree as other jurisdictions such as:

Regulations

- *Standards/labelling and regulations and codes on buildings*

Residential measures

- *Residential home audits*
- *Clothes washing machine rebates*
- *Love Your Garden audits*
- *Evaporative cooler maintenance programs*
- *Rainwater tank programs including maintenance programs to improve savings.*
- *The High Water Users and One to One water saving programs*

Non-residential

- *The waterless wok program*
- *Glasswasher program*
- *Public open space program*

New examples

- *SWC MUDs/High Rise program*
- *Valencia Water – Water SMART and Allocations programs*
- *Thames Water – Propelair program*
- *Digital metering programs – Greenredeem.*

Also programs focusing on careful customer segmentation to tap into the more difficult customer groups will be necessary. In addition regional programs will need to also tap into larger family households to gain greater savings, specific segments such as holiday homes, maintenance programs for older properties, programs that take advantage of the “community spirit” as well as working one on one with the larger non-residential customers.

These are just a few of the opportunities that this rapid research study has identified. As we look to the future - efficiency, systems thinking and digital approaches will need to be integral to water and wastewater service provision going forward. Well-directed research, trialling and demonstration of innovative approaches will be essential. The Melbourne water service providers and government showed leadership in the water industry with the former Smart Water Fund and have a major opportunity to continue this leadership role as we embrace the transition to fourth generation infrastructure and the digital era.

Importantly, this research shows that others nationally and internationally are currently grappling with the same issues and thus collaboration and sharing of information will be key.

7 REFERENCES

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