Water smart homes in Greater Sydney:
A field guide for the future

Prepared for Sydney Water
By the Institute for Sustainable Futures

October 2021

Research Team

- Dr Rachael Wakefield-Rann
- Dr Simon Fane
- Alexandra Butler

Citation

Wakefield-Rann, R., Fane, S., Butler, A., 2021 *Water smart homes in Western Sydney: A field guide for the future*, prepared for Sydney Water Corporation, by Institute for Sustainable Futures, University of Technology Sydney, August 2021

Acknowledgements

We gratefully acknowledge Sydney Water staff for their substantial expertise and the time and interest they have dedicated to this project. This project was funded through the Sydney Water Water Conservation Innovation Fund and commissioned by Sydney Water.

We also thank the community members and experts interviewed for their time and insights, and visual communication studio Parallel Designs (www.parallellines.design) for their collaboration and development of the visual narratives.

About the authors

The Institute for Sustainable Futures (ISF) is an interdisciplinary research and consulting organisation at the University of Technology Sydney. ISF has been setting global benchmarks since 1997 in helping governments, organisations, businesses and communities achieve change towards sustainable futures. We utilise a unique combination of skills and perspectives to offer long term sustainable solutions that protect and enhance the environment, human wellbeing and social equity.

For further information visit: www.isf.uts.edu.au

Institute for Sustainable Futures
University of Technology Sydney
PO Box 123 Broadway, NSW, 2007
www.isf.uts.edu.au

Glossary of technology descriptions

A key of technologies as presented within the visual narratives in this project is included as Appendix A: Technologies within visual narratives key.

Table A Technology descriptions

Precinct technologies	
Bioretention bed	A soil bed where water drains through and removes soluble pollutants and organics by natural bacterial biofilms.
Rain garden	Designed landscape site that collects and filters stormwater to reduce flow rate, quantity and pollutant load of runoff.
Reuse tank	A tank for the temporary storage of filtered water for distribution around a precinct. Prompted to empty in preparation for rain events.
Smart irrigation	Irrigation system that automatically adjusts watering controller based on local conditions to respond to pre-set watering triggers.
Building technologies	
Green roof & walls	Live vegetation planted on the exterior roofs and walls of a building to assist greening and cooling and enhance privacy.
Leak control valves	The valve provides alerts for suspected leaks and can be set to automatically shut off water supply if a leak is detected.
Efficient hot water system	Energy efficient water heaters using electric heat pumps to reduce energy use.
Smart hot water	System that allows water heaters to behave like a 'battery', operating only at times when renewable energy from Photo Voltaic (PV) systems is cheap and abundant.
Smart meters	Meters that measure water use with a wireless communication capacity. High frequency readings provide data about water use patterns and potential leaks.
Social network platform	A smart phone or computer application that allows information to be shared to compare water use across apartments or buildings within a precinct or city.
Smart rainwater system	A system that provides accurate rainwater use data and assists with precinct level stormwater management.
Decentralised recycled water system	A system for in-building collection, treatment and reuse of wastewater.
Resource recovery system	A system for the sustainable separation and recovery of nutrients. Urine diversion technology in toilets is part of this system.
Home technologies	
Laundry	
Greywater processing unit	An innovative water recycling system that collects used water from the shower and processes it for safe reuse.
Smart control washing machine	Self-monitoring wireless connected machine that washes clothes effectively with less water and energy.
Kitchen	
Smart control dishwasher	A dishwasher with inbuilt auto load sensing technology that changes temperature and speed of wash to suit the load.
Smart control taps	A tap with smart features to record the number of activations and water use and stores the information in the cloud.

Bathroom	
Digital shower	Aftermarket add on that displays water used per shower and can light up to indicate different messages.
Healthy bathroom system	Integrated bathroom system that monitors resident's health. The mirror notifies the resident and app alerts the care manager.
Smart control shower	Networked shower with a control and notification display panel. Regularly updates the cloud on water usage.
Smart control toilets	This toilet is self-metered and able to detect and report on activations and water use.
Smart health toilet	A toilet that monitors for signs of disease through the analysis of biomarkers.

Executive Summary

This report presents the research from Stream 2 of a three-part project conducted by the Institute for Sustainable Futures for Sydney Water, exploring how smart technologies may transform water use practices in commercial buildings and homes in Greater Sydney, and particularly new areas in Western Sydney, over the next ten years. The focus of each Stream is:

- Stream 1: A trial of smart bathroom fixtures in commercial and public buildings to test their capacity to improve water and energy savings.
- **Stream 2: An exploration and visualisation of how smart water technologies could transform water use practices in the homes of the future in Greater Sydney across diverse communities.**
- Stream 3: A synthesis of the prior two streams that considers the implications of disruptive in-building digital water technologies for Sydney Water and the water industry over the next ten years.

The primary goal of Stream 2 was to understand the challenges, opportunities and considerations that may be raised through the implementation of water-connected smart technologies at household, building and precinct scales. In particular, the research investigated the implications for improving water conservation and other outcomes for water, wastewater and stormwater systems, and water users.

This Stream was focused on technologies and systems that may be adopted in newly developed and rapidly expanding areas of Greater Sydney and particularly in the high growth regions of Western Sydney. This is with a view to understanding how they may help realise the New South Wales (NSW) government's vision for the region as a liveable and sustainable, cool-green parkland city.[1] While the focus of this research has been in one region, the findings have implications for developments across the city as a whole.

The research findings have implications not only for Sydney Water, as it plans for and navigates a digital transformation, but also other utilities, property developers, urban planners, all levels of government, and communities involved in and impacted by the creation of a sustainable and liveable city.

Approach

To explore how smart technologies may transform water use practices in homes over the next ten years, and provide Sydney Water with useful insights to guide this transition, this research was based on an innovative transdisciplinary methodology combining social science, engineering and visual communication design. The approach included literature reviews, workshops and interviews with Sydney Water staff, community focus groups, expert interviews and the development of 'visual narratives' based on the types of development that can be expected in new areas of Greater Sydney.

Key findings

The research findings are expressed in a set of five hypothetical visual narratives designed to aid Sydney Water in thinking through the key questions, hurdles, and opportunities likely to emerge in a transition towards smart water systems and fixtures in homes across Sydney. The narratives each explore how the introduction of digital technologies into different types of domestic water practices and dwellings may create specific opportunities and concerns for different users and parts of the water system.

The narratives do not serve as predictions, nor do they endeavour to capture all the potential variables that may affect how smart water technologies are adopted into domestic practices, or their effects on different demographic groups or types of residential dwellings and infrastructures. Rather, they provide a conceptual tool through which some of the most salient questions and considerations that may emerge in planning for a digital transition within buildings and homes over the next ten years can be anticipated. The visual narratives are arranged according to the different types of dwellings that, based on key planning documents, are likely

[1] Sydney Water (2019), Re-imagining water in Western Sydney - Western Sydney Regional Master Plan, Sydney Water, Aecom Aurecon Joint Venture (AAJV), Marsden Jacob Associates.

to characterise new residential development within Greater Sydney and the 'Western Parkland City'[2] in particular. These include: a mid-range apartment complex, a high-end eco-luxury dwelling, a social housing development, and an aged care retirement village. We also present these dwellings in the context of a hypothetical precinct (see Figure A) to show how home practices and technologies may interact with the infrastructures and service providers at this community scale.

Figure A The hypothetical 'Precinct' showing the four explored dwelling types

The key visual narratives are:

Precinct. The precinct visual narrative develops a view of how the four hypothetical dwellings explored might be located in a neighbourhood in a newly developed area of Greater Sydney. It shows how certain building-level technologies have the potential to contribute to city-level water conservation and blue green infrastructure objectives, and how they might interact with other infrastructures at a precinct scale.

The Nest: mid-range apartments. The mid-range apartment visual narrative presents a typical medium-density apartment complex designed for young families, couples and single occupants expected to characterise a high percentage of the new development over the next decade. The narrative explores how diverse occupant groups with diverse water literacies and practices interact with water efficiency technologies in various ways that may create challenges and opportunities for water conservation and users.

Arcadia: eco-luxury apartments. The eco-luxury apartment narrative explores a high-end apartment building that has an 'ecosystem' of integrated smart water, energy and resource systems. While only accessible to a small portion of the population at present, this dwelling type models a view of what could be achieved should no barriers of cost, participation, technology, or data governance exist. It demonstrates the emerging capabilities of cutting-edge technologies and the opportunities and potential issues they may carry, in addition to the unique issues and challenges associated with hyper-connected systems.

The Green: social housing: Western Sydney currently has a high percentage of households living in social housing compared to the rest of NSW, and this is expected to increase further over the next decade.[3] Given

---

[2] Greater Sydney Commission (2018), Greater Sydney Region Plan: A Metropolis of Three Cities, https://www.greater.sydney/metropolis-of-three-cities/vision-of-metropolis-of-three-cities/western-parkland-city-vision, visited July 2021.

[3] SGS Economics and Planning (2018) *Demand for social and affordable housing in WSCD area*, report prepared for NSW FHA. Accessible online at: https://communityhousing.org.au/wp-content/uploads/2018/12/20180311-NSW-FHA-WSCD-Social-and-Affordable-Housing-Demand-Report-Variation-Update-FINAL.pdf

that these dwelling types often involve different tenancy arrangements and stakeholders to conventional rental properties, this visual narrative explores some of the specific issues, vulnerabilities and corresponding opportunities that exist for these households in a transition to more domestic smart water technologies.

Grevillia Gardens: aged care retirement village. In the context of an increasing ageing population in Greater Sydney, and NSW more generally, the state government has identified the need to provide options to enable people to remain self-sufficient for as long as possible.[4] This visual narrative explores some of the potential ancillary benefits that could be realised to support this population through the use of water-connected smart technologies for health monitoring and management, and the new considerations such technologies raise across private and institutional contexts.

A Field Guide for the Future

The final section of this report condenses some of the key considerations and questions raised in the visual narratives into a 'field guide for the future', which outlines six central themes or 'orientation markers' to help guide future planning and decision making for Sydney Water as they navigate a near term digital transformation. The orientation markers include:

Equitable benefits for users. Ensuring equal access to benefits will become increasingly important as technologies are rolled out in homes, particularly for socio-economically marginalised users.

Data privacy and trust. User trust in technology providers, including utilities, and the protection of user privacy will be essential to technology uptake and efficacy.

Technological interoperability. Effectively networked technologies from the scale of the household to the precinct will be crucial to the realisation of the numerous system benefits. Issues of how to connect diverse devices and support users and organisations to maintain them will need to be addressed.

Waste avoidance. Unnecessary electronic waste associated with digital technologies, and energy waste linked to non-essential data collection, should be avoided to prevent adverse environmental impacts.

Data coordination. The coordination of data governance operations and protocols between Sydney Water and other stakeholders (e.g. government, manufacturers) and internally will be crucial for system functionality and usability.

Infrastructure and maintenance. It is critical that new buildings and urban infrastructures are equipped to accommodate the introduction of smart technologies, and that there are adequate maintenance and upgrade protocols and resources to keep them functional. This may be an issue for smaller stakeholders such as 'mum and dad' landlords and some body corporates.

Next Steps for Research in this Area

The next steps in the current research program are the completion of Stream 1 (which is currently on hold due to the COVID-19 situation impacting occupancy at the trial site) and Stream 3, which will synthesise the research to date and engage a wider group of water industry stakeholders.

There are also a number of potential areas of research arising from this research program that Sydney Water could consider exploring. These include: an in-depth ethnographic exploration of how user practices are transformed by smart water technologies; new forms of engagement and targeted conservation messaging; trials of smart technologies at household and precinct scales; data sharing barriers and opportunities between utilities, product manufacturers and customers; smart hot water systems in a water and energy smart home; and the issues and options associated with avoiding waste linked to smart water technologies. These ideas are each described briefly in the Conclusions section of this report.

---

[4] NSW Govt (2020), Ageing well in NSW: Action Plan 2021-2022, https://www.facs.nsw.gov.au/download?file=798430

Contents

Appendices

Figures

Introduction

Sydney Water has commissioned the Institute for Sustainable Futures (ISF) at the University of Technology Sydney (UTS) to undertake a program of research exploring how smart technologies could transform water use practices and promote water savings in commercial buildings and homes in Sydney over the next ten years. As the city enters a period in which challenges associated with population growth, drought, an ageing population, urban heat and more extreme weather events are accelerating, emerging technological capabilities offer an opportunity to reconsider and reimagine how water is used to meet the needs of the city into the future.

This research program is divided into three research streams. This report relates specifically to Stream 2.

- Stream 1: A trial of smart bathroom fixtures in commercial and public buildings to test their capacity to improve water and energy savings.
- **Stream 2: An exploration and visualisation of how smart water technologies could transform water use practices in the homes of the future in Greater Sydney across diverse communities**.
- Stream 3: A synthesis of the prior two streams that considers the implications of disruptive in-building digital water technologies for Sydney Water and the water industry over the next ten years.

The overall research program is focused on emerging digital water technologies targeting end-uses, and their potential implications for water systems, water conservation and community water practices over the next ten years. In Stream 2, our goal is specifically to understand what role these technologies may play at household, building and precinct scales in improving water conservation and other outcomes for water, wastewater and stormwater systems. We focus on how systems may be affected in rapidly expanding areas of Greater Sydney and consider how these technologies might help realise the New South Wales (NSW) government's vision for a new, liveable, sustainable and cool-green Western Parkland City.[5]

The emergence and effects of digital technologies are still uncertain and will be significantly guided by the decisions of utilities, technology providers, governments and other stakeholders in the next few years. As a result, this research focuses on highlighting the potential challenges and opportunities that may emerge for Sydney Water as digital technologies unfold in the near future. The purpose of this report is therefore not to provide a prescriptive roadmap or set of actions, but to highlight key points where deliberation and decisions will be needed. These findings will be most relevant for Sydney Water but will also be of interest to other stakeholders who play a role in establishing the vision of a Western Parkland City or in the growth of Greater Sydney more broadly.

Stream 2: Aims and Scope

The aim of Stream 2 is to investigate the potential for and implications of smart water technologies intended to transform user practices in the home. In particular, our aims were to explore, the:

1. potential benefits of the inclusion of smart technologies in everyday residential water practices for different groups in the community and for rapidly changing urban ecosystems across Sydney;
2. potential concerns that these technologies, and the new data flows they create, may raise for the community and Sydney Water; and
3. key decision points for Sydney Water over the next ten years that will help guide the introduction of smart technologies into homes to ensure they generate outcomes that are equitable, and achieve maximum benefits for water conservation and the local environment.

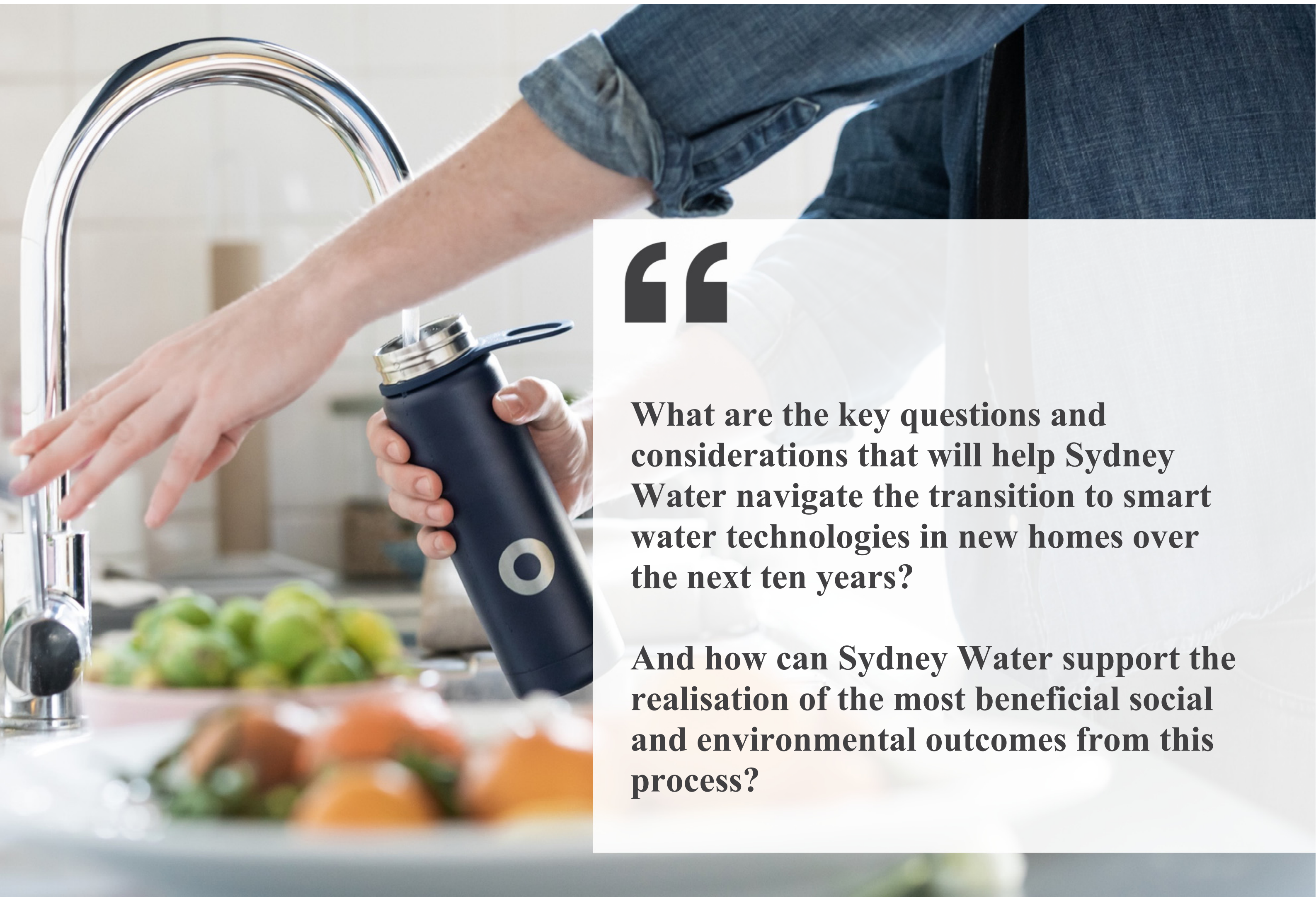
---

[5] Greater Sydney Commission (2018), Greater Sydney Region Plan: A Metropolis of Three Cities, https://www.greater.sydney/metropolis-of-three-cities/vision-of-metropolis-of-three-cities/western-parkland-city-vision, visited July 2021.

Given these aims, the key questions that guided Stream 2 of this research program were:

- *What are the key questions and considerations that will help Sydney Water navigate the transition to smart water technologies in new homes over the next ten years?*
- *And how can Sydney Water support the realisation of the most beneficial social and environmental outcomes from this process?*

The scope of this project is limited to transformations in new dwellings in the growing areas of Greater Sydney over approximately the next decade, although the impacts of decisions beyond this time horizon have also been considered. We also acknowledge that many existing homes across the city will be retrofitted with smart technologies during this period. While they are not the explicit focus of this report, many of the insights apply equally to old and new dwellings.



What are the key questions and considerations that will help Sydney Water navigate the transition to smart water technologies in new homes over the next ten years?

And how can Sydney Water support the realisation of the most beneficial social and environmental outcomes from this process?

Background and context

In order to investigate how smart water technologies may transform water systems and domestic practices in Sydney into the future it is important to understand the contextual factors likely to affect how they are implemented and adopted. This section presents critical background information for understanding:

1. The goals, challenges and plans guiding the development of Greater Sydney and the 'Western City',

2. The history and emerging trajectory of home water technologies, and

3. How smart home technologies have already transformed domestic practices for different groups in the community. While these are not the only contextual factors at play, they will be critical in guiding how digital water transformation unfolds in the future.

Growing a water smart city

A metropolis of three cities

In 2018 the Greater Sydney Commission (GSC) released the latest version of the Greater Sydney Region Plan: 'A Metropolis of Three Cities'. This plan sets out a vision for Sydney as three interconnected cities by 2056: the established Eastern Harbour City, the developing Central River City and an emerging Western Parkland City.[6] Liveability and sustainability are core elements of the plan, together with infrastructure and productivity. Water management underpins many of the Plan's objectives, including those addressing: waterway health, public open space, urban tree cover, green grids, water reuse, and extreme heat.

The Western Parkland City

The Western Parkland City vision is for a polycentric city with established centres at Liverpool, Greater Penrith and Campbelltown-Macarthur with a new city centre and commercial/industrial areas (such as Sydney Science Park) associated with an international airport at Badgerys Creek.[7] Central to the City vision is the development of a cool green corridor of parklands running along South Creek. Developments along this corridor are intended to be "cool and green neighbourhoods…with generous open space in a parkland setting"[8] with walkable and shaded suburbs and centres.

In meeting its vision for a new liveable and sustainable city in the Western part of Sydney, the GSC and NSW Government face a complex set of challenges[9], including:

- Rapid population growth, with the number of residents expected to reach over 1.5 million people by 2056 – around double the current figure.
- Unprecedented infrastructure investment, with over $6 billion committed to projects in the region. This will create capacity constraints as well as localised environmental impacts.
- Climate change, with hotter and drier conditions expected in coming decades. In early 2020 Penrith experienced a day time temperature of 48.9.C. Such peaks are projected to increase.
- A heat island effect. Already a dry and hot area, Sydney's west had 46 days over 35ºC in 2018. The metropolitan area is commonly significantly warmer than its surrounds. This is due to hard surfaces absorbing heat and a lack of green spaces with enough shade or cool/wet areas.

---

[6] Greater Sydney Commission (2018), Greater Sydney Region Plan; A Metropolis of Three Cities, https://www.greater.sydney/metropolis-of-three-cities/vision-of-metropolis-of-three-cities/western-parkland-city-vision, visited July 2021.

[7] Ibid.

[8] Ibid.

[9] Sydney Water (2019), Re-imagining water in Western Sydney - Western Sydney Regional Master Plan, Sydney Water, Aecom Aurecon Joint Venture (AAJV), Marsden Jacob Associates.

- Water security, with major droughts becoming an increasing concern. Dry periods are intensifying and becoming longer as the climate shifts. Currently, the region's water security is reliant on potable water supplies and adequate rainfall in the Warragamba Dam catchment.
- Pressures on regional waterway health. As the region's urban footprint expands, more pressure will be placed on the sensitive waterways of the Hawkesbury-Nepean River system. Traditional forms of development produce urban run-off that both pollutes and creates damaging water volumes after rain. Public access demands on waterways will also increase in line with population growth.

Water management for the Parkland City

To meet the Western Parkland City vision, land and water planners have acknowledged that there is a need for a new approach to water management in the region.[10] This includes the need for wastewater reuse and stormwater harvesting. There have been several initiatives dedicated to imagining and planning for (at a strategic level) integrated and sustainable urban water management.

A 'Sector Review' of South Creek has been led by Infrastructure NSW.[11] The review has advised the NSW Government on options and decisions for achieving the vision of a cool green parkland city that integrates land use and water cycle planning. It has involved the development of:

- Landscape design guidelines and a blue/green infrastructure framework
- A series of potential recycled water schemes
- A regional stormwater and waterway management plan
- Organic waste management planning for food and green wastes
- Urban design principles to mitigate the heat island effect
- A regional flood model.

Sydney Water has developed a Regional Master plan for Western Sydney.[12] The plan looks at four alternative servicing pathways towards either a:

- Drained City, based on conventional servicing
- Water Cycle City, with non-potable wastewater reuse and stormwater harvesting to retain water within the landscape
- Water Centric City, with decentralised integrated water servicing throughout the region based on small scale recycled water and stormwater harvesting at a precinct scale
- Water Resilient City, with wastewater and stormwater captured and purified for drinking water.

Their analysis determined that the current 'Drained City' pathway would not deliver the vision of a 'green and blue' Western Parkland City. Instead, a 'Water Cycle City' pathway would be more likely to achieve this vision, with the potential to move onto either a 'Water Centric' or 'Water Resilient' pathway in the future.

The Department of Planning Industry and Environment (DPIE) is currently finalising the Greater Sydney Water Strategy which will replace the 2017 Metropolitan Water Plan and address water security for Greater

---

[10] Harris, C., (2020) Rethinking water to make for a better and more liveable Western Sydney, Built Environment, WaterSource, Australian Water Association, https://watersource.awa.asn.au/environment/built-environment/rethinking-water-make-better-more-livable-western-sydney/ ; Sydney Water (2020) Urban Typologies and Stormwater Management – achieving a cool, green, liveable Western City Parklands, Report by Bligh Tanner, Architectus and Sydney Water, 2020.
[11] Infrastructure NSW (2020) Infrastructure NSW Annual Report 2019-20, https://www.infrastructure.nsw.gov.au/media/2735/annual-report-2019-2020-insw.pdf, July 2021.
[12] Sydney Water (2019) Re-imagining water in Western Sydney - Western Sydney Regional Master Plan, Sydney Water, Aecom Aurecon Joint Venture (AAJV), Marsden Jacob Associates.

Sydney[13]. The development of the Strategy has taken a whole of water cycle approach, considering each of Sydney's regions, with the aim of securing Sydney's water supplies against drought and climate change[14].

In supporting the Western Parkland City vision, Sydney Water has initiated a number of innovative projects and trials, including a:

- local water recycling plant, with innovative recycled water services and a research facility at the Sydney Science Park[15]
- trial of smart irrigation with recycled water for cooling and greening at Sydney Olympic Park[16]
- trial of 'Hydraloop' in-home greywater recycling systems[17]
- trial of smart metering with customer feedback with Sydney Water staff[18]
- planned trial of the use of smart irrigation for urban cooling and greening.

By exploring the role of smart devices, this current program adds to these innovative trials (with the Stream 1 commercial building pilot). The current report also highlights the potential for further trials of smart water devices in various residential settings in the future.

The evolution of home water technologies in Australia: from efficient to 'smart'

The emergence of efficiency

Water technologies in the home have undergone many superficial changes over the last century, from the replacement of ornate wooden toilets with ceramic, to refrigerators with ice machines, yet many water technologies have largely remained functionally unchanged for decades.

One notable trend in domestic water technologies has been the move towards greater water efficiency since the mid-1980s. Beginning with the development of the dual flush toilet in Australia, the efficiency of domestic water fixtures and appliances has increased significantly since this time.

The Millennium drought (1996-2010) saw a national focus on water demand management and increased water efficiency across the country. This shift towards greater efficiency was driven by a combination of technical innovation, government regulations such as the WELS (Water Efficiency Labelling and Standards) scheme in 2006, large-scale utility lead programs, and a wide range of communications campaigns promoting water saving to communities. These measures were also accompanied by a move to individual metering for most properties (if not all apartments) and to volumetric pricing for water used from scheme supplies in almost all Australian jurisdictions. The combined impact was a dramatic decrease in the amount of water used within homes and buildings across Australia. The drop in Sydney's total demand from 500 L/p/d in 1990, to 425 L/p/d in 2003, and 277 L/p/d in 2020 is evidence of these changes and innovations.[19]

Since this time, demand levels across the state have been relatively consistent in residential environments, despite a steady increase in the population. Reasons are likely to be an increase in public awareness of water efficiency, higher levels of efficient products on the market, higher water prices, increases in recycled water and wastewater treatment and improved leakage management.[20] While these savings show promise and the capacity for change in water use practices, further engagement is needed to prepare communities

---

[13] Planning Industry & Environment (2021) Planning for Sydney – Sydney Metropolitan Water, https://www.planning.nsw.gov.au/About-Us/Sydney-Metropolitan-Water/Planning-for-Sydney, visited July 2021.
[14] NSW Department of Planning industry and environment (2020) NSW Submission to the Productivity Commission Inquiry into National Water Reform https://www.pc.gov.au/__data/assets/pdf_file/0005/274550/subdr138-water-reform-2020.pdf, July 2021.
[15] Pavey, M., (2020) Sustainability Partnership Builds Water Resilience in the West, Media Release, https://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mjm0/~edisp/dd_234351.pdf.
[16] Pers Com Andrew Tovey, TULIP Program Manager and Senior Research Consultant at ISF, April 2021.
[17] Pers Com Andre Boerema from Sydney Water, May 2021.
[18] Pers Com Monica Heinrich from Sydney Water's CX lab, August 2020.
[19] Sydney Water (2017) Water Conservation Report 2016-2017, http://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mdq3/~edisp/dd_047419.pdf
[20] Ibid.

for continued challenges of climate adaptation, population growth and to meet requirements of the Sustainable Development Goals (particularly SDG 6 clean water and sanitation and SDG 11 sustainable cities and communities).

The shift towards water efficient fixtures and appliances has had profound implications for cities and urban areas across Australia, and the utilities that service them. The cost savings in avoided infrastructure, including reduced demand for large scale new supplies (particularly dams) and across networks, have been significant. The outcomes for water utilities have also been largely beneficial in terms of cost savings, water taken from waterways, decreased releases of effluents, energy and greenhouse savings as a result of (principally hot) water being saved. However, there have been some negative impacts for utilities, such as lower water sales, and isolated reports of impacts to sewers from lower wastewater flows that have needed to be managed. In addition to these material impacts, the shift to efficiency has fundamentally transformed how water demand is conceived of and forecasted and the role of utilities in demand management.

This transition to greater water efficiency in appliances continues to progress. Some showers are now available that have as low a flow rate as 5 L/min and recycling shower units exist that circulate the water until it reaches an ideal temperature and exits the showerhead.[21] Advancements have also been made in white goods, where a number of waterless technologies have been added. Washing machines are now available that use nylon polymer beads instead of water to clean clothes, which are more absorbent than water and remove stains effectively.[22] Vacuum or air jet assisted toilets are also becoming increasingly available in a commercial setting, with the potential to extend to domestic buildings in the future. Some of these allow for separate collection of food and other waste for anaerobic digestion, energy generation and nutrient recovery.

In parallel to these recent advancements in water efficiency, a range of digital water technologies have begun to emerge. Findings from ISF's review of emerging digital technologies has been included as Appendix B: Emerging digital technologies. Depending on how these technologies are designed and implemented, they could drive further water use efficiency and water conservation, in addition to other beneficial outcomes for communities and the environment. As with the 'water efficiency revolution' before it, the emergence of smart water technologies within homes is likely to have a range of anticipated and unexpected impacts on utility systems and water users.

Digital transformation

At a whole-of-society level, digital transformation includes concepts such as the Internet of Things (IoT), Big Data and Smart Cities, and the many new forms of technologies, infrastructures and expertise that accompany them. As there is no commonly agreed upon definition of digital transformation, it is used variously to describe both emerging technologies and infrastructures, and new organisational practices and outcomes for society.[23] It is not only affecting the way that businesses, organisations, processes and information systems are organised, but changing the types of experts who have the knowledge to transform how societies use resources. Digital transformation also refers to how everyday life is increasingly shaped and mediated by digital technologies and information. According to Hoolohan et al.[24], when taken together, these definitions of digital transformation "…encompass the mechanisms through which transformations occur, and the outcomes by which their social, political, and ecological implications can be observed."

In the context of the water sector, digital technologies are being developed for a range of uses with the potential to provide many benefits for water systems, utilities and users. Some examples of potential improvements include:

---

[21] Liu, A., Turner, A. & 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.
[22] Xeros Technologies (2021) Technologies – Sustainable Technology for Consumers and Industry, https://www.xerostech.com/technologies, visited July 2021.
[23] Hoolohan, C., Amankwaa, G., Browne, A.L., Clear, A., Holstead, K., Machen, R., Michalec, O. and Ward, S., (2021). Resocializing digital water transformations: Outlining social science perspectives on the digital water journey. *Wiley Interdisciplinary Reviews: Water*, *8*(3), p.e1512.
[24] Ibid.

- Remote sensing, accessibility[25] and enhanced visualisation capabilities to improve monitoring and predictive capacity for water flows and water quality, which may aid in the anticipation of problems caused by drought, contamination, and floods.
- Digital metering (or smart metering) both within utility networks and for individual properties, which provides real time and higher frequency data of flow rates and volumes. This data can help extend the life of assets, reduce leaks and improve the reliability of water and wastewater systems.
- Improved modelling capacity of complex water systems through Big Data to reduce uncertainties and promote improved risk management.
- Machine learning and artificial intelligence to enable understanding of complex water flows and events.
- Virtual or augmented reality technologies such as digital twins to simulate infrastructures for training and maintenance.
- Blockchain and cryptocurrencies to improve the transparency of water-related transactions to improve security.
- SCADA (Supervisory Control And Data Acquisition) systems, to improve monitoring and control of a wide range of water and wastewater networks and treatment systems.

In homes and buildings a range of new appliances, fixtures and devices are being introduced that incorporate innovative and new elements that often challenge the original affordances of products. The capabilities of existing technologies are being pushed and extended to enable more ways of understanding and engaging with water use practices to further improve water systems.

Aside from the adoption of smart technologies developed by appliance manufacturers with the goal of improved efficiency, smart technologies provide opportunities to enable the community to play a greater role in collecting data on different aspects of water based on their own needs and concerns, such as localised water contamination and quality, and how building pipes and other infrastructure are affecting drinking water. In addition to these potential benefits for water conservation and the functionality of water systems, community organisations around the world have developed a range of low-cost digital sensing devices to enable greater citizen participation in data collection, based on concerns they care about. For example, the open source, low-cost water monitor RIFFLE[26] was created to document water quality up and downstream of potential polluters and the toilet sensor CATTfish, designed to detect when water has been polluted by fracking.[27]

Citizen engagement in the development and deployment of smart technologies can also help achieve precinct and city-level sustainability objectives by providing new and more forms of data. This may come in the form of greater engagement in researcher-led citizen science programs, or sensing for the purpose of more participatory forms of decision making. Even in places where water quality does not present an immediate health hazard to local environments, citizen sensing practices can help to establish deliberative processes that allow citizen priorities and concerns to be included in decision making and planning.[28]

Accounting for social practices

The way that people conduct everyday activities such as laundering their clothes or getting ready for work in the morning, are largely responsible for how much water and energy a home consumes and how much waste it produces. Extensive research has demonstrated that changing social standards for hygiene and

---

[25] Watson, R., Mukheibir, P., Falletta. J., & Fane, S. (2018).The Bathroom of the Future – Prospects for Information and Control, prepared by the Institute for Sustainable Futures (UTS) for the GWA Bathrooms and Kitchens Group.
[26] ReyMazon, P., Keysar, H., Dosemagen, S., D'Ignazio, C., & Blair, D. (2018). "Public Lab: Community Based Approaches to Urban and Environmental Health and Justice". *Sci Eng Ethics*, 24, 971–997.
[27] D'Ignazio, C., & Zuckerman, E. (2017). "Are we citizen scientists, citizen sensors or something else entirely? Popular sensing and citizenship for the internet of Things". In B. S. De Abreu, P. Mihailidis, A. Y. L. Lee, J. Melki, & J. McDougall (Eds.), *International handbook of media literacy education* (pp. 193–210). New York: Routledge.
[28] Pritchard, H., & Gabrys, J. (2016). "From citizen sensing to collective monitoring: Working through the perceptive and affective problematics of environmental pollution". *GeoHumanities*, 2(2), 354–371.

cleanliness, thermal comfort, and increasing time pressures, among other trends, have contributed to higher levels of resource and energy use in the home.[29] While it is easy to blame individuals for these changes in practice, and propose that they can be solved via improved education and awareness, these are trends observed at a whole-of-society level. Practices are often tied to what is socially acceptable (e.g. it is not acceptable to wear the same shirt two days in a row to work), time pressures that make it difficult for people to choose a more sustainable, less labour intensive options (e.g. putting clothes in the dryer rather than hanging them out), or infrastructures and technologies that encourage people to consume resources in a particular way (e.g. the standard cycle on some washing machine programmed for high usage). Addressing unsustainable levels of water use, and associated energy use, in the home must therefore account for social conventions, how our bodies have become habituated into certain ways of doing things, and how technologies and infrastructures guide behaviour in particular ways.

There has been limited research to date examining how smart water technologies influence water use practices. However, there is an emerging body of research in Australia examining the use of smart energy-related technologies in the home. This highlights the importance of understanding the diversity of device use practices, and the different types of constraints, priorities, materials and cultural factors that determine if and how technologies are adopted. Importantly, it also considers if technologies function as intended and benefit their users. Research into how these technologies have been envisaged, who they have helped or excluded, their uptake and use, as well as their realisation of intended benefits may be instructive for what may be expected in the water sector.

The report *Digital Energy Futures: review of industry trends, visions and scenarios for the home*[30] evaluated the prevailing assumptions that are present in industry generated scenarios about how people will engage with energy-related smart technologies in the home. Some key findings that question the assumptions of technology providers and energy utilities that may also have relevance to smart water technologies included:

- Many people do not want to be active digital technology users.
- A diversity of often conflicting preferences and practices are operative within each home.
- Technologies will need to accommodate external disruptions (such as extreme heat events or pandemics) and practice fluctuations (new people moving into the home), rather than assume rigid and consistent practices.
- The labour and responsibility for repair and maintenance is often significant.
- Technology “lock in”[31] that prevents devices from being easily swapped, removed or upgraded is a risk with certain smart technology providers.
- Participants experienced a higher level of difficulty with the installation and operation of off-the-shelf technologies than was expected, and often reported limited benefits.
- Operational and installation difficulty, device interoperability issues and limited or unreliable access to smartphones and supporting infrastructure restricted the potential usefulness and benefits of smart home systems. They found that technology enthusiasts, men and energy vulnerable households were more likely to successfully install and use the devices.
- Some households, and particularly those with children, were unsure or worried about the entry of more digital technologies into their home lives.

[29] Shove, E., Pantzar, M. & Watson, M. (2012) *The dynamics of social practice: Everyday life and how it changes*, Sage Publications; Strengers, Y. & Maller, C. (2014) *Social practices, intervention and sustainability: beyond behaviour change*, Routledge.
[30] Dahlgren, K., Strengers, Y., Pink, S., Nicholls, L., & Sadowski, J. (2020). Digital energy futures: review of industry trends, visions and scenarios for the home. Monash Emerging Technologies Research Lab. Accessed 1 July 2021: https://www.monash.edu/__data/assets/pdf_file/0008/2242754/Digital-Energy-Futures-Report.pdf
[31] Technology lock-in broadly refers to a process by which a technology supplier necessitates that for certain technologies, and the systems they operate within, to function they must only use their products. Technology users consequently become stuck with a certain system or supplier, even where they may be better off with an alternative.

Research has also found that specific groups within the community will face different challenges and receive different benefits from using smart home technologies. For example, in the recent study *Smart Homes for Seniors*[32], researchers found that older Australians served to gain significantly through the use of smart technologies for purposes such as remaining connected to family, maintaining everyday routines through reminders, and labour-saving functions. However, these groups also strongly depended on high levels of ongoing technical support to use and troubleshoot the devices. They also often struggled with the physical capabilities required to use them such as hearing and tactile strength. These findings have important implications for the way that smart water technologies are integrated into homes in the future.

This project considers how the integration of smart water technologies into diverse peoples' homes may influence their practices, and how these in turn may modulate the efficacy and uptake of smart technologies. We take practices to mean the combination of materials (infrastructures, technologies, products, objects and bodies) meanings (ideas, motivations and values) and competencies (bodily skills, knowledge and habits) that make up everyday life and guide how resources are used in the home.[33] For example, showering is a practice that involves water, a shower, personal care products, a water heater, and all the pipes and other infrastructures that deliver this water to and away from the bathroom (materials). It also involves the mobilisation of ideas about what it means to look, smell and feel clean, how often society expects one to clean, commitment to water conservation and responsibility, or a desire to save money (meanings). Finally, it involves actions that relate to how one has been taught to shower properly, how to use the soap and shampoo, and what it feels like to be clean (competencies).

To address the project aims, we sought to consider how the everyday practices of different groups of people in new areas of Greater Sydney will have effects on, and be affected by, the introduction of water smart technologies in the near future.

[32] Strengers, Y., Duque, M., Mortimer, M., Pink, S., Eugene, A., Martin, R., Nicholls, L., Horan, B., Thomson, S. (2021), *Smart Homes for Seniors: Intelligent Home Solutions for Independent Living*, Final research evaluation report, McLean Care, Monash University and Deakin University, Melbourne, Australia.
[33] Shove, E., Pantzar, M. & Watson, M. (2012) *The dynamics of social practice: Everyday life and how it changes*, Sage Publications; Strengers, Y. & Maller, C. (2014) *Social practices, intervention and sustainability: beyond behaviour change*, Routledge.

Methodology

This project has melded social science methods with engineering and visual communication design (see Figure 1 Methodology diagram). Our transdisciplinary[34] methodology has been both collaborative and evolutionary in its development, and focused on exploring the issues raised by introducing smart water technologies into homes and communities from various perspectives.

The approach is innovative and represents a first for the water industry in the way it explores the connections and mutual influence of diverse social practices that occur within dwellings, and the practices of institutions and infrastructures at the precinct scale. It does this through a combination of qualitative research – including interviews with experts across the water industry, housing, smart technology and data governance, and focus groups with community members – and desktop research and visual narratives.

We present hypothetical visual narratives of the near future that retain a state of ambivalence in which multiple potential futures remain possible depending on decisions that are made at critical junctures. These are intended to raise important questions, and highlight the flow-on effects of decisions across the connected social, environmental, institutional and technological systems considered. In doing this, they embody the contingent and often messy interactions that may emerge when diverse, interacting aspects of a transition to a smart water future are considered together. This approach diverges from and complements many common ways of visualising speculative future scenarios with utilities, which tend to explore sets of extreme trajectories in isolation.

The value of the approach taken in this project lies in its potential to highlight key considerations and questions to guide deliberation and action over the next ten years based on the developments Sydney Water are likely to encounter. Perhaps most importantly, this approach to visualising the future enables the exploration of the different types of issues and benefits that might arise for different parts of the community. These include age, socio-economic status and cultural background, as well as the interaction of these factors with the design of the dwellings and technologies. The demographic groups and dwelling types selected were informed by the range of planning and forecasting reports relevant to GSC's Western Parkland City and discussed in the 'Growing a water smart city' section of this report.

Finally, the literature review, qualitative research and visual narratives informed the 'field guide for the future' presented in the final section of this report. This guide provides a set of 'orientation points' to help Sydney Water navigate key considerations and questions that may arise in response to certain actions (or inaction), involved in the implementation of systems related to digital transformation. While primarily highlighting considerations for Sydney Water, the field guide also indicates where actions may need to be taken by other actors (such as policy makers, planners and developers) for certain interventions or technologies to achieve the desired outcomes.

[34] Definitions of transdisciplinarity are diverse. We take ours from: Wickson, Carew, Russell (2006), Transdisciplinary research: characteristics, quandaries and quality, *Futures* 38, 1046 -1059

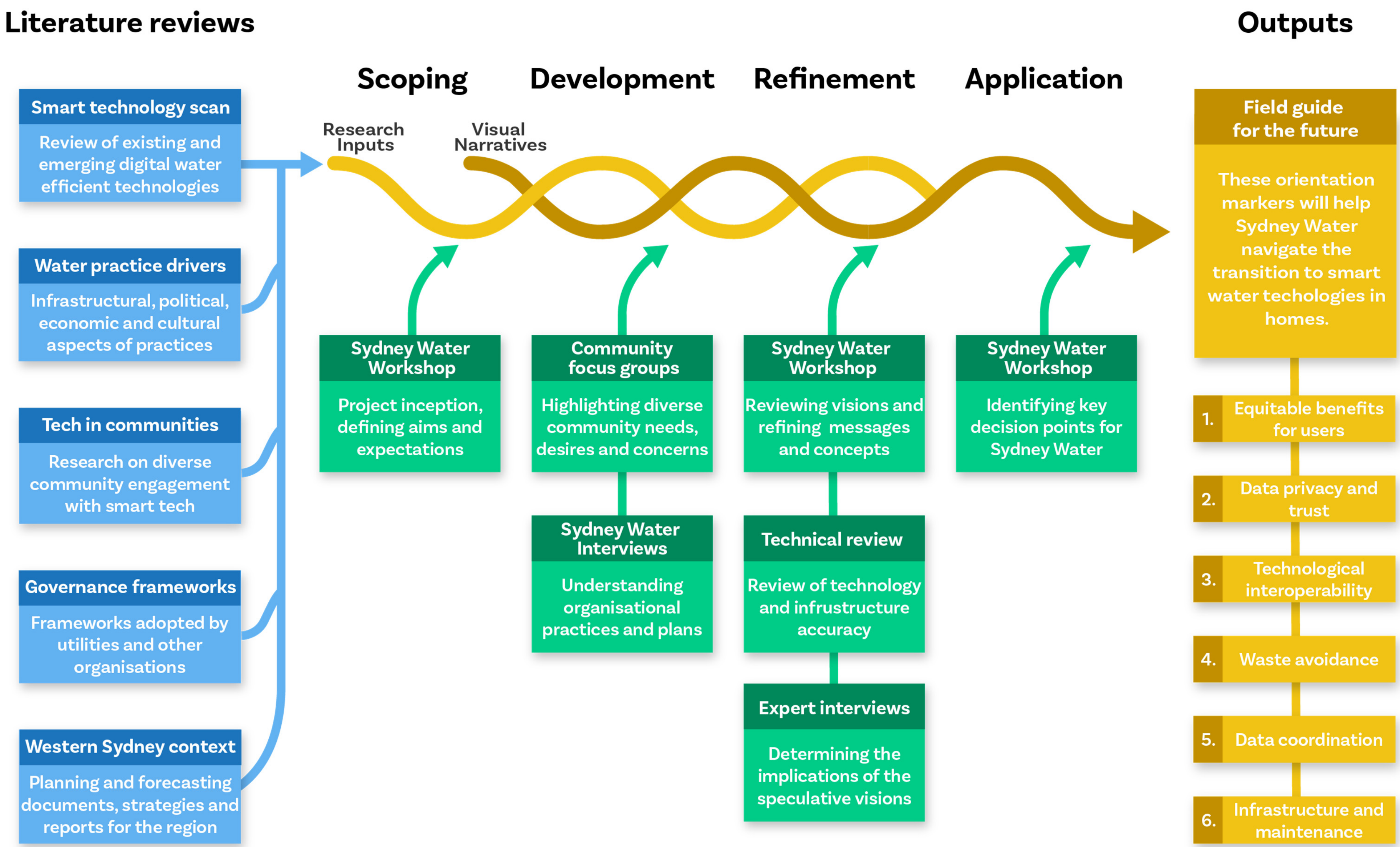


Figure 1 Methodology diagram

Methods

As shown in Figure 1 the project involved a first stage of reviewing a wide range of information to provide the initial inputs for developing the visual narratives and 'field guide for the future'. This was followed by a second stage of scoping, development, refinement and applying of the visual narratives. The final stage of the research included developing outputs and reporting. The methods utilised in the research are described below.

Literature reviews

The first stage of the project involved high level, targeted literature reviews covering the following areas:

- Structural drivers of domestic water practices
- The infrastructural, political, economic and cultural aspects of domestic water practices in Australia and internationally.

Community experiences of smart/digital domestic technologies

This included a review of academic and grey literature, examining how diverse communities have engaged with smart technologies in the home in Australia, and the challenges and benefits that have emerged for different groups.

Data governance frameworks for smart technology

Several frameworks exist that that have been adopted by utilities and other relevant organisations to ensure the effective and ethical management of data from digital devices. These were examined for their relevance.

Visions and scenarios for Greater Sydney and the Western Parkland City

A review of the current Greater Sydney planning context included planning documents, strategies and reports from state government, planning authorities and utilities, indicating the relevant planning priorities and forecasts for the Western Sydney region.

Smart technology scan

As part of the first stage of the project we also conducted a smart water technology scan. Our aim was to understand the types of digital water technologies currently on the market and in development, and the types of practice changes they are promoting. We reviewed over 300 distinct technologies designed for use within homes, buildings or groups of buildings (precincts). From this review, patterns emerged regarding the focus of innovation and the types of changes they are attempting to promote.

The review included technical databases (BlueTech Research[35] and W-Lab Isle Portal[36]), water efficiency certifiers (e.g. Smart Approved Water Mark), suppliers (e.g. Bunnings, The Good Guys, Harvey Norman and Reece) and manufacturer websites of specific technologies the identified smart water-connected domestic technologies that are currently on the market or under development.

Sydney Water Workshops

Three workshops with staff from diverse areas of Sydney Water were conducted over the course of the project. The purpose of Workshop 1 was to understand the key needs and priorities of Sydney Water, and the relevant programs they were already running. Workshop 2 involved a review of progress and findings based on the literature review, interviews and focus groups. Workshop 3 focused on the implications of the findings for Sydney Water and how they could be usefully integrated into future planning.

---

[35] BlueTech Research (2021) https://www.bluetechresearch.com/, accessed Dec 2020
[36] W-Lab Isle Portal (2021) https://www.isleutilities.com/services/w-lab, accessed Dec 2020

Focus groups and interviews

To learn more about the needs and concerns of the community, and refine our understanding of the social and technical aspects of a transition to greater integration of smart water technologies in homes, we conducted community focus groups, interviews with Sydney Water and interviews with external experts.

Sydney Water interviews

Interviews were conducted with Sydney Water staff in roles across the organisation to understand their needs, challenges, priorities and plans. These included people focused on the following areas: public health; data management and governance; digital technologies; user experience; water efficiency programs; strategy and planning; service planning and waterway health.

Community focus groups

Five online focus groups were held over February and March 2021 with 34 Sydney residents from diverse demographic groups to understand: Their needs, concerns, interests and thoughts about the integration of smart water-connected technologies into their homes; and gain feedback on the initial findings and ideas developed by the researchers characterising the key opportunities and challenges for water-connected smart domestic technologies in the near future.

Expert interviews

To test the findings and assumptions developed in our literature reviews, focus groups and Sydney Water interviews, we conducted online interviews in April 2021 with experts who understand specific social and institutional dimensions of technological uptake in different communities. This included consultation with a government representative working in social housing and a social scientist with expertise in the relationship between changing water technologies and water practices across diverse contexts. We also sought interviews with aged care providers and developers to further nuance our understanding of these contexts, but did not receive a response.

Visual narrative design

Based on the findings of the literature reviews, technology scan and initial Sydney Water workshop, we engaged a visual communication designer, Parallel Lines, to develop a set of visual narratives depicting hypothetical near future (ten years) domestic water practices using digital technologies. The value of using visual narratives over plain text is its capacity to make complex scenarios and relationships tangible in a way that brings them to life. This process also highlighted relationships and questions that provided a unique way for us to explore and understand some of the challenges, opportunities and trends that may emerge for Sydney Water. The visual narratives were developed in a highly iterative process including the ISF research team, the designer, and feedback from Sydney Water, external experts and the community via the focus groups.

Visual narratives: exploring potential water smart homes

This section presents five visual narratives to aid with the thinking through of the key questions, hurdles, and opportunities likely to emerge in a transition towards smart water systems and fixtures in homes in Greater Sydney, with a particular focus on the new areas developing in Western Sydney, over the next ten years. Each visual narrative explores one or more of the most critical considerations, possible developments and questions for Sydney Water that arose in our desktop and qualitative research. As noted above, the visual narratives to do not serve as predictions, nor do they endeavour to capture all of the potential variables that may affect the adoption of smart water technologies and their effects on different groups or infrastructures. Rather, their purpose is to provide a conceptual tool through which some of the most salient questions and considerations that may emerge in planning for a digital transition can be anticipated.

Figure 2 The hypothetical 'Precinct' showing the four explored dwelling types

The visual narratives each present flows of water and data that are likely to be affected by the introduction of water-connected smart technologies in the home, including the variables influencing these flows and the related consequences. The visual narratives are arranged according to the different types of dwellings that are likely to characterise new residential development in the region based on key planning documents, and the range of relationships to water, data and technology that these infrastructures may create. These include: a mid-range apartment complex, a high-end eco-luxury dwelling, a social housing development, and an aged care retirement village. We also present these dwellings in the context of the speculative precinct to show how home practices and technologies interact with the infrastructures and service providers at that scale. Importantly, each visual narrative shows how diverse home practices and technological configurations influence how the technologies may function, both in the house and as part of interconnected environments, and the factors that may influence the realisation of their intended benefits. More detailed descriptions of the visual narratives and their elements are presented below, including the key considerations and opportunities for Sydney Water going forward, and additional considerations that emerged in the exploration of each narrative.

When viewing the visual narratives it is important to keep in mind:

- There are many stakeholders that will play an important role in the transition of homes to smart water technologies. While we have indicated certain points where these agents exert influence, the scope and intention of this project is to highlight the key decision points and domains of action and responsibility for Sydney Water. Future projects focused on mapping the other stakeholders and their responsibilities and influence could complement this work.
- Each visual narrative does not capture all potential technologies or practices within an imagined dwelling, rather they are each intended to highlight a particular aspect of a system or practice.
- The visual narratives are not prescriptive, but exemplify potential eventualities, practices and combinations of technologies for the purpose of thinking through outcomes and key decision points.
- Water and data flows are indicative only and have not been quantitatively modelled.
- It has been a focus of the project to ensure that a diverse range of technologies, dwelling types and practices have been displayed, but there will be some systems and groups that are not represented due to the limits of the visual format and the project.

As some of the visual narratives are quite information rich, please note that all the visuals have also been included in a larger landscape orientation as Appendix C: Visual narratives.

The Smart Precinct

Figure 3 The smart precinct overview

Context

Water use at the precinct level is integral to Sydney Water's water cycle management planning.[37] The precinct visual narrative develops a view of how the four hypothetical dwellings explored might be located in a neighbourhood in a newly developed area of Western Sydney.

To align with the broader NSW Government and GSC vision for a Western Parkland City, Sydney Water has developed 'urban typologies' for precincts, characterised by cool, green, urban neighbourhoods. These typologies have been considered in the development and refinement phase of this visual narrative.[38]

This visual narrative also shows how certain building-level technologies have the potential to contribute to city-level water conservation objectives, and how they might interact with infrastructures at a precinct scale. Several precinct scale smart technologies have also been incorporated, including those related to stormwater harvesting and management, water quality and quantity monitoring, and water reuse.

[37] Hoban, A., Freeman, J., Mendis, H., Stanish, O., Ip, I., Gillam, P. & Saunders, E. (2020) Western Parkland City: Urban Typologies and Stormwater Solutions. Report by BlighTanner, Architectus and Sydney Water, May 2020
[38] Sydney Water (2020) Urban Typologies and Stormwater Management – achieving a cool, green, liveable Western City Parklands, Report by Bligh Tanner, Architectus and Sydney Water, 2020

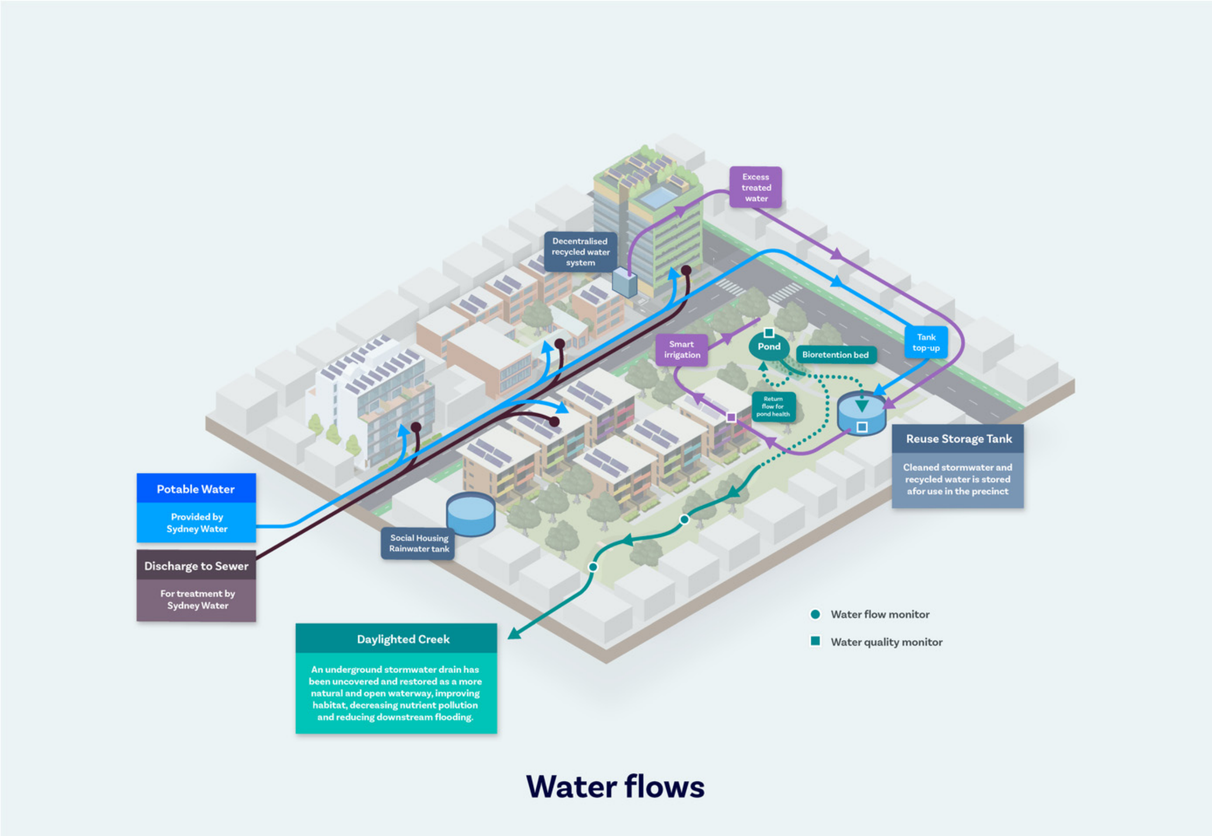


Figure 4 Precinct water flows

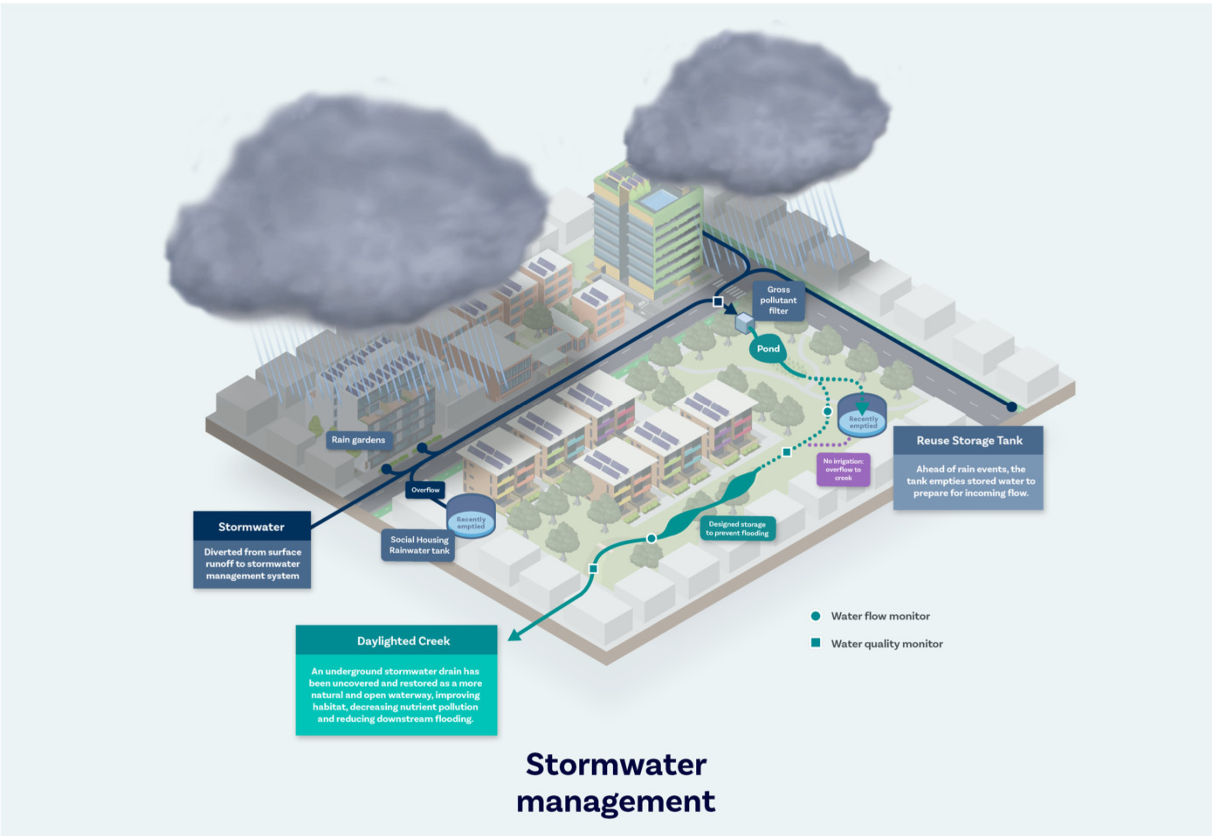


Figure 5 Precinct stormwater management

Key considerations

- **Integrated systems**. If technologies are considered in isolation (i.e. only at a dwelling level), rather than as part of an integrated planning approach, there is a risk of precinct-wide benefits being lost. We highlight several benefits associated with early integration, such as the capacity to use excess recycled water from an apartment block for irrigation in precinct open spaces.
- **Targeted and consistent conservation messages.** If users are receiving different sets of targeted conservation messages from technologies at the precinct and dwelling scales, there is a risk of causing confusion or an excess of communication that may prompt residents to disengage. A coordinated approach to messaging across scales may therefore be required.
- **Inequality.** Existing inequalities and vulnerabilities in the community may be exacerbated by barriers to technology access and control throughout a precinct. Along with other stakeholders such as manufacturers and government, water utilities can play a role in shifting barriers to access for disadvantaged users.
- **Data coordination**. If robust data governance structures are not set up initially it may become increasingly difficult to amalgamate and access water use data from different data owners across the precinct. If this challenge is not effectively managed, detailed data from entire buildings may be only accessible to private water utilities and not Sydney Water.

Opportunities

- **Insight into water use**. Smart technologies can provide a picture of how different parts of the city are using water over time, from the dwelling to the regional scale, highlighting where additional support or infrastructure may be required.
- **Cooling and greening.** Optimised digital systems connecting recycled wastewater, community rain tanks and local harvested stormwater can contribute to greening and cooling effects. They can also help ensure that water flows are efficient and responsive to climatic conditions.
- **Education.** Digital technology has the capacity to play a large role in community water engagement and enhance public water literacy. Publishing live precinct water use data and creatively engaging the public in community water efficiency initiatives could also provide transparency and increase trust.
- **Risk mitigation.** Smart irrigation and stormwater management technologies have the potential to mitigate flood risks from heavy rain events. Digital monitoring of water quality can also provide assurance to communities around local waterways.
- **Optimised precinct management**. Integrated data sharing from smart devices and meters can improve operations in real time, as well as enable fine grained planning at the precinct scale. This could enhance flow and pressure management as well as enabling peak demand management for potable water or wastewater flows. Precinct scale planning might also reduce overall demand for potable water, create opportunities for interconnected storage solutions or allow for the trading of alternate water sources.

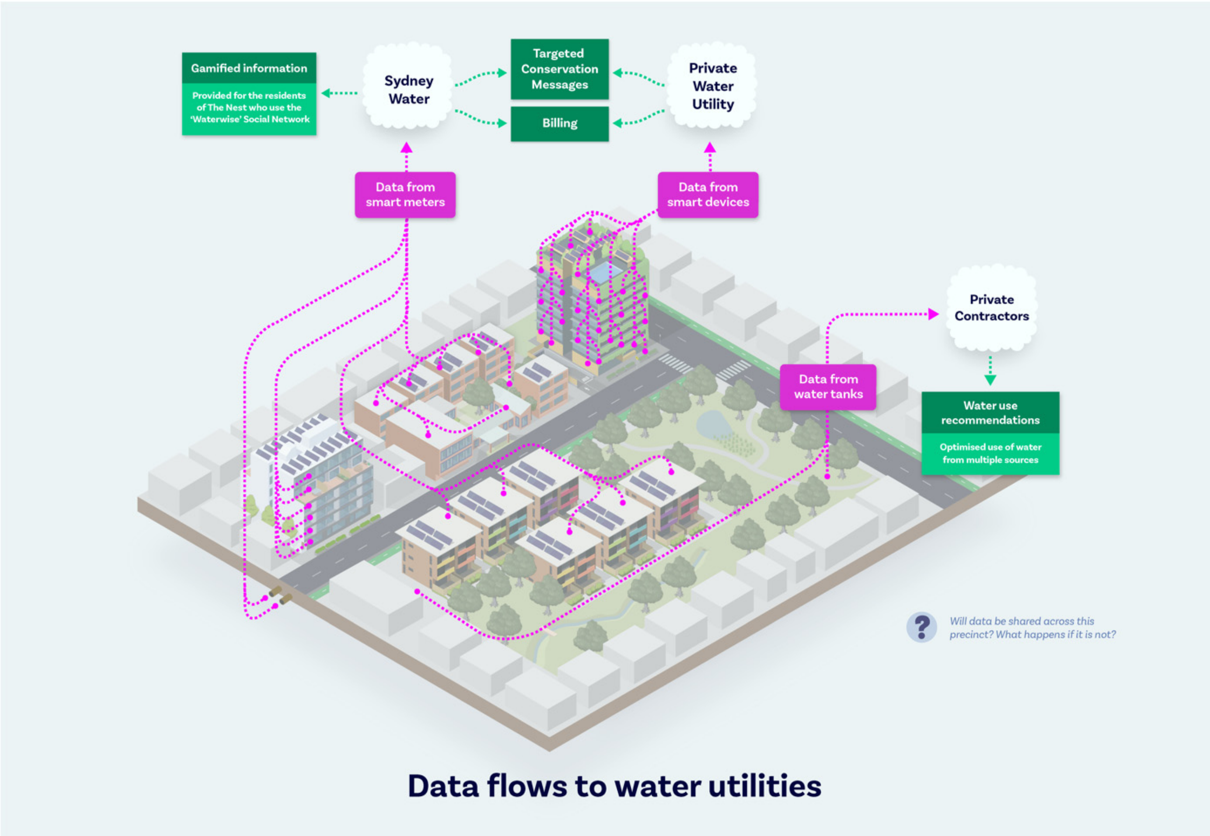


Figure 6 Precinct data flows to water utilities

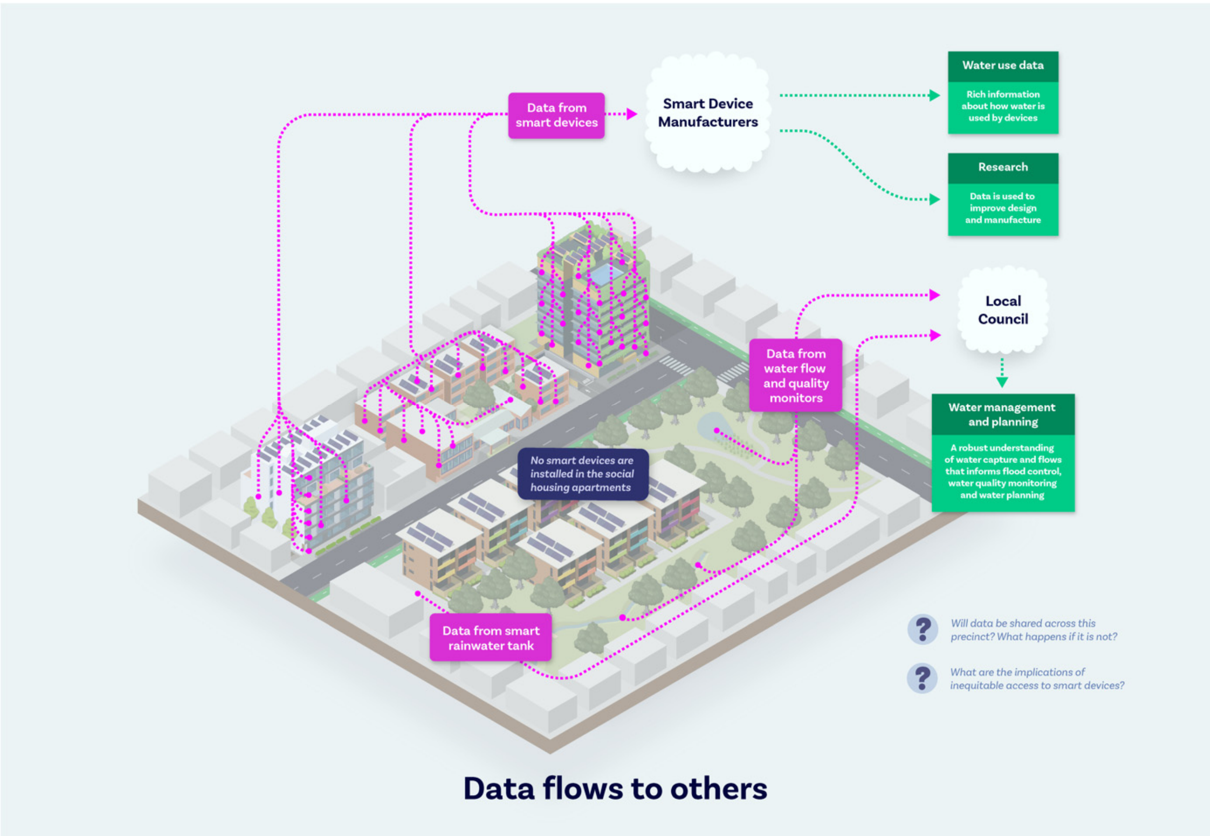


Figure 7 Precinct data flows to others

Additional considerations

There are a number of additional considerations that exist at a precinct level that are not represented in the visual narratives. For example, multiple parties owning different parts of the precinct data could present sharing and privacy issues if not well managed. There are also opportunities for greater system optimisation through technologies (such as Artificial Intelligence) to improve real time responses to flow and pressure demands. Digitising cooling towers and ground heat pumps could also present opportunities to further optimise the cooling and electricity use alongside water use.

In addition to the digital technologies represented in the visual narrative, other technologies offer further opportunities. For example, it could be useful to consider how digital technologies could play a part in achieving water sensitive urban design at a precinct level. Septic Tank Effluent Pump (STEP) systems have also not been considered in the visual narratives but would allow the control of wastewater flows from building allowing sewer pipe and plant down-sizing.

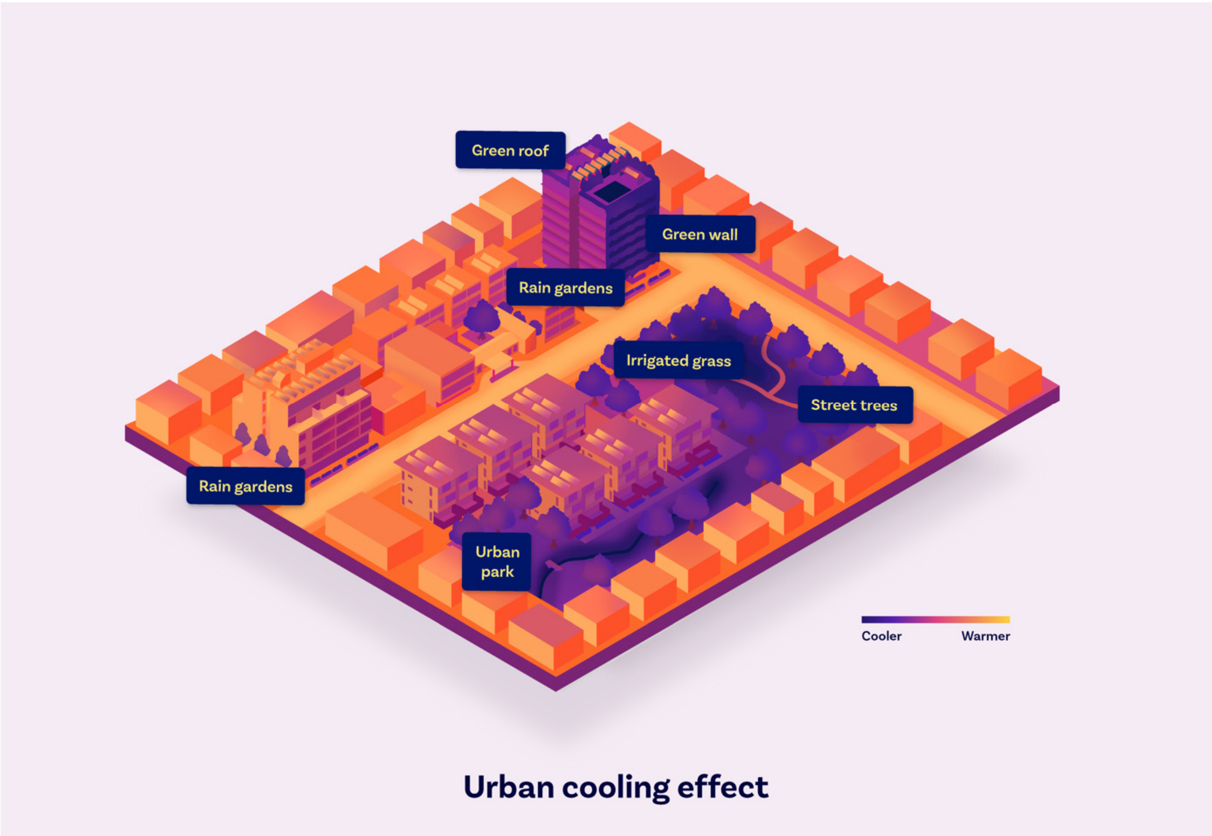


Figure 8 Precinct urban cooling effect

The Nest: mid-range apartments

Figure 9 Mid-range apartments overview

Figure 10 Mid-range apartments: diverse people, diverse practices

Context

The Western City region of Greater Sydney has been identified as a key growth area[39] and is one of the most culturally and linguistically diverse areas of NSW.[40] The hypothetical mid-range apartment dwelling explored in this visual narrative represents a medium density apartment complex designed for young families, couples and single occupants that are expected to characterise a high percentage of the new development in Western Sydney over the next decade. This narrative explores how diverse occupant groups with diverse water literacies and practices may interact with water efficiency technologies in various ways. The efficacy of digital and other efficiency-oriented technologies is contingent on the complex interplay of water-use practices and the design of the technologies and buildings.

This visual narrative also identifies the potential for digital technologies to empower users to save more water. Residents are shown to be interacting with their building's social media platform that 'gamifies' water conservation at an apartment level and encourages water savings between neighbours. This type of platform could be used to benchmark usage and facilitate knowledge sharing and community encouragement.

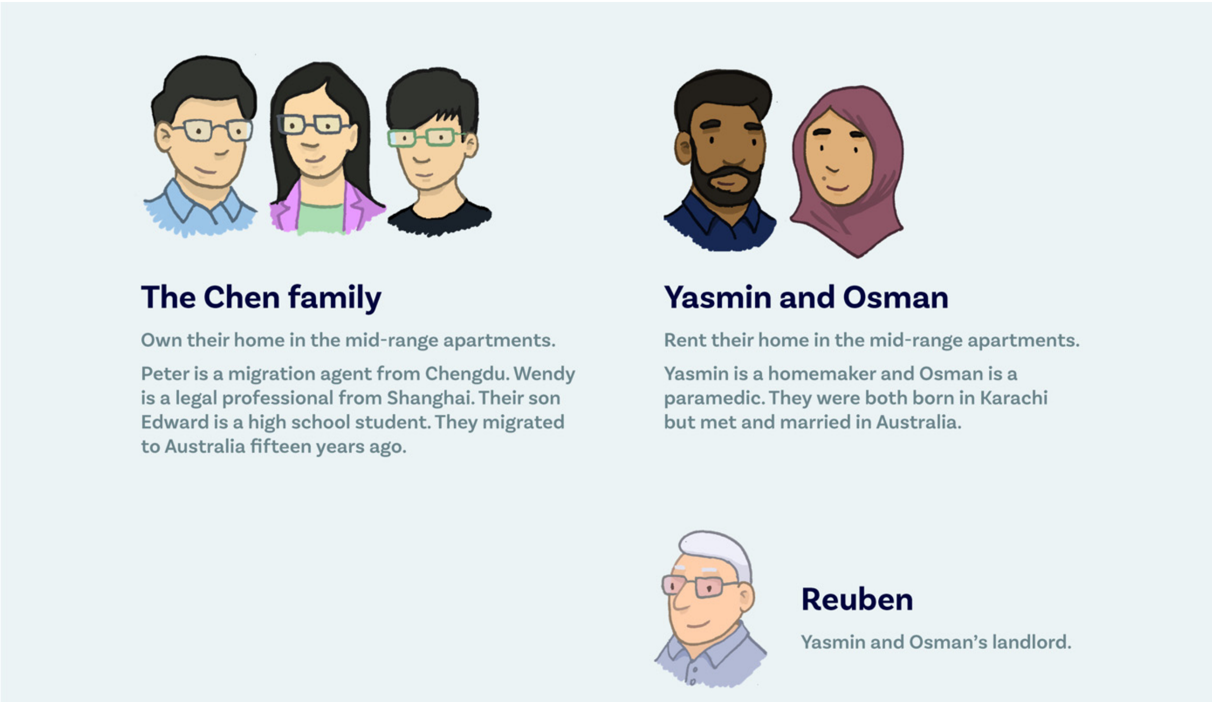


Figure 11 Mid-range apartments: character introductions

Key considerations

- **Existing water practices.** The efficacy of smart technologies will be contingent on how they are integrated within everyday domestic water practices. Community engagement alongside digital smart meter technology could allow Sydney Water to better understand the diversity of water use practices, and the interplay between practices and technology.
- **Overwhelmed users.** There is a concern that residents may receive duplicate data or unnecessary information from multiple sources and may disengage with the data as a result.
- **Data access from dwellings**. Unless adequate protections are established, household water use data could be accessed by property owners, companies, building managers, or member of strata, raising privacy concerns. To ensure user privacy, data needs to be able to be separated or amalgamated so that parties are only receiving appropriate data.

[39] Greater Sydney Commission (2018), Greater Sydney Region Plan A Metropolis of Three Cities – connecting people, March 2018
[40] Capuano, G., (2015), Western Sydney profile – a region of diversity and growth, informed decisions, February 2015

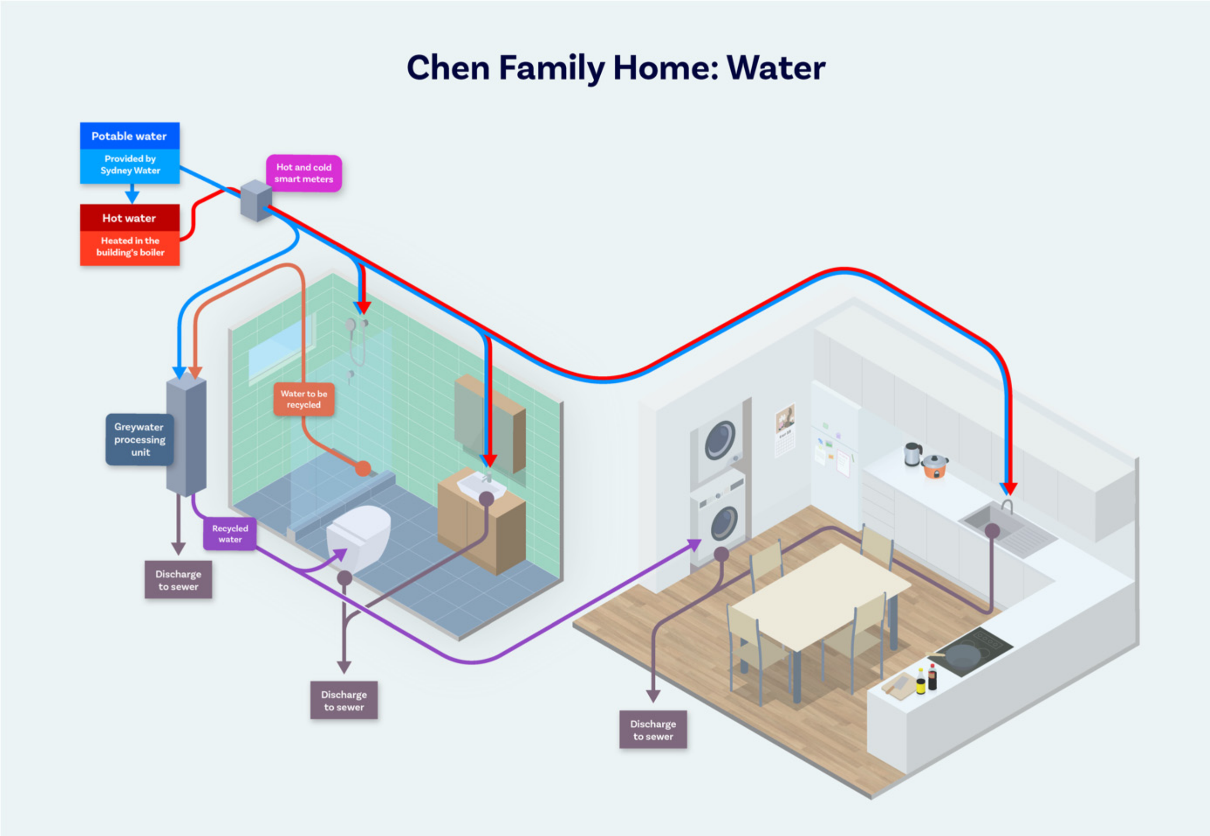


Figure 12 Chen Family Home: Water

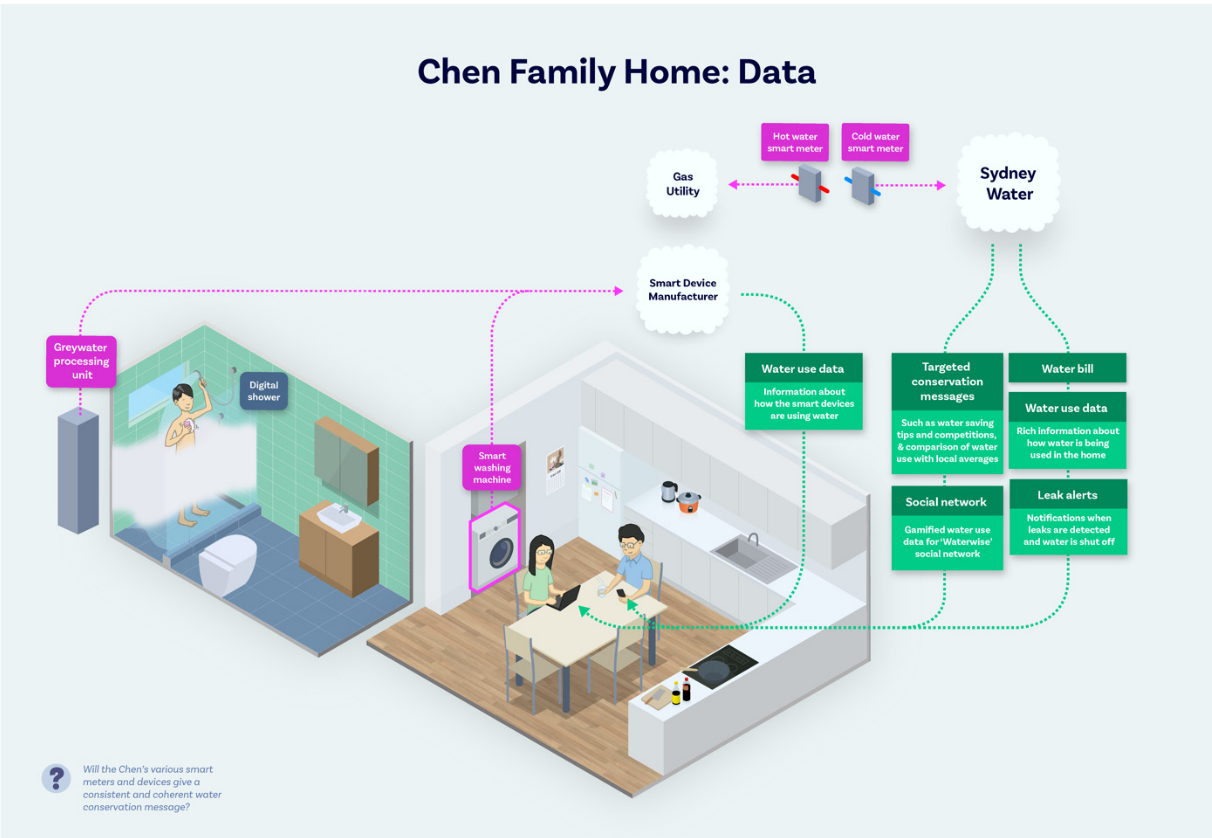


Figure 13 Chen family home: Data

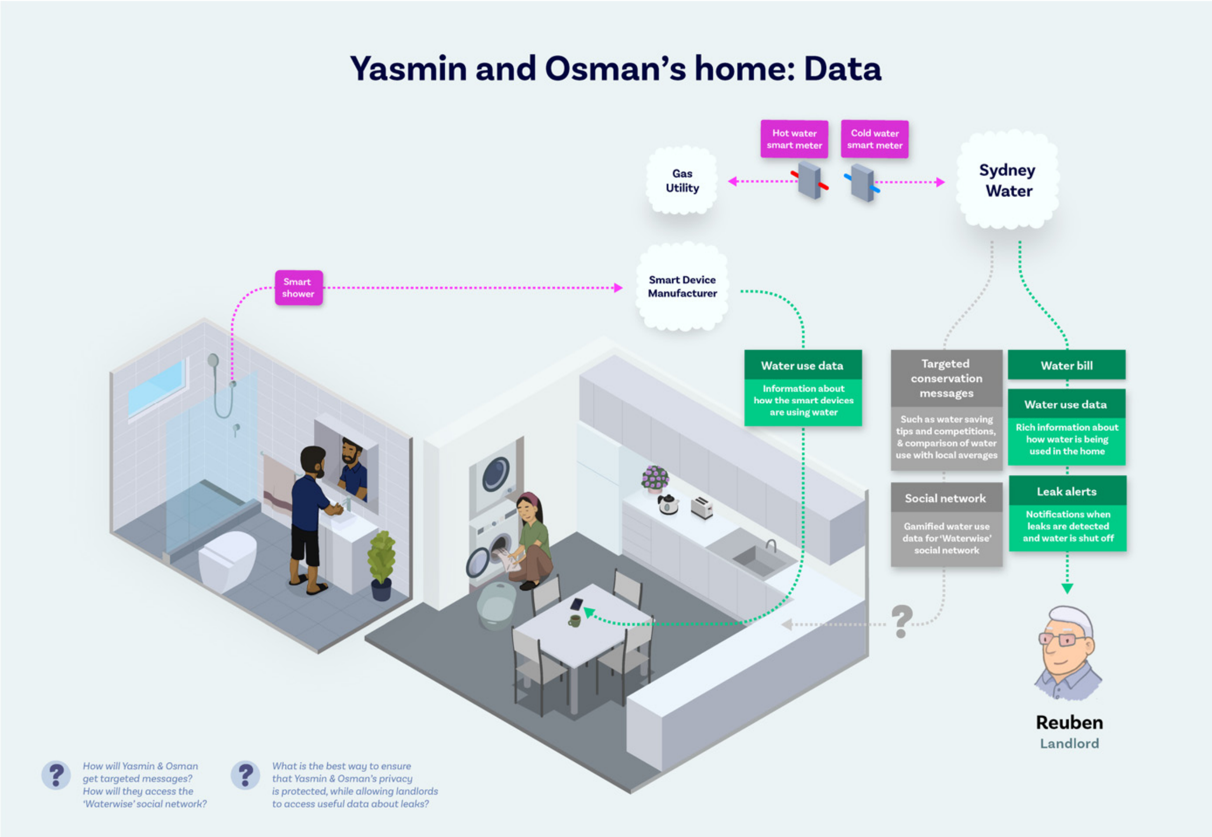


Figure 14 Yasmin and Osman's home: Data

Opportunities

- **Understanding water use priorities**. Different members of a household often have different water practices and levels of commitment to conserving water. For example, community members frequently noted the challenges they had convincing teenage children to take shorter showers. Conversations about water use are potentially enabled by detailed household usage information from smart meters.
- **Novel forms of engagement**. Smart meter data allows targeted conservation messaging to different user groups, and the potential to foster new forms of engagement. For example, water use could be 'gamified' via a digital app or platform that allows people to compete at a dwelling or precinct scale to reduce water consumption. This type of platform may also enable neighbours to share ideas or practices to work together to achieve water savings.
- **Reuse and recycling.** Many household opportunities exist for recycling wastewater and further saving domestic water consumption. A greywater processing unit has been explored in this visual narrative.
- **Automatic leak detection and shut off**. Smart systems allow for leak detection systems which detect, alert and shutoff leaks. This reduces water loss and costs associated with prevented damages.

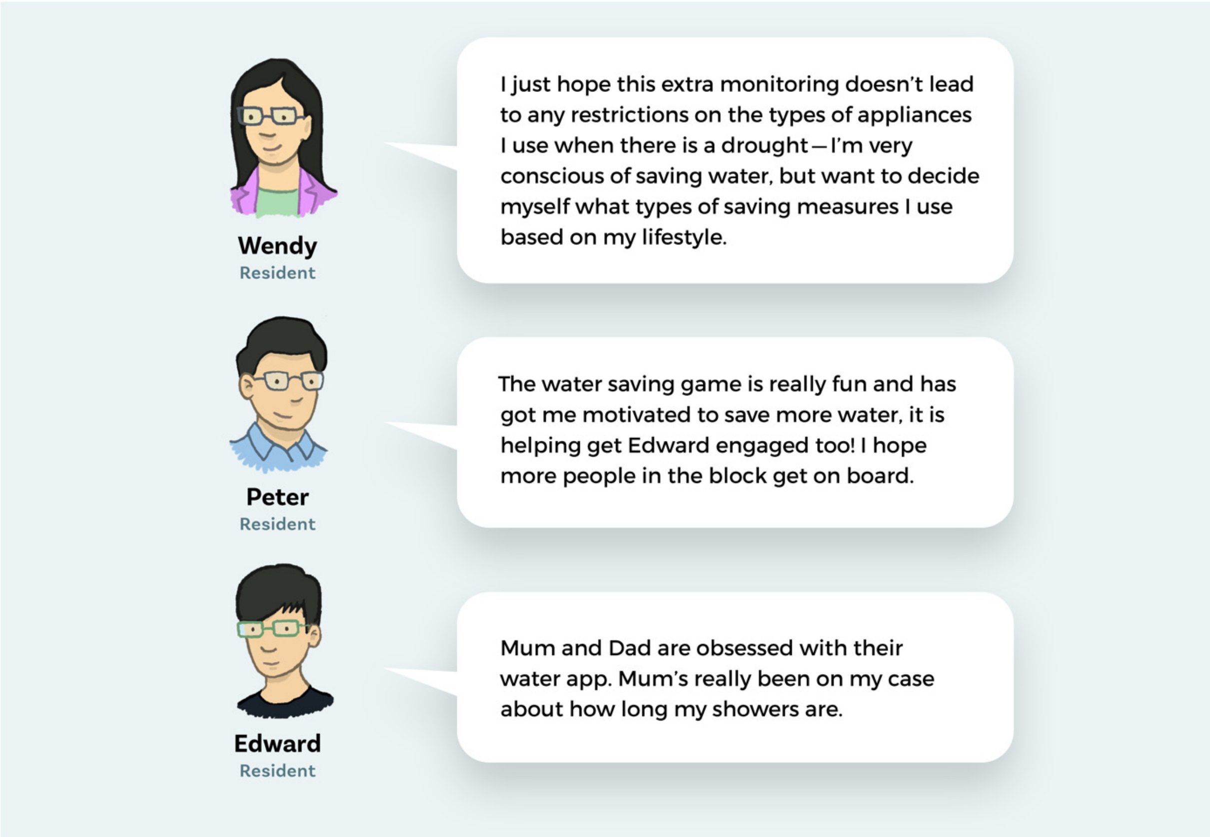


Figure 15 Mid-range apartments: Residents' comments

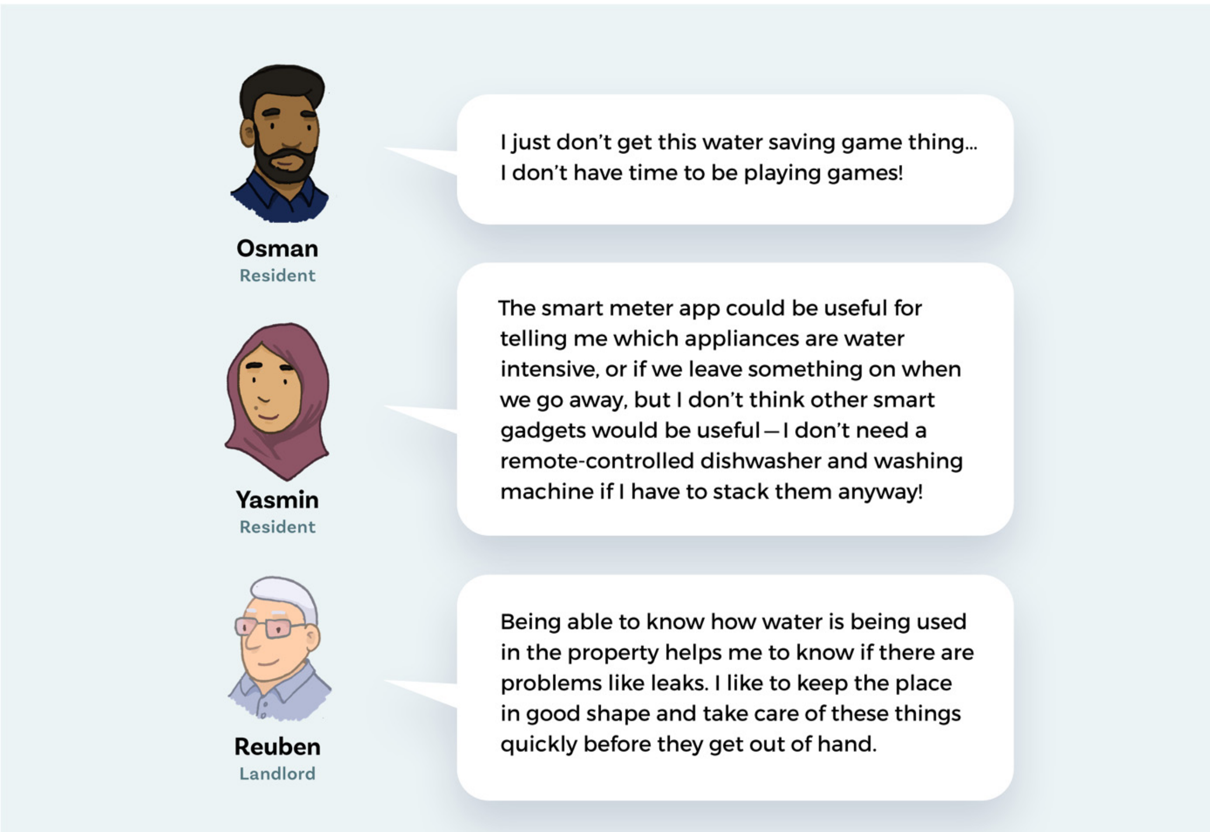


Figure 16 Mid-range apartments: Tenant and Landlord's comments

Additional considerations

In addition to the considerations explored in this visual narrative, there are a number of additional points that could have been included. For example, smart technologies may enable a more robust understanding of the occupancy data of dwellings. In particular smart metering alongside smart application user data would provide Sydney Water with a mechanism to understand tenant demographics.

There are also further opportunities for co-design of conservation efforts between utilities and the community, for example prioritising restrictions in a drought. Access to smart meter data and social media platforms enables user feedback and more collaboration.

Building scale greywater reuse was not considered in this visual narrative. However, the reuse of untreated wastewater that has not come into contact with toilet waste, kitchen sink waste, dishwasher waste or similarly contaminated sources would be a good opportunity to explore further at a building level. Greywater includes wastewater from bathtubs, showers, bathroom wash basins, clothes washers and laundry tubs.

Figure 17 Mid-range apartments: 'Waterwise' social network

Arcadia: Eco-luxury apartments

Figure 18 Eco-luxury apartments overview

Context

The eco-luxury apartment narrative explores a high-end apartment building that has an ecosystem of integrated water efficiency systems. This visual narrative describes what could be achieved should no barriers of cost, participation, technology, or data governance exist. While less representative of a common dwelling type, it demonstrates the emerging capabilities of cutting-edge technologies and the opportunities and issues they may carry. It depicts a system moving towards optimal water efficiency and system functionality, through an integrated platform of smart meters, monitors, devices and AI control in which water conservation and water reuse is continually optimised.

This dwelling has been assumed to have been developed by a private utility under the Water Industry Competition Act 2006 (WICA) which aims to encourage private-sector investment and innovation in the water and wastewater industries. The private utility purchases bulk potable water from Sydney Water and then aims to retain as much as possible within the apartment system through wastewater treatment and recycling. Even nutrients would be recovered through a urine separation scheme, which would aim to ensure minimal wastewater leaves the system. Wastewater would be discharged to Sydney Water's sewerage network at cost and excess recycled water would be sold to the precinct for irrigation.

The residents living in this apartment block are assumed to have a high level of water and technological literacy and minimal cost barriers. Their buy-in for this apartment is that it has been developed and marketed as a 'top of the line sustainable ecosystem'. Nearly all of the water appliances have smart control capacity which enables residents to see a detailed breakdown of their water usage.

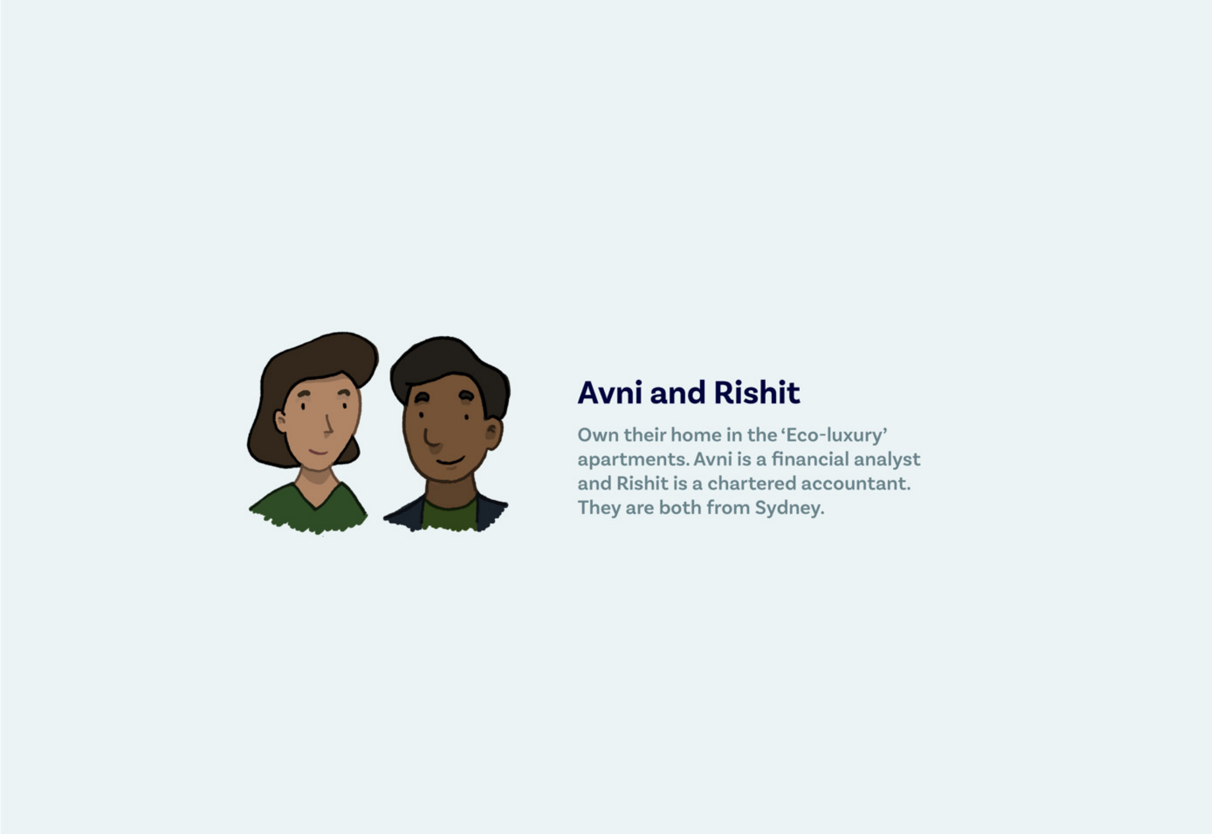


Figure 19 Eco-luxury apartments: Character introductions

Key considerations

- **Digital housekeeping.** In households using smart devices, the time required to ensure system interoperability, functionality and to troubleshoot often negates the time-saving promise of having them installed. Some research suggests that the 'digital housekeeping' required to maintain device connectivity commonly falls to men, which has had the perverse effect of increasing the traditional household labour burden of women in some heterosexual relationships.[41] Assessing the interoperability and necessity of devices, and the provision of adequate technical support are therefore important considerations.
- **Complacency.** There may be a risk in networked environments that residents can become less aware of water usage as they rely on technologies to monitor and control their usage. This delegation to smart systems may therefore increase potential complacency in the use of water, and result in more water being used.
- **Technology lock-in.** In interconnected systems it is generally a lot more difficult to switch out one device and to integrate a different brand or type into the system without affecting its operability. This lock-in negates the users' capacity to update to more effective technologies or make selections that better suit their practices.
- **Waste.** An excess of unnecessary smart devices could result in unsustainable levels of material and energy use associated with both devices and sensors. Establishing protocols and policies to ensure that devices are returned and recycled at end of life, and that high quality durable technologies are installed, will be important to avoid new waste streams.
- **Data privacy and misuse**. There is a risk that device data could be accessed by prior residents or previous house occupants (i.e. previous owners, housemates or partners). There is the potential for this data to be misused to understand when a home is occupied, or to access devices remotely.

---

[41] Strengers, Y., & Kennedy, J. (2020). *The smart wife: Why Siri, Alexa, and other smart home devices need a feminist reboot*. MIT Press.

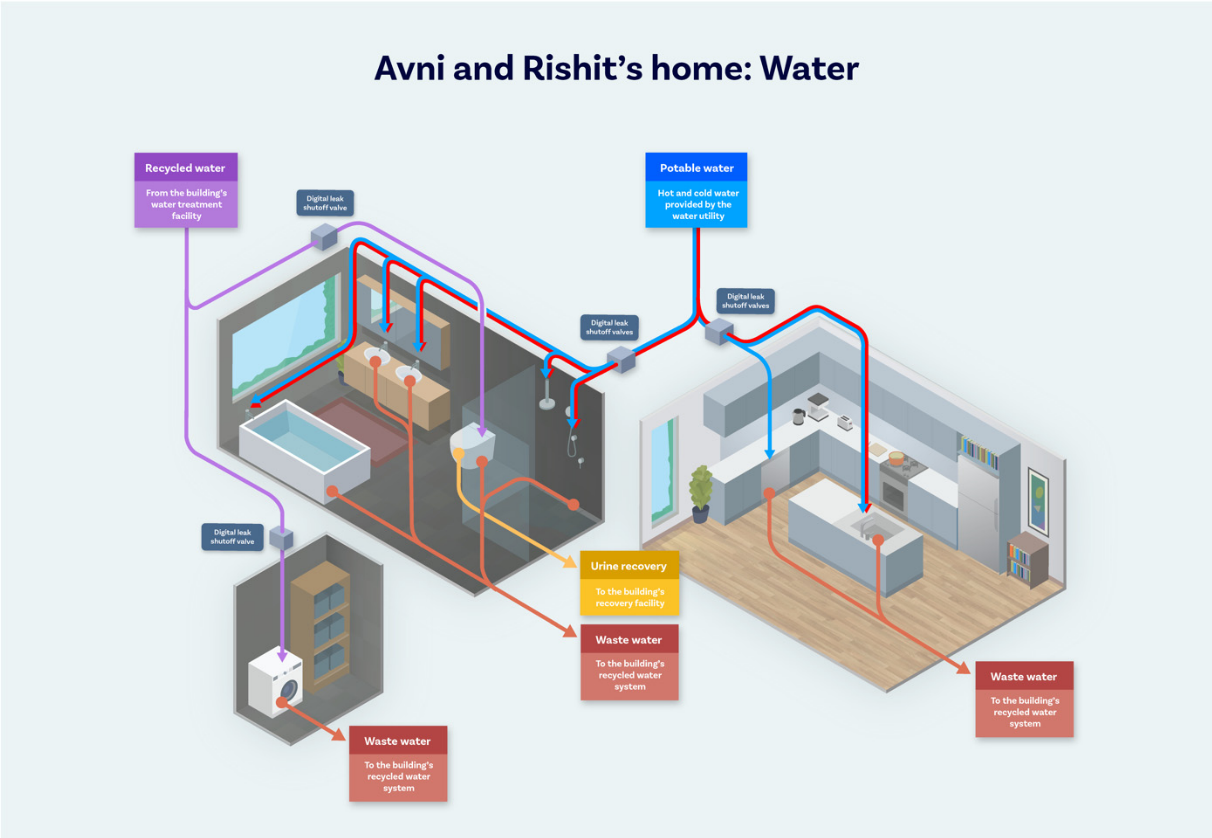


Figure 20 Avni and Rishit's home: Water

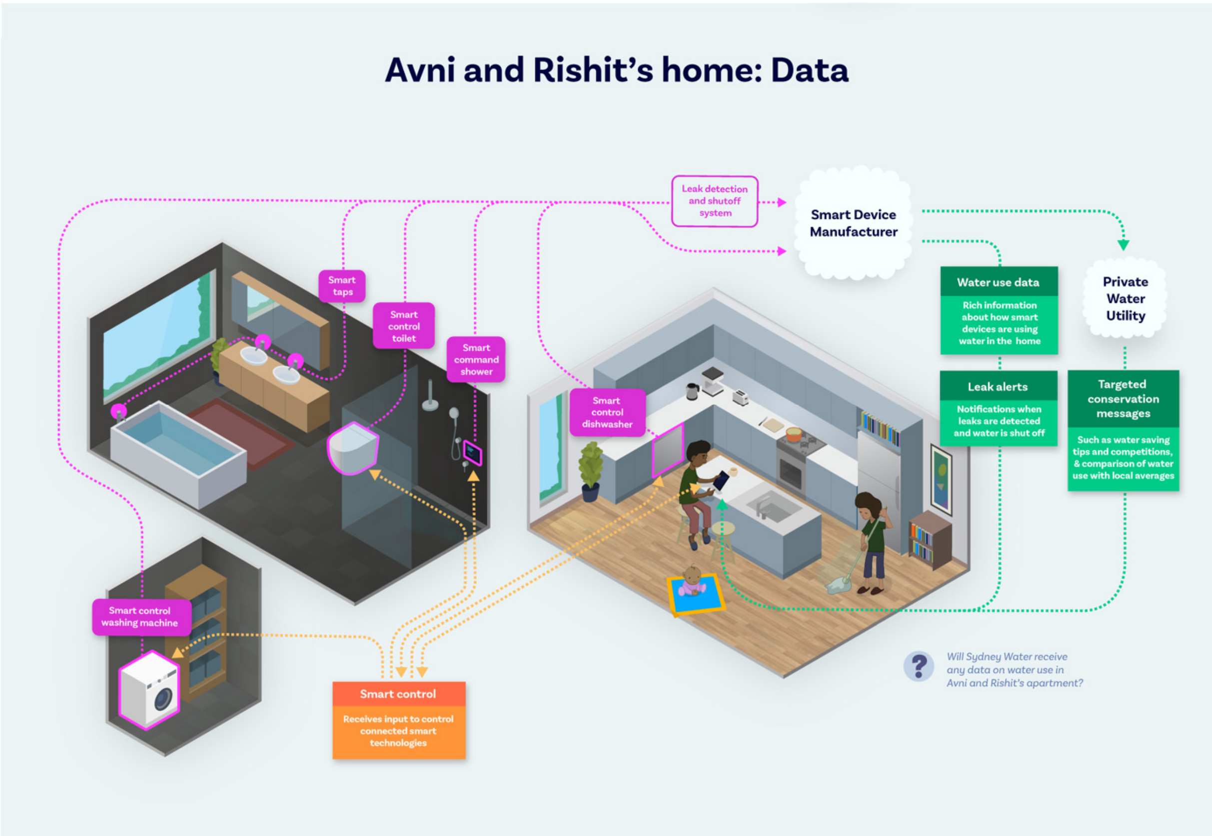


Figure 21 Avni and Rishit's home: Data

Opportunities

- **Associated savings**. A reduction in water use can also mean a reduction in energy use and related carbon emissions associated with moving, treating, and using water.
- **Streamlined user interfaces**. An integrated system would enable a single platform to be used to control all aspects of the system. This would make it simpler and more accessible for residents to engage with their water use and targeted messaging.
- **Detailed water use insights**. Insights about how and when water is used could increase understanding about the water practices of residents and what demand management solutions may be most effective.
- **Trading of alternate water sources**. Interconnected water storage solutions enhanced by smart technologies across a precinct allow for the optimisation and trading of alternate water sources.
- **Reduced cooling load.** Green walls and roofs integrate additional cooling benefits into the building and decrease the air conditioning burden and associated water and energy use.
- **Nutrient capture and reuse.** Separation of urine at source provides the opportunity to treat and use those nutrients on-site and capture and transport for off-site use. Nutrient capture from wastewater streams is likely to be a key aspect in developing a 'circular economy' of water/wastewater systems as phosphate and other micronutrients in urine are currently non-renewable inputs to our food systems.[42]
- **Trialling technologies and strategies**. The intention of this ecosystem is to reduce water where possible through default settings, highly efficient devices, user prompts and alerts. A data driven environment could create opportunities for investigation into the best strategies to reduce water use.

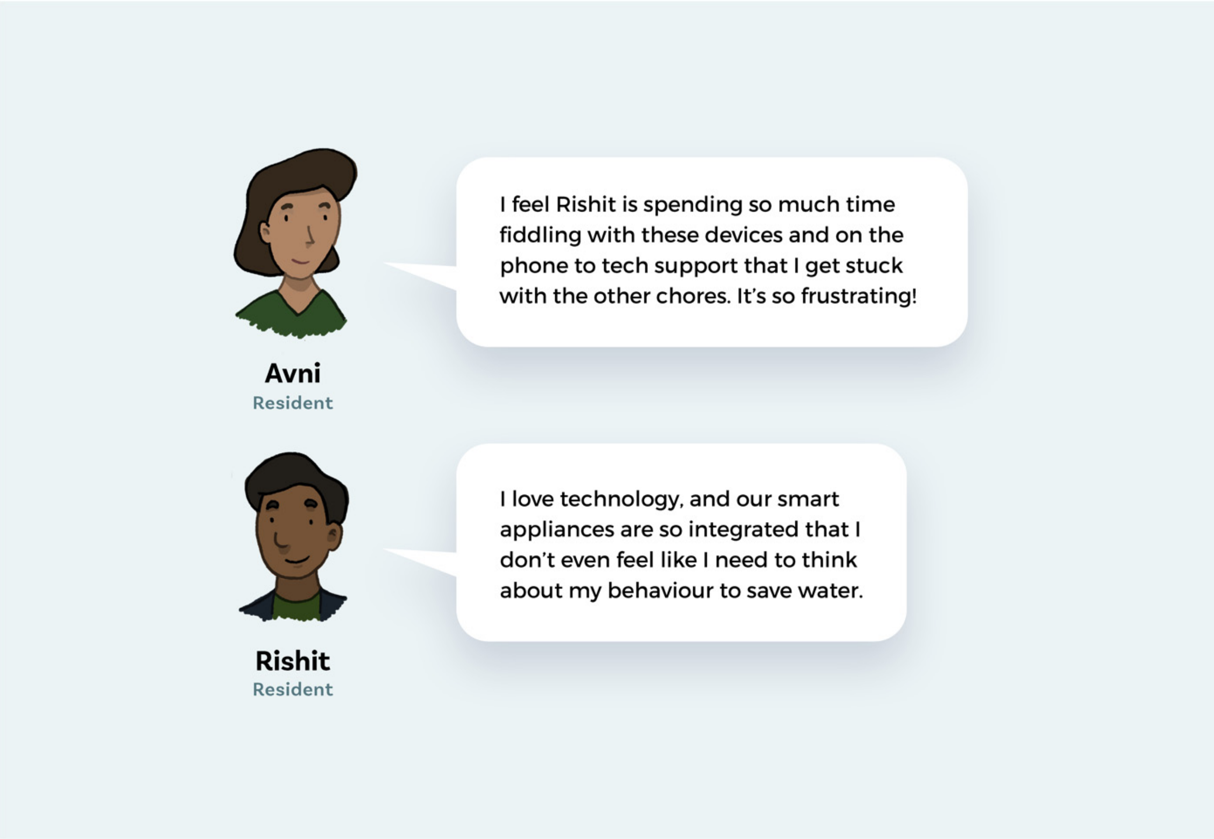


Figure 22 Eco-luxury apartments: Residents' comments

[42] Cordell, D., Drangert, J.O., S. White, 2009, The story of phosphorus: global food security and food for thought, Global environmental change, vol 19,2 pp 292-305

Additional considerations

It was not practically possible to incorporate many other technologies into the visual narrative. For example, food waste collection could be incorporated into this ecosystem, which would allow for the reuse of organic waste. Digital monitoring and automatic water shut off could also allow for full potable recycled water at the building scale, particularly for hot water. Smart monitoring in sewer pipes would enable initiatives like automatic adjustment of flushing to take advantage of existing in-building sewer flows to reduce water used in the flushing process.

It was also noted that if edible gardens were planted and irrigated from the building's recycled water, a period of potable/rainwater irrigation prior to harvest and consumption may need to be incorporated.

Figure 23 Eco-luxury apartments: Water systems

The Green: social housing

Figure 24 Social housing overview

Context

Social housing refers to secure and affordable rental housing for people on low incomes with housing needs, including public, community and Aboriginal housing.[43] Western Sydney currently has a high number of households living in social housing compared to the rest of NSW. While approximately 12% of all households in NSW are located in Western Sydney, 16% of NSW households in social housing are in the region.[44] Some estimates suggest demand for social housing in Western Sydney is expected to grow by more than 28,000 households between 2016 and 2036, representing an average annual growth rate of 2.0%. As a result, it is important that the needs of social housing residents are accounted for in the planning of future residential smart water practices.

Given that social housing often involves different types of tenancy arrangements and stakeholders to conventional rental properties, this visual narrative explores some of the specific issues and opportunities that may emerge in these households.

There are many ways that social housing is arranged with institutional and government partners. A common arrangement is for properties to be owned and managed by NSW Land and Housing Corporation (L&H), with tenancy arrangements and engagement under the purview of the Department of Communities and Justice (C&J). Under this configuration at present, Sydney Water sends water bills to L&H, who then passes the bills for water use, including any outstanding charges, on to social housing tenants. L&H do not own any domestic appliances, such as dishwashers and washing machines, but can encourage water saving appliances through directing tenants to rebate schemes and using interior design features to guide product choices, such as laundries in which front loading washing machines fit best. L&H are responsible for the assets that form part of the property, including additions such as water tanks. The cost of maintaining these assets is a primary concern for the responsible government departments.

---

[43] NSW DCJ (2019) *Social Housing*. Accessible online at: https://www.facs.nsw.gov.au/housing/help/ways/social-housing
[44] SGS Economics and Planning (2018) *Demand for social and affordable housing in WSCD area*, report prepared for NSW FHA. Accessible online at: https://communityhousing.org.au/wp-content/uploads/2018/12/20180311-NSW-FHA-WSCD-Social-and-Affordable-Housing-Demand-Report-Variation-Update-FINAL.pdf

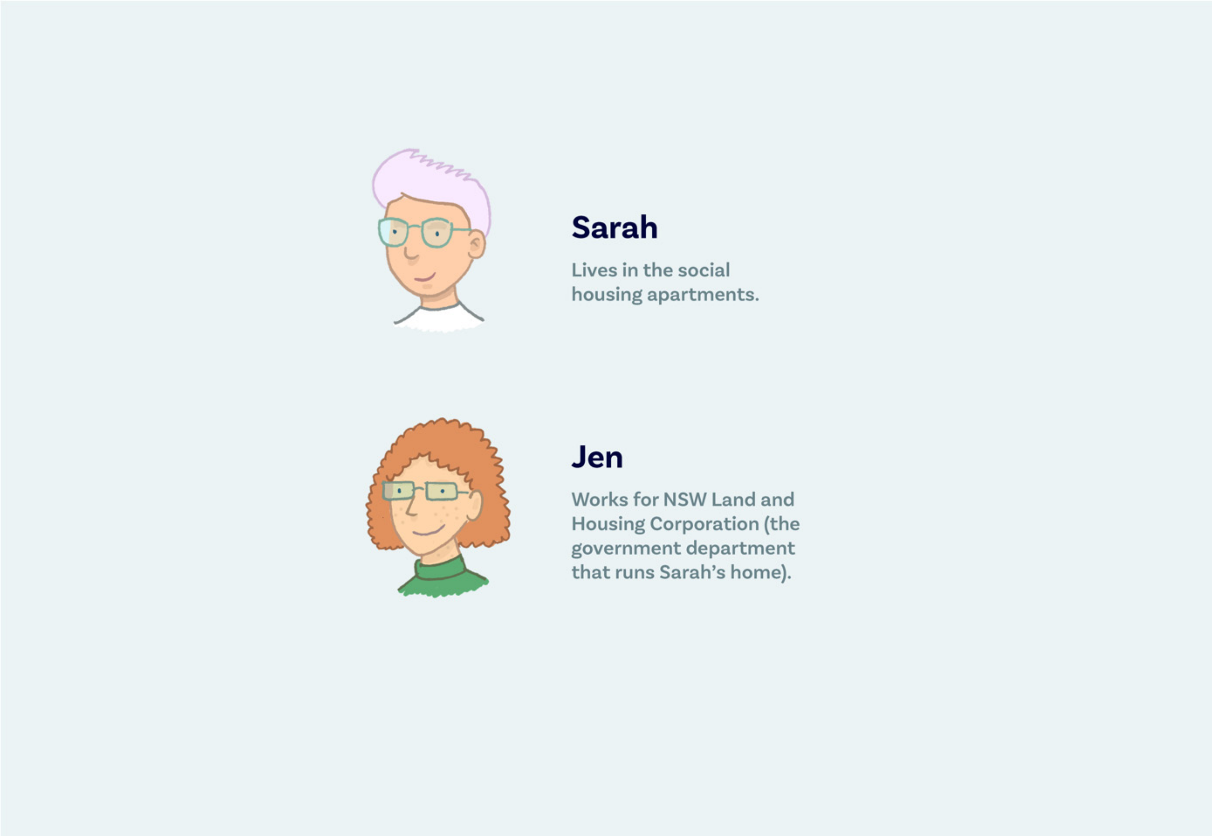


Figure 25 Social housing: character introductions

Key considerations

- **Relevant data.** The capacity to change billing system is probably limited within the type of social housing arrangement presented. As a result, ways of enabling residents and government to receive the types of information most likely to benefit them will be important.
- **Consistent data.** If tenants are provided with raw usage data, there is a chance that the discrepancy between these values and those represented on the water bill (which also includes arrears and debts) may cause confusion. The way information is communicated is consequently an important consideration.
- **Access to data.** It has been estimated that around 70% of social housing tenants have smartphones, enabling usage data from smart metres to be provided to these residents. For those without smartphones, there are opportunities to utilise other channels. This will necessitate access to information that links individuals with their properties. Information design and user experience should be co-designed with government to ensure this information is presented in the most beneficial way.
- **Protecting the vulnerable.** As there is a greater chance that vulnerable or marginalised people will be occupying social housing, a key consideration will be ensuring extra care is taken to protect the privacy of tenants, and for the technologies to be used in such a way as to reduce financial and other forms of stress on residents (through rebates for example). Reassurances that the data gathered will not be used by government for other purposes are likely to be required.
- **Technological literacy.** Findings from expert interviews suggest that the most effective interventions in terms of water conservation have been those that require low engagement time and effort from residents. Given concerns regarding maintenance costs, devices that require a high level of technological literacy, maintenance and time to set up and troubleshoot may therefore not be as effective as the implementation of water efficient fittings for some appliances. This visual narrative consequently has limited smart features, aside from the smart meter that delivers beneficial information about leaks and usage practices.

- **Resourcing requirements.** New data systems and practices may need to be established in the related government departments, including L&H and C&J, to manage the new types of data they will be receiving about things such as leaks and asset maintenance needs. One concern that has been raised by some stakeholders is that more alerts generated by sensors may demand sometimes unnecessary maintenance that will be difficult to resource.

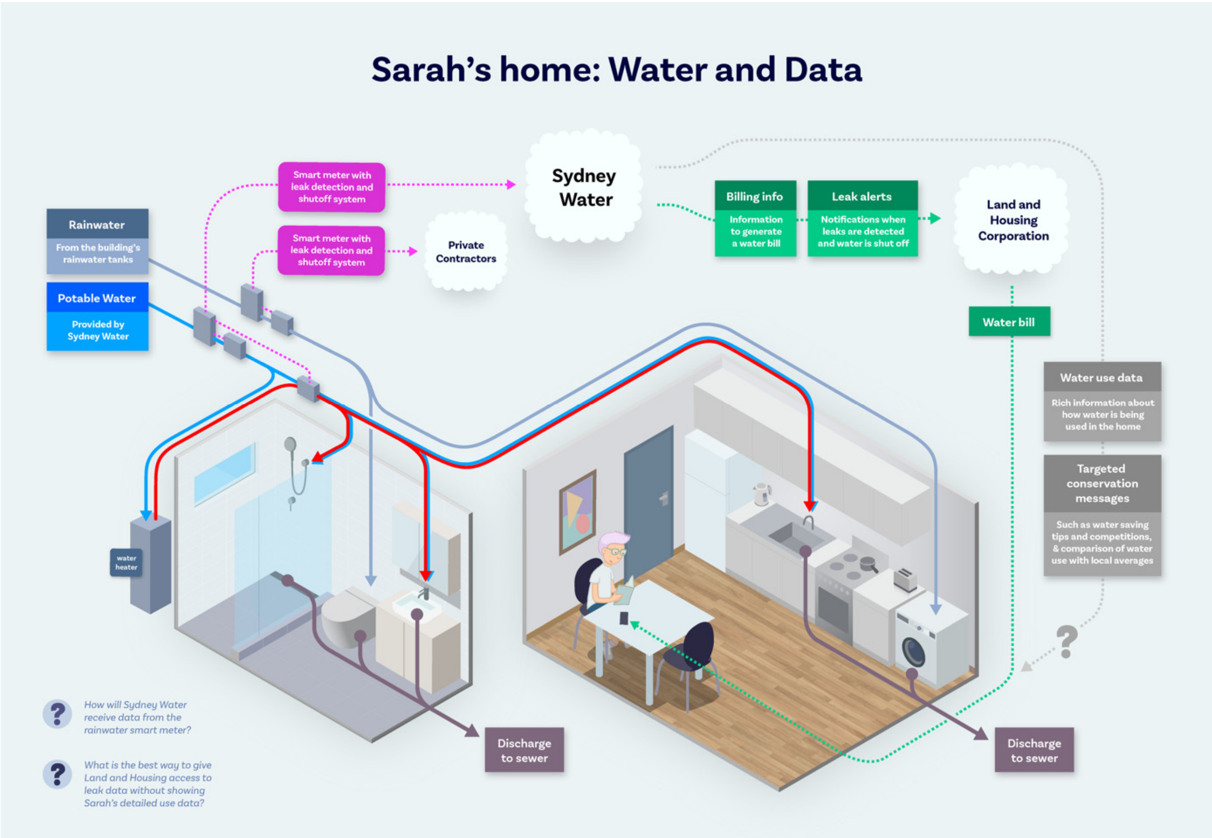


Figure 26 Sarah's home: Water and Data

Opportunities

- **Accurate leak alerts.** L&H are currently only able to receive alerts for leakages in properties that exceed 3.5 kilolitres a day, and even then, the alert is often not received until well after the leak began. The leak detection technologies presented in this visual narrative would enable L&H to receive real time leakage information, in addition to information about other assets they are responsible for maintaining.
- **Maintenance alerts.** Smart devices for common fixtures and appliances have the potential to be linked to the appropriate service provider to alert regarding repair or maintenance at regular intervals. These alerts could be directed to L&H for an initial review or directed immediately to the relevant tradesperson.
- **Demand management opportunities.** Insight into residents' water use practices and the trends of social housing may assist Sydney Water in developing targeted initiatives that assist social housing residents to save water i.e. targeted rebates or retrofits.

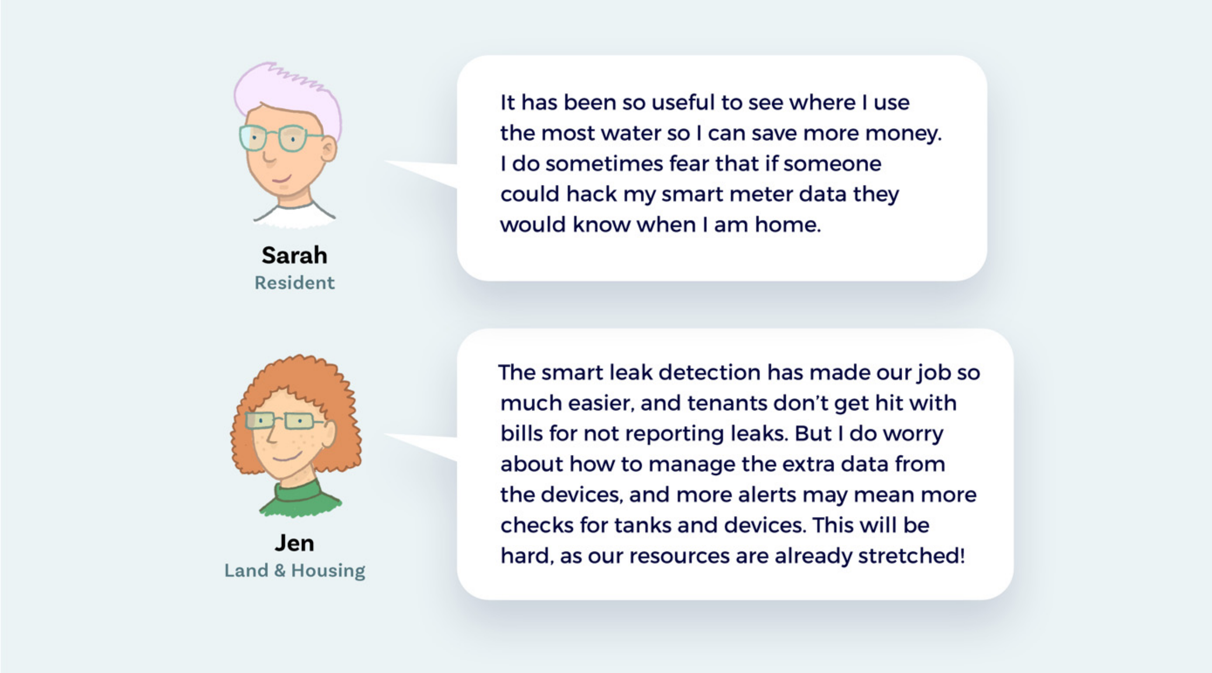


Figure 27 Social housing: Resident and Land and Housing's comments

Additional considerations

Increasingly, non-government organisations are entering into arrangements with government to provide and administer social housing, often as part of mixed residency developments. As these new arrangements become more common, the unique opportunities and challenges they afford will need to be understood. For example, housing managed by a private entity may have more funds to spend of things such as technology and infrastructure maintenance that are challenging for government to resource. However, a profit imperative may result in cost-cutting in other areas that adversely affect social housing residents.

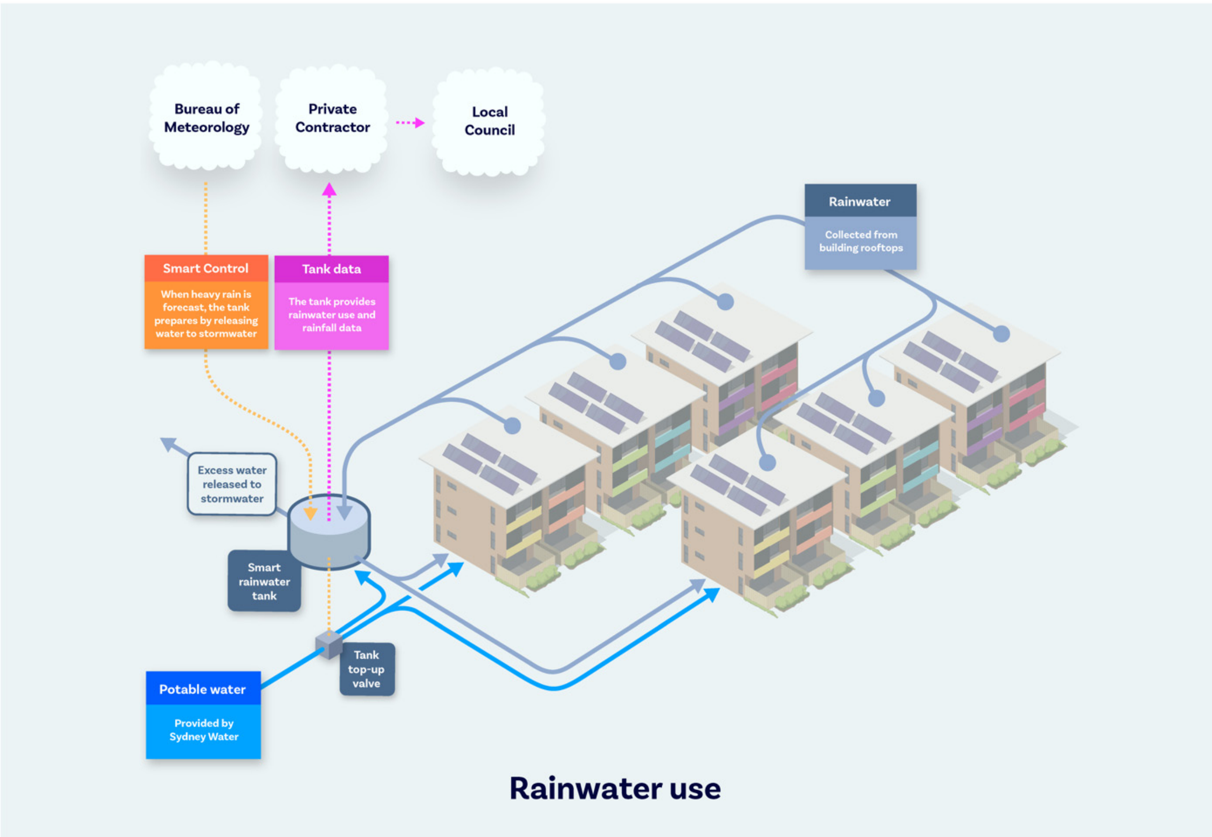


Figure 28 Social housing: Rainwater use

Grevillia Gardens: Aged care retirement village

Figure 29 Aged care retirement village overview

Context

Regional projections suggest that Western Sydney will have a substantial ageing population in the near future. The state government has identified the need to provide options to enable ageing people to remain self-sufficient for as long as possible as a key priority.[45] This visual narrative explores some of the potential ancillary benefits that could be realised to support this population through the use of water-connected smart technologies that do not relate explicitly to the conservation of water. In the case of bathroom technologies, there is great potential for the integration of health monitoring and management functions.

This visual narrative also explores the potential optimisation of water and energy through a 'solar sponge'. Solar sponges store excess energy from photovoltaic systems in the form of hot water rather than through the use of a conventional battery. This would be able to be used at off-peak times to ensure that excess solar energy is not wasted. A solar sponge option would be possible across multiple dwelling types.

In addition, this narrative explores how the relationship between water users and Sydney Water may be modulated by intermediary stakeholders. To do this, a care manager who looks after residents has been introduced. While not living at the facility, the care manager plays an integral role in the use of water efficient appliances in the homes, and is the main receiver of data from smart devices.

[45] NSE Govt (2020), Ageing well in NSW: Action Plan 2021-2022, Accessed 1 July 2021: https://www.facs.nsw.gov.au/download?file=798430

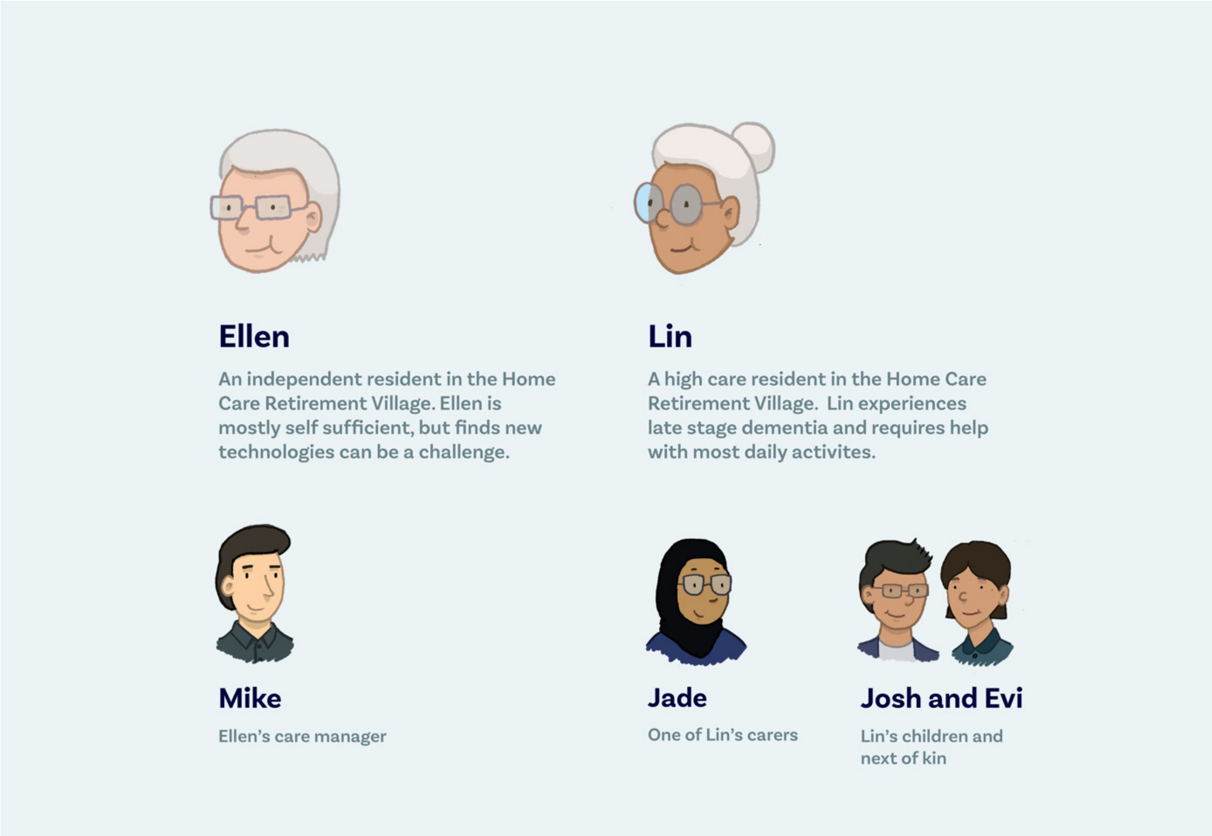


Figure 30 Aged care retirement village: Character introductions

Key considerations

- **Delegation of care to technology.** There is a risk that the introduction of additional support technologies to aged care operations could be used to justify further cuts to staff and other forms of resourcing. It will be critical to consider how smart technologies may assist carers to do their jobs more effectively, and residents to feel more empowered, while avoiding perpetuating current issues of under-resourcing and high resident to carer ratios. The other related concern relates to the risk of staff being micromanaged through digital surveillance. For example, checking how often staff wash their hands may be beneficial for overall hygiene, but may be perceived as overbearing and undermine trust.
- **Access and usability.** Balancing the potential benefits afforded by digital technologies and usability requirements will be an important consideration in contexts involving ageing residents. While there are differing levels of technological literacy in the elderly population, on average, their familiarity with and capacity use many emerging digital technologies is more limited. User interface and device design will play an important role in enabling accessibility.
- **Time and cost.** The time and financial costs of upskilling already time-stretched carers to effectively use the new technologies, and the time required for additional reporting and support that may emerge from their use, will also be critical considerations.
- **Privacy**. In situations where intermediaries play a central role in the use of smart devices and where external parties are involved in care, such as family, additional data management protocols may be required to ensure residents' privacy is maintained.

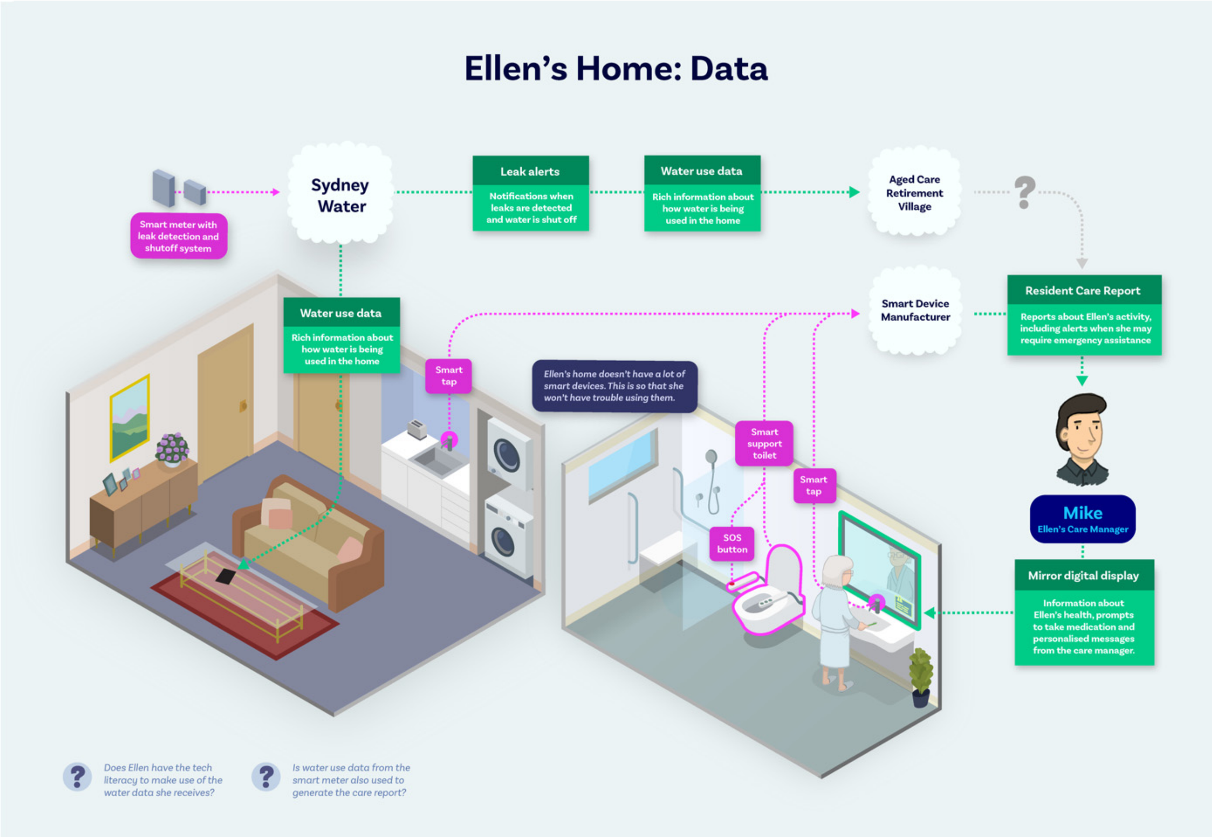


Figure 31 Ellen's home: Data

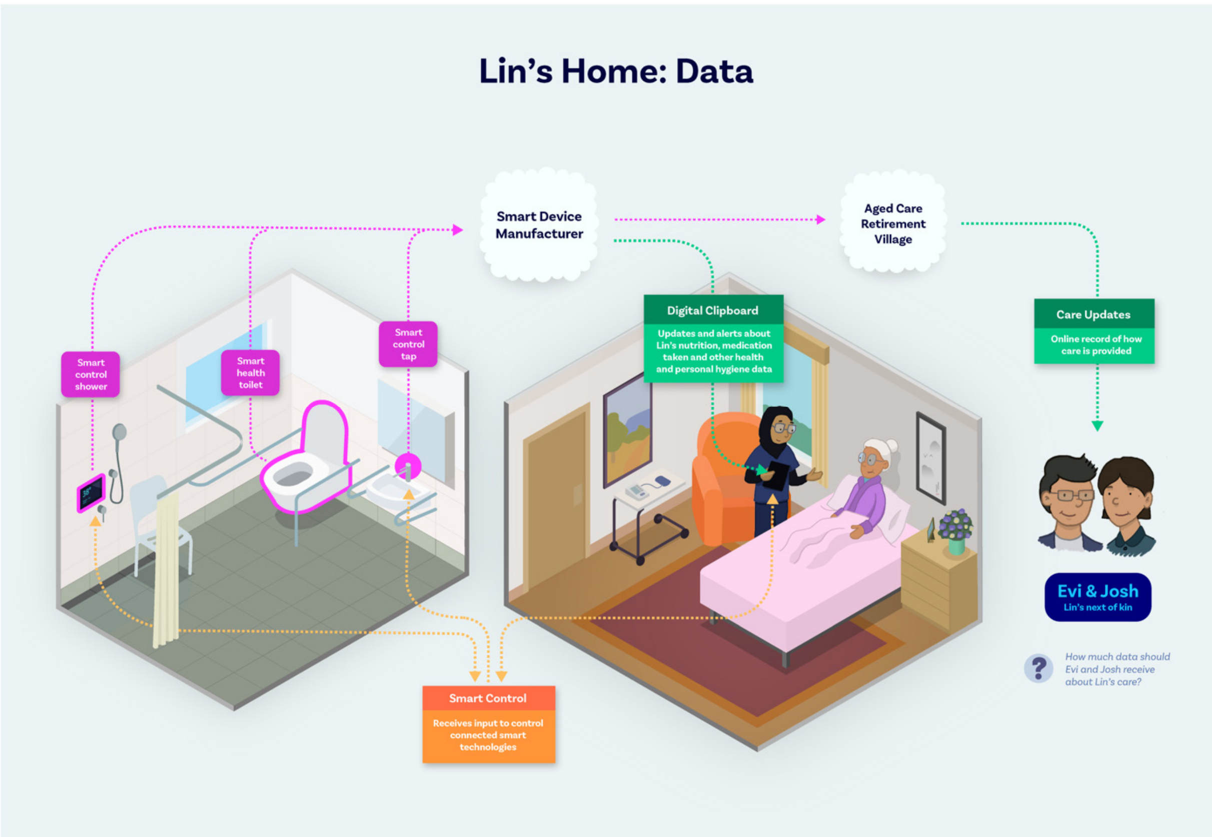


Figure 32 Lin's home: Data

Opportunities

- **Device assistance.** Smart devices with automatic shut-off capabilities can prevent fixtures from being left on or used unnecessarily. For example, a tap can be automatically switched off after an elderly resident with dementia forgets to close the tap after use.
- **Reminders and alerts.** Smart devices can be used to prompt water use, for drinking, cleaning or even to alert residents to take medication. Health information and prompts from smart devices could empower residents in independent or low care environments to stay more self-sufficient for longer. Alerts can also be sent to care managers or families if a device has not been used for a certain period of time, to prompt them to check in on the resident.
- **Relieve resourcing constraints.** More data collection on aged care operations could also provide important insights to care organisations and regulators about any need for additional resourcing.

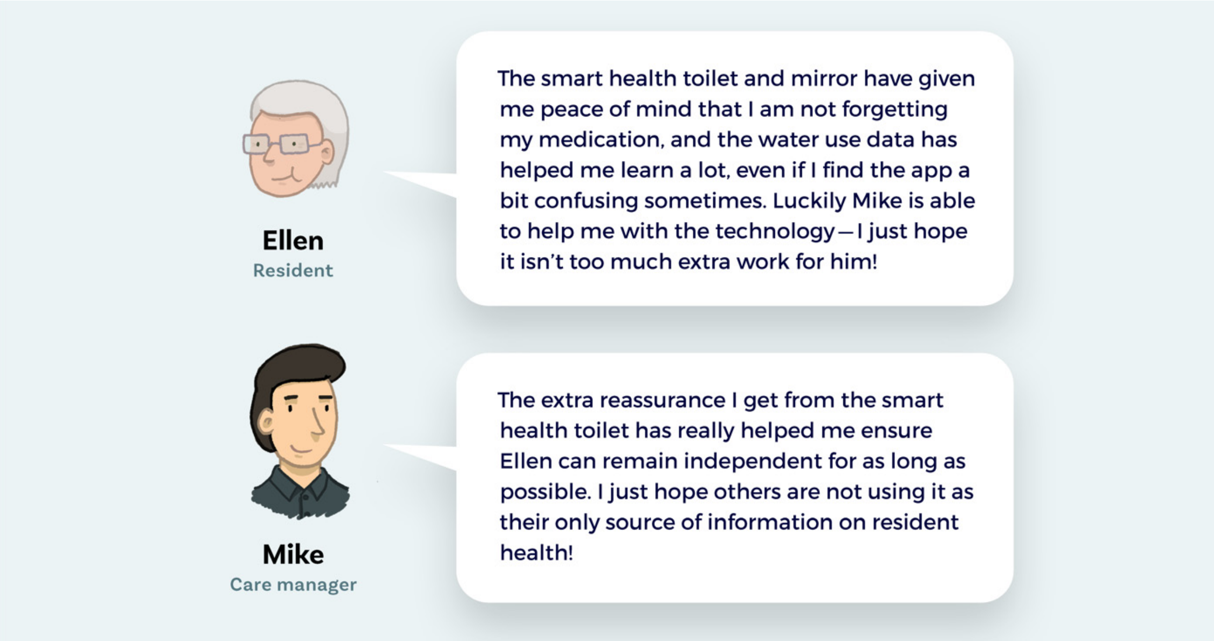


Figure 33 Aged care retirement village: Resident and care manager comments

Figure 34 Aged care retirement village: Carer and next of kin comments

Additional considerations

Common areas have not yet been considered in this visual narrative. Shared spaces, such as kitchens, laundries and pools, are significant sites for water use practices and will need to be considered and integrated into water efficient systems.

Re-circulating showers would be another beneficial technology for care managers of higher care residents as they can heat up the shower while doing other tasks without wasting excess water or energy as would be the case in some models.

An improved understanding of the constituents in aged care wastewater via smart technologies may also enable greater knowledge of disease incidence and medication use in the future.

Figure 35 Aged care retirement village: Linking water and energy

A field guide for the future: orientation markers

This section presents a set of ‘orientation markers’ for Sydney Water which frame many of the key considerations and deliberation points explored in the visual narratives. These should help Sydney Water shape its response to how digital water futures unfold in homes in Greater Sydney. Taken together, these markers are intended as a guide to help orient future planning for Sydney Water based on the change processes that are likely to unfold. They can assist Sydney Water in shaping the direction of the emerging digital technology transition in home water systems, and across the city more broadly, to ensure that water conservation, system optimisation and community benefits are realised in the near future.

The orientation markers are not presented in order of importance. Rather, the key questions for now (0-5 years) and what comes next (5-10 years and onwards) are addressed within each respectively. While this guide is focused on questions and considerations for Sydney Water, it also highlights where other stakeholders have responsibilities, and cooperation and collaboration will be required to achieve the desired outcomes.

Equitable benefits for users

Ensuring equal access to benefits will become increasingly important as technologies are rolled out in homes, particularly for socio-economically marginalised users.

Now

- → How can available data be customised for different users, based on their different interests, needs and access requirements?
- → How can technologies be integrated into environments such as aged care in a way that maximises benefits, while ensuring devices are usable to those with lower technological literacy and different accessibility requirements?
- → How will cost barriers be removed to enable greater access?
- → How will diverse user practices be accommodated in the design of appliances and user interfaces?
- → How will tenant privacy be protected while allowing them access to their use data, social networks and important targeted conservation information?

Next

- → How are equitable access and benefits measured and evaluated?
- → Have the benefits of digital technologies benefited some groups over others?

Technological interoperability

Technologies working together from the scale of the household to the precinct will be crucial to the realisation of their benefits. Issues of how to network diverse devices and support users to maintain them will need to be addressed.

Now

- → How can users be adequately supported when devices fail to remain connected and operate as intended?
- → How will interoperability issues between different manufacturers be navigated while avoiding becoming 'locked in' to one system?
- → What additional systems and support are required to ensure device manufacturers are able to measure water use in a standardised way?

Next

- → Are digital technologies working as part of a functional "ecosystem" from the household to the precinct scale?
- → Have manufacturers encouraged technology lock in?
- → How do networked systems respond to Internet and connection breakages? Are devices still be usable and collecting data?

Data privacy and trust

User trust in technology providers, including utilities, will be essential to technology uptake and efficacy. Ensuring that data privacy concerns are addressed will be essential.

Now

- → How can the quality, quantity and security of data across a precinct be managed?
- → Are there benefits to data sharing with third parties (e.g. manufacturers, the Bureau of Meteorology, insurance companies, or community groups)? And how can it be achieved without compromising user interests?
- → How will property owners receive necessary information without exposing private tenant usage data?
- → How can data be selectively provided to organisations such as social housing providers (e.g. leak alerts), while preventing access to tenant usage data?
- → What role can the community play in determining data sharing with other stakeholders?
- → Are regulatory changes required to enable useful data to be safely exchanged?

Next

- → Has user privacy been adequately protected?
- → How are the vulnerabilities of diverse users being accounted for?
- → Is data being effectively shared to ensure systems are functional from the dwelling to the precinct scale?

Figure 36 Orientation points (1 of 2)

Waste avoidance

Preventing unnecessary electronic waste associated with digital technologies, and energy waste linked to non-essential data collection should be avoided to prevent adverse environmental impacts.

Now:

- How can unnecessary digital technology deployment and data collection be prevented?
- What end of life protocols can be put in place to ensure technologies can be and are reused or recycled at end of life?
- How can early decommissioning of devices due to malfunction or wear be avoided?
- What support will be required (e.g. testing, logistics, aggregation, safety) to ensure devices and batteries are directed to appropriate pathways at end of life?
- Has government established adequate regulations and incentives to enable waste avoidance and promote producer responsibility?

Next:

- How can the relative necessity or redundancy of devices be periodically evaluated?
- Has additional waste associated with digital technologies been avoided?

Infrastructure & Maintenance

It is important that new buildings and urban infrastructure are equipped to accommodate the introduction of smart technologies, and that there are adequate maintenance and upgrade protocols and resources to keep them functional.

Now

- How can Sydney Water engage developers to ensure new dwellings are equipped for the installation of smart meters and other smart water technologies?
- How can Sydney Water support building and infrastructure owners to ensure sensors and smart devices are adequately maintained?
- As beneficial technological upgrades and innovations become available, how will timely uptake be ensured? What barriers are currently in place to the timely adoption of new technologies?

Next

- Have smart technologies and related infrastructures been adequately maintained to ensure system functionality and equitable access?
- Has Sydney Water adopted an agile approach to technology uptake?

Data coordination

The coordination of data governance operations and protocols between Sydney Water and other stakeholders (e.g. government, manufacturers), and internally, will be crucial for system functionality and usability.

Now

- How will Sydney Water establish a coordinated approach to data management across different areas of the organisation?
- How can it be ensured that different devices provide consistent and accurate water conservation data, particularly if owned or managed by different organisations? For example, if rainwater tanks are not connected to a smart meter, or are metered by another entity, such as local government, there is a risk that the smart meter data could significantly underrepresent actual water use.
- How can Sydney Water productively collaborate with organisations that are at different stages in their implementation of smart devices and data governance structures? And how will discrepancies in systems and priorities be resolved?

Next

- Based on user feedback, how can more collaborative options for device design, data collection and sharing be established?
- Has a coordinated system for managing data been established within Sydney Water and externally?

Figure 37 Orientation points (2 of 2)

Conclusions and further research

This study has shown that the manner in which smart water technologies are integrated into diverse households, with an array of water use practices, will be important for several reasons. These include ensuring that:

- intended water conservation and other benefits are realised;
- users are not adversely affected by the introduction of these technologies, through issues such as data privacy breaches; and
- that additional material and energy waste is not created through the implementation of smart devices without an established benefit.

The research has assumed that a digital transformation of residential water metering, monitoring, plumbing fixtures and water-using appliances is to a significant extent inevitable. To realise the potential benefits of digital technologies, the current practices of water governance and regulation and existing systems of knowledge and expertise will need to be altered. Decisions made now will influence the extent to which utilities, like Sydney Water, and other stakeholders can shape these changes rather than being subject to them.

With a focus on new developments in Greater Sydney, and in Western Sydney particularly, this study has set out to answer the questions: What are the key questions and considerations that will help Sydney Water navigate the transition to smart water technologies over the next ten years? And how can Sydney Water support the realisation of the most beneficial social and environmental outcomes in this process? In answering these questions, the research has produced a series of visual narratives, each presenting flows of water and data within various dwelling types. These visual narratives address the variables influencing and consequences of the water and data flows. It also presents a series of 'orientation makers' that aim to guide the implementation of smart water technologies via questions that will need to be considered over time.

Prior to this study, there had been limited research looking at how smart water technologies might integrate into, and change, diverse everyday residential water practices. It is clear from this research that if left unconsidered, a digital transformation of water in the home has the potential to further deepen existing social and environmental problems, rather than improve them. Conversely, smart water technologies have great potential to enable new forms of user engagement and participation, water conservation and integrated system optimisations at a building or wider scale.

Despite these clear findings, the introduction of smart water technologies potentially has a large number of flow-on effects for other systems, water and data infrastructures and the everyday lives of users. It is therefore unsurprising that this study has raised a number of questions. These in turn suggest several possible focal areas for future research in this area. Some of these are explored below.

Next steps in the current research program

The next steps are to complete Stream 1 and conduct Stream 3 in this program of exploring how smart water technologies could transform water using practices in commercial buildings and homes.

Stream 1 is a trial of Caroma's 'Smart Command' technology with smart taps, toilets, urinals, showerheads and leak detection valves installed across three floors of a commercial office building in Rhodes. Caroma are partners with ISF and Sydney Water in the trial. The floors are also sub-metered with high resolution smart meters. The research is exploring the potential to understand water use and water using practices in a commercial environment and to test targeted conservation and/or hygiene interventions. The trial is currently on hold as the floor remains unoccupied at the current time due to COVID-19 related disruption.

Stream 3 is designed as a synthesis of the research from Steam 1 and the current study. It will develop a white paper or discussion paper and consider the implications of in-building smart water technologies for the Australia water industry over the next ten years. The intention is to engage with a wider group of water industry stakeholders including from other water utilities to further explore some of the questions and issues raised by the research to date.

Potential next steps for further research

There are a number of potential areas of research that arose in the current project that Sydney Water could consider exploring further. Six of these are described below.

Exploring user practices in relation to smart water technologies

One area of further research could study water use practices to explore what different groups of people are currently doing with water and if and how smart technologies could alter these practices.

This type of ethnographic research could examine how smart technologies are integrated into the lives and water use practices of users. It would also look at whether and how these technologies are adopted and consider how they could be modified. For example, there may be other materials, infrastructures or forms of engagement which could help improve outcomes for the participants. It would be a form of 'user testing' in the context of everyday practices and would build our understanding of the factors influencing technological uptake and effective ongoing use, as well as address questions raised under the 'equitable benefits for users' orientation marker.

Such research would be well suited to exploring particular cohorts and settings, such as seniors and age care residences, or might be applied to look at the implications for diverse water use practices with the introduction of smart meters with customer feedback (in a context similar to the mid-range apartment visualised above).

New forms of engagement and targeted conservation messaging

Sydney Water is already piloting smart meters with targeted messaging with a group of Sydney Water staff. Further pilots could engage with general customers and test different approaches to engaging with users on how to use water more efficiently or take up more water efficient fixtures and appliances.

Some of the ideas described in the mid-range apartment visual narrative might be trialled. These include: providing personalised information, differentiated messaging to different user groups, in-building displays of water use or water saved, and/or 'gamification' via a digital app and platforms that allow people to compete as households or in groups of households to conserve water.

As noted, in the mid-range apartment visual narrative there is a potential to foster new forms of engagement with water use and conservation. One example was of neighbours sharing ideas or practices to work together to achieve water savings. Such interactions might also be studied in a pilot study.

Trials of smart technologies at household and precinct scales

Sydney Water is currently engaged in trials of smart technologies at both the household and precinct scales. It has imported and is installing a number of in-home recycling 'Hydraloop' systems that take greywater from showers and treat it for use in toilets and other non-potable uses. Sydney Water is also part of a trial at Sydney Olympic Park of smart irrigation that uses recycled water and an array of sensors to explore the optimisation of water use for cooling and greening.

Further trials might include:

- In collaboration with a smart rainwater tank supplier, linking tanks to Bureau of Meterology (BOM) data and looking at the benefits of optimising rainwater and pre-wetting clay soils to maximise water conservation and minimise stormwater runoff.
- Extending the above trial to a cluster of smart rainwater tanks in a small catchment. These might be optimised for both water conservation and localised flood mitigation.
- Using smart technologies to make integrated water work at the precinct level. This would be a trial to optimise the use of harvested stormwater, rainwater and recycled wastewater for a range of benefits.

Such trials could address questions raised under the 'infrastructure and maintenance' orientation marker.

Exploring data sharing barriers and opportunities between utilities, product manufacturers and users

Addressing questions raised under the ‘technological interoperability’, ‘data privacy and trust’ and ‘data coordination’ orientation markers, the issues around data sharing are highly significant for how the implementation of smart water technologies occurs. They are also questions that pervade other areas of digital transformation, both within the water industry and in other sectors.

Due to the range of issues and multiple perspectives needed to find solutions, this area of study potentially lends itself to a problem-centred transdisciplinary exploration. Such a study would draw on a range of expertise in fields such as Information Communications Technology (ICT), data analysis, urban water and social science. UTS as an organisation is well represented in these fields of knowledge.

Exploring waste avoidance issue

The questions around waste generation and the potential to avoid, reuse and recycle smart technologies should be explored by Sydney Water. Sydney Water already considers the recyclability of water meters as a selection criterion for new contractors.

The introduction of smart meters will see new waste issues emerge in relation to their batteries in particular. With over two million properties in Sydney, and smart meters generally needing replacement more regularly than mechanical meters, this could become an area of particular focus in best practice product stewardship.

Whether end of life stewardship is managed by Sydney Water or its contactors, oversight of this process falls to Sydney Water, and striving for best practice not just in waste management and recycling but also waste avoidance could be a valuable area for further research.

Smart hot water systems in a water and energy smart home

Energy efficient domestic water heaters using electric heat pumps are an important enabling technology for reducing energy use and moving towards net zero carbon emissions. These were illustrated in the aged care visual narrative above as the ‘solar sponge’. As shown, a smart water heater can also act as a type of battery, operating only at times when renewable energy is cheap and abundant to support increased grid penetration of renewables. However, to fully realise the potential of smart water heaters requires the integration of data on hot water use, smart energy meter data and energy market data. Such data can also be used to feed back to residents to promote conservation of hot water.

A research project might investigate and estimate the potential of smart hot water systems with monitoring and control, while identifying technical, regulatory and market barriers.

UTS

Institute for
Sustainable
Futures