NAVIGATING THE DIGITAL TRANSFORMATION OF WATER USE IN THE HOME USING VISUALISATIONS OF POSSIBLE FUTURES

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KEYWORDS

Smart Homes, Smart Cities, Water Futures, Water Efficiency, Liveable Communities, Resilient Systems

ABSTRACT

To realise the benefits of smart water technologies in homes and communities, changes to current data governance practices and thinking about local water management are needed. Decisions made now will influence the extent to which utilities can shape these changes to maximise community benefits and avoid new issues.

Using visualisations of possible futures within a cool-green precinct, with differing household types, we identified 'orientation markers' to help Sydney Water, and other stakeholders, navigate issues and decisions that will arise in response to emerging in-building and in-precinct digital water devices, including smart: meters, fixtures, appliances, irrigation, on-site recycling and tanks.

INTRODUCTION

In recent years concepts such as 'smart water', 'digital water' and the 'digital utility' have become common in the water sector. With the exception of customer smart meters, the focus has been on technologies that can digitise the monitoring and control of utility infrastructures or digital platforms for utilities to manage their staff and communicate to customers. In general, conversations about smart infrastructures and digital transformation have not addressed the potentials for nor issues raised by digitally connected smart water technologies within residential buildings and inside homes.

Smart water appliances, fixtures and devices are starting to be introduced into homes and residential buildings. These products incorporate digital elements and connections with the aim of enhancing their common function or enabling innovative features. Examples include smart clothes washing machines and dishwashers that monitor and control water and energy use, and are Wi-Fi connected. Such machines have been on the market for a number of years. More recent examples are smart taps, showers and toilets that enable the monitoring and control of water use at the fixture and are also Wi-Fi enabled. Some smart showers and taps have digital interfaces with a touch screen so users can choose their setting while usage information (flow rates, flow time, use counts, water temperature) are stored to the cloud. At a building scale a range of smart tank technologies are being used to control non-potable water sources and eco-values are automatically monitoring water use and shutting off identified leaks.

The primary aim of this research was to understand the challenges, opportunities and considerations that may be raised through implementing water-connected smart technologies at household, building and precinct scales. We focused on technologies and systems that may be adopted in newly developed and rapidly expanding areas of Western Sydney, with a view to understand how they might deliver multiple benefits and help realise the New South Wales Government's vision for the region as a liveable and sustainable, cool-green city (Greater Sydney Commission 2018). While focused on development within Western Sydney, this study is widely applicable to other areas.

The project first involved developing a series of 'visual narratives' for different households using smart water technologies in the near future. These households existed within four buildings in a hypothetical precinct, with the possible role of digital water devices visualised at these various scales. The visualisations illustrated how smart water technologies could transform water use practices in the homes and diverse communities of Western Sydney within the next decade.

With Sydney Water staff and other experts, the visualisations, across the four dwelling types and the precinct, were used to explore the potential implications of the emergence of in-building and in-precinct digital water devices. This exploration drew insights into what the key issues were and therefore what the decision points could be. These insights were then synthesised into several 'orientation markers' to guide Sydney Water with the anticipated digital transformation. The research findings have implications not only for Sydney Water, as it plans for and navigates a digital transformation of water

use in the home and local communities, but also other utilities, property developers, urban planners, and all levels of government, involved in and impacted by the creation of a sustainable and liveable city.

METHODOLOGY

The novel research methodology combined social science, engineering, and visual communication design. The broad steps were:

Initial research and scoping

The initial stage of the research involved reviewing a wide range of information in order to provide the initial inputs for developing the visual narratives. A series of literature reviews covered:

1.Growing a water smart city. This involved looking at the goals and challenges articulated in planning for the Western Parkland City within Greater Sydney.

2. The evolution of home water technologies in Australia from efficient to smart. This included a reflection on the history of water conservation technologies and how these had developed in Australia in the early 2000's as well as the emerging trajectory of home smart water technologies. Questions of data governance, ownership and privacy were also cover.

3. Accounting for social practices. This looked at research on how smart home technologies have already transformed domestic practices for different groups in the community. The research to date had not considered water-connected smart technologies but highlighted the importance of factors such as existing cultural practice, gender, and age in how people engaged with these technologies in their homes.

As part of the initial research a scan of smart water technologies was also conducted. The aim was to understand the types of digital water technologies currently on the market in Australia and internationally. The review collated over 300 distinct smart technologies/products designed for use within homes, buildings or precincts.

Development of the visualisations

Based on the findings of the literature reviews and technology scan as well as an initial workshop with Sydney Water staff, we engaged a visual communication designer. They assisted in the development of a set of visual narratives depicting hypothetical near future (ten years) domestic water practices using digital technologies. The development of the visualisations included testing with experts and community focus groups of customers from diverse demographics.
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. Rather, they provide a conceptual tool through which salient questions and considerations may emerge to plan for a digital transition within buildings and homes.

The types of technologies presented in the visualisations included: smart meters with customer feedback, smart appliances and fixtures (taps, toilets, showers) with digital monitoring and control, smart health toilets for the elderly, smart in-home greywater systems, smart tanks of various types, leak monitoring and control valves, 'solar sponge' hot water and smart irrigation systems. These digital Wi-Fi connected water technologies are combined with others designed to meet liveability and sustainability goals at a local level, such as in-building wastewater reuse, urine separation, rain gardens, bioretention and systems green walls.

Exploring the implications

An internal workshop and interviews with Sydney Water staff were used to explore the consequences of the near future scenario being visualised. In the workshop, groups identified key triggers, and the implications of each of the visuals over the short, medium and long term. This was across three themes of: (i) Technical drivers and tech-readiness, (ii) Data governance and interoperability, and (iii) User practices and engagement.

Developing a 'field guide for the future'

The findings were synthesised onto a set of orientation markers (see Figure 1 for an example) to guide Sydney Water (and other stakeholders) in navigating key considerations and questions that may arise in response a digital transformation of water use in the home and local communities.

All the visualisations referenced in this paper, the complete field guide, as well as the full write up of the research have been included in a report on this project which is available from the UTS and Sydney Water web sites (Wakefield-Rann, *et al.,* 2021).

THE VISUALISATIONS

Five linked scenarios were developed as visual narratives with 34 images in total. Eight images are included in the paper (see Figures 2 to 9). The remaining images can be sourced in the full report.

The Precinct.

The precinct visual narrative develops a view of how the four hypothetical buildings explored might be located in a neighbourhood in a newly developed

area within the Western Parkland City. It shows how certain building-level technologies have the potential to contribute to city-level water conservation and blue green infrastructure objectives, as well as how they interact with other infrastructures at a precinct scale. Several precinct scale smart technologies have been incorporated, including those related to stormwater harvesting and management, water quality and quantity monitoring, and water reuse.

Five images where develop as part of this visual narrative for the precinct of which two (Figures 2 and 3) are included in this paper. These show water flows (on a sunny day) and data flows to utilities.

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 new development over the next decade in expanding areas. The narrative explores how diverse occupant groups with diverse water literacies and practices interact with water saving technologies in ways that create challenges and opportunities for water conservation and users.

Seven images were developed for this visual narrative. The images highlight: the diverse water practices and products in each apartment, specific issues with renters and novel forms of engagement including gamification and waterwise social network.

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 dwellings are assumed to have been developed by a private utility under the NSW Water Industry Competition Act 2006 (WICA). As seen in Figure 4 the building incorporates multiple systems to allow captures and reuse for wastewater and nutrients. Figures 5 and 6 then show the water and data flows in one of the apartments in the building. The apartment shows a fully automated smart control of all water fittings and appliances. An image showing householder responses is in the full report.

Social housing

Western Sydney currently has a high percentage of households living in social housing compared to the rest of NSW. This dwelling type also often involves different tenancy arrangements and stakeholders to conventional rental properties. This visual narrative explores some of the specific vulnerabilities and corresponding opportunities that exist for these households in a transition to more domestic smart water technologies. Issues raised included: data consistency and relevance to the context, data access and technological literacy, the need to protect vulnerable residents and the likely resourcing issues for agencies. Opportunities included: leak alerts, maintenance alerts, targeted water conservation messaging and demand management program offers to help the tenants with water, energy and corresponding bill savings.

The three images for this visual narrative are included in the paper these show. Figure 7 data and water flows, Figure 8 residents' responses and Figure 9 the smart rainwater use system integrated into the development.

Aged care and retirement village

With an ageing population in Greater Sydney, and NSW more generally, the state government has identified the need for options that enable people to remain self-sufficient for as long as possible (NSW Govt, 2020). This visual narrative explores some of the 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 institutional contexts.

This visual narrative included five specific images covering issues of privacy, who has access to monitoring data, and usability. The opportunities identified included: devise assisted care, health alerts and reminders, hygiene improvements and a means to provide families with an assurance of care.

A FIELD GUIDE FOR THE FUTURE

The orientation markers in the field guide condense the key considerations and questions raised into six central themes to help guide future planning and decision making. A card on each of these themes was developed with prompting questions at key stages of water use transformation. Figure 1 is an example of one of the marker cards and questions. The six themes are:

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 system benefits. How best to connect diverse devices and support users and organisations across platform, remains 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.

CONCLUSION

Highlights of the project included developing a:

- Novel approach to developing near term scenario visualisations of urban water futures
- Series of detailed visual narratives that illustrate possible futures for four diverse household types.

This allowed for an exploration of the potential benefits and impacts of smart water technologies in homes and communities, and led to six orientation markers to help guide thinking on this issue and decision-marking for utilities.

The visualisations and orientation points should help Sydney Water shape its response to the digital water future as it unfolds in homes and communities, particularly in Western Sydney. Taken together, they are intended to help orient Sydney Water based on the change processes that are likely to unfold. They can assist Sydney Water and others in shaping the direction of the emerging digital technology transformation in some elements of in-home, in-building and in-precinct water systems, and across the city more broadly. This can ensure that community benefits such as water conservation and liveable cool-green communities are realised.

ACKNOWLEDGMENT

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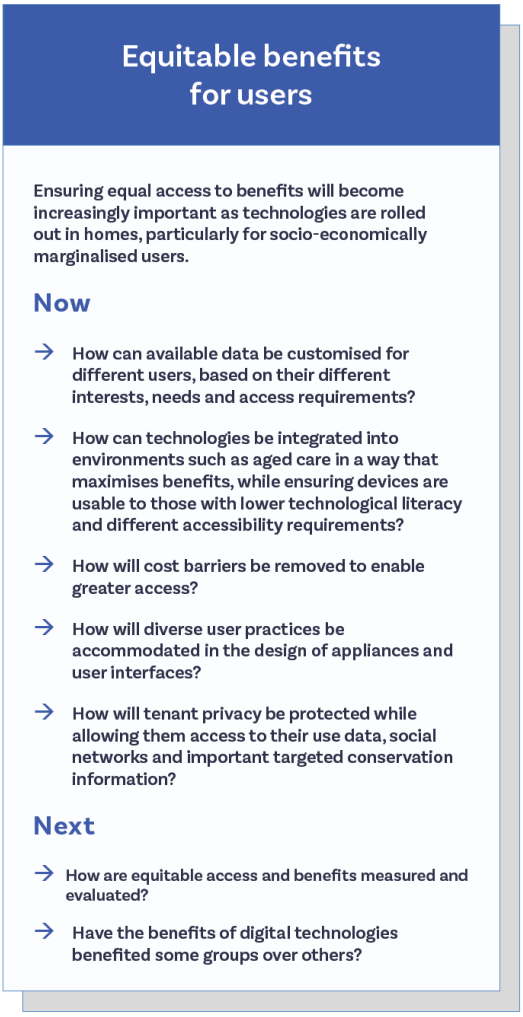

Figure 1 Example of orientation marker

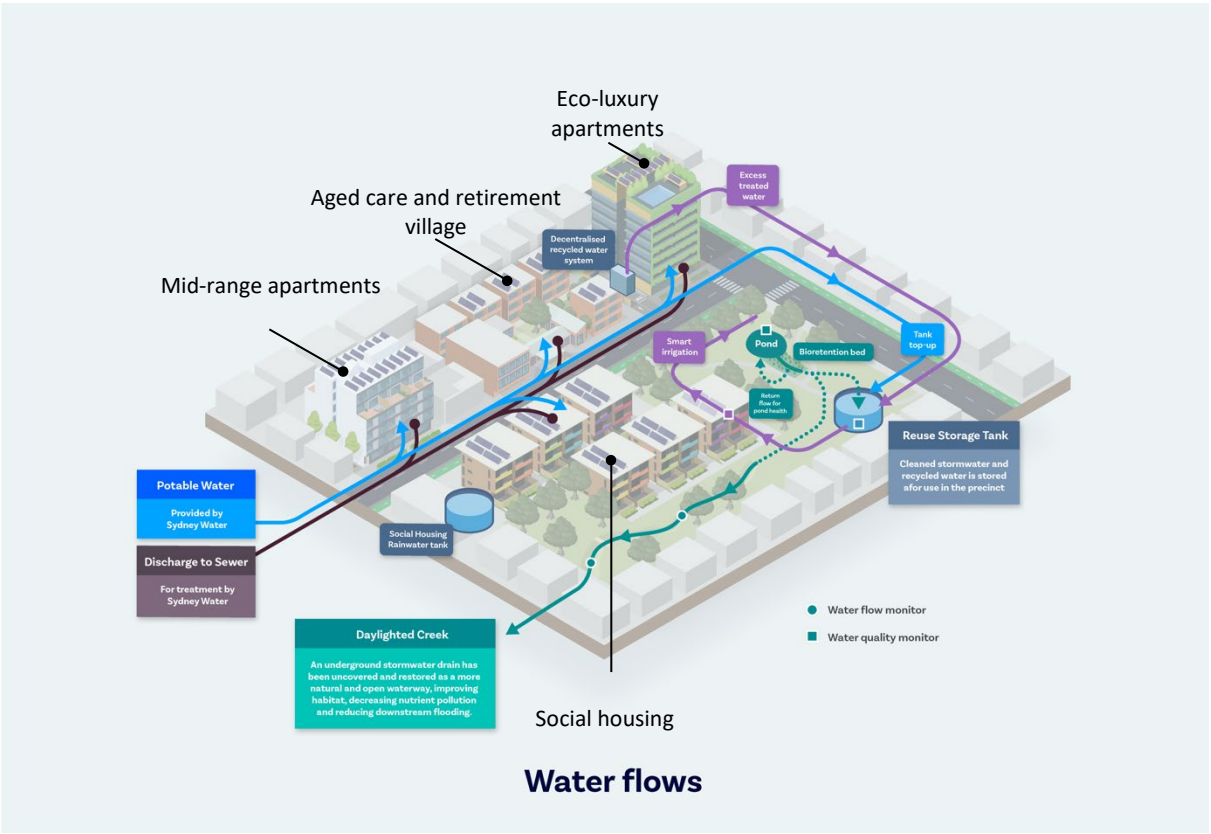

Figure 2: Water flows in hypothetical 'Precinct' showing the four explored dwelling types

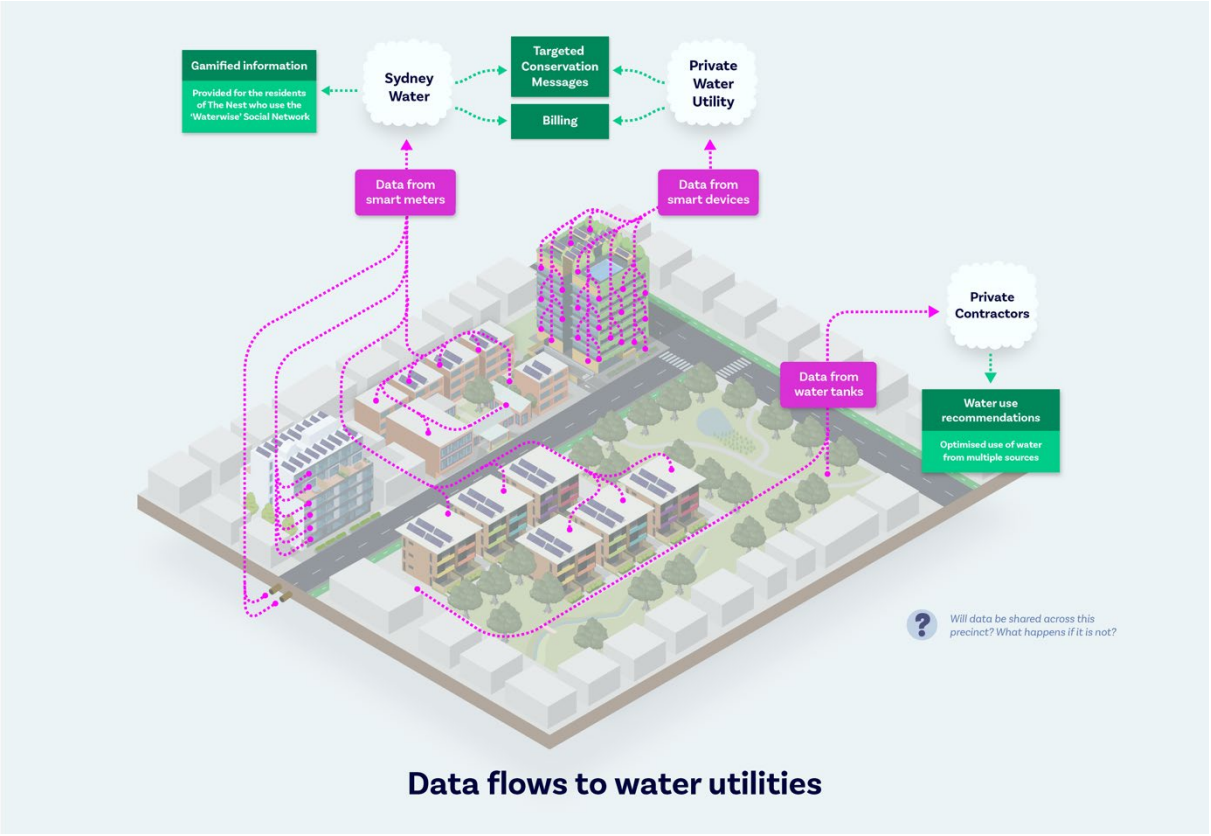

Figure 3 Data flows to water utilities across the Precinct

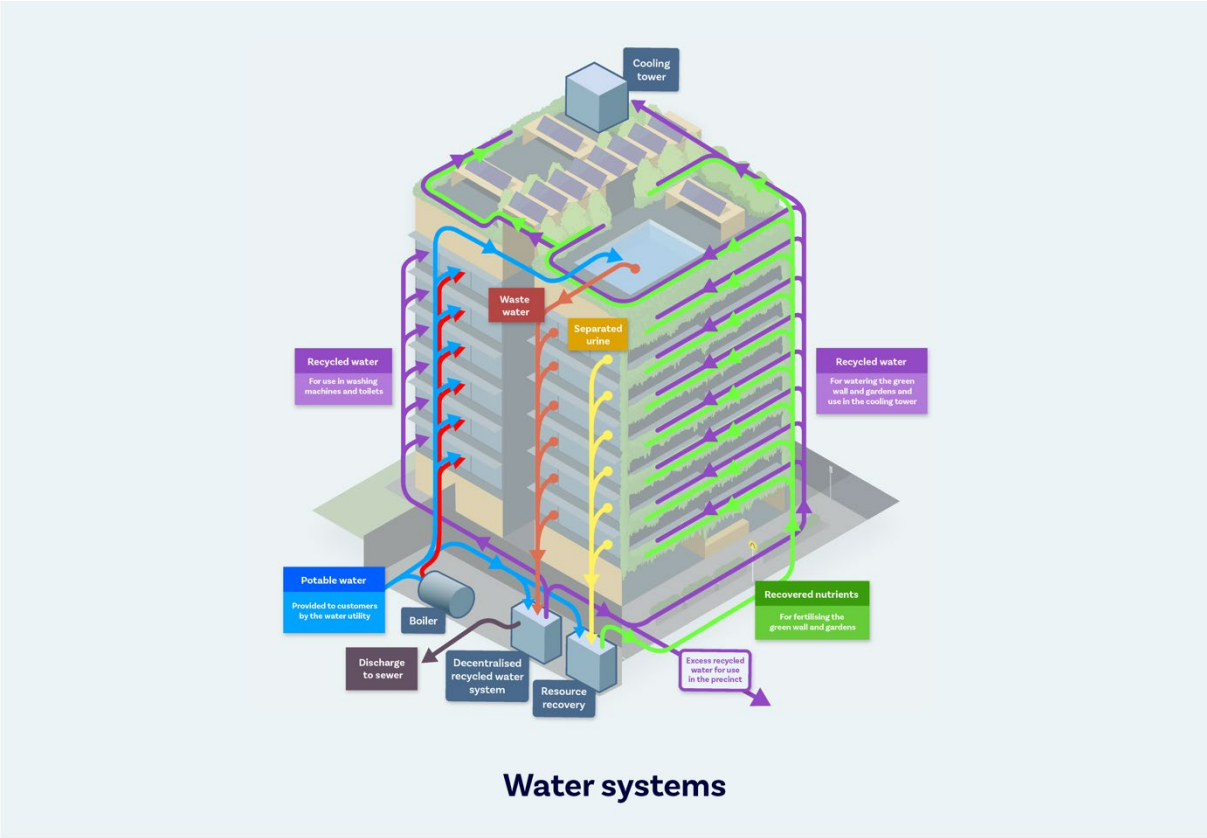

Figure 4: Eco-luxury apartment scenario - exploring intergraded building water systems

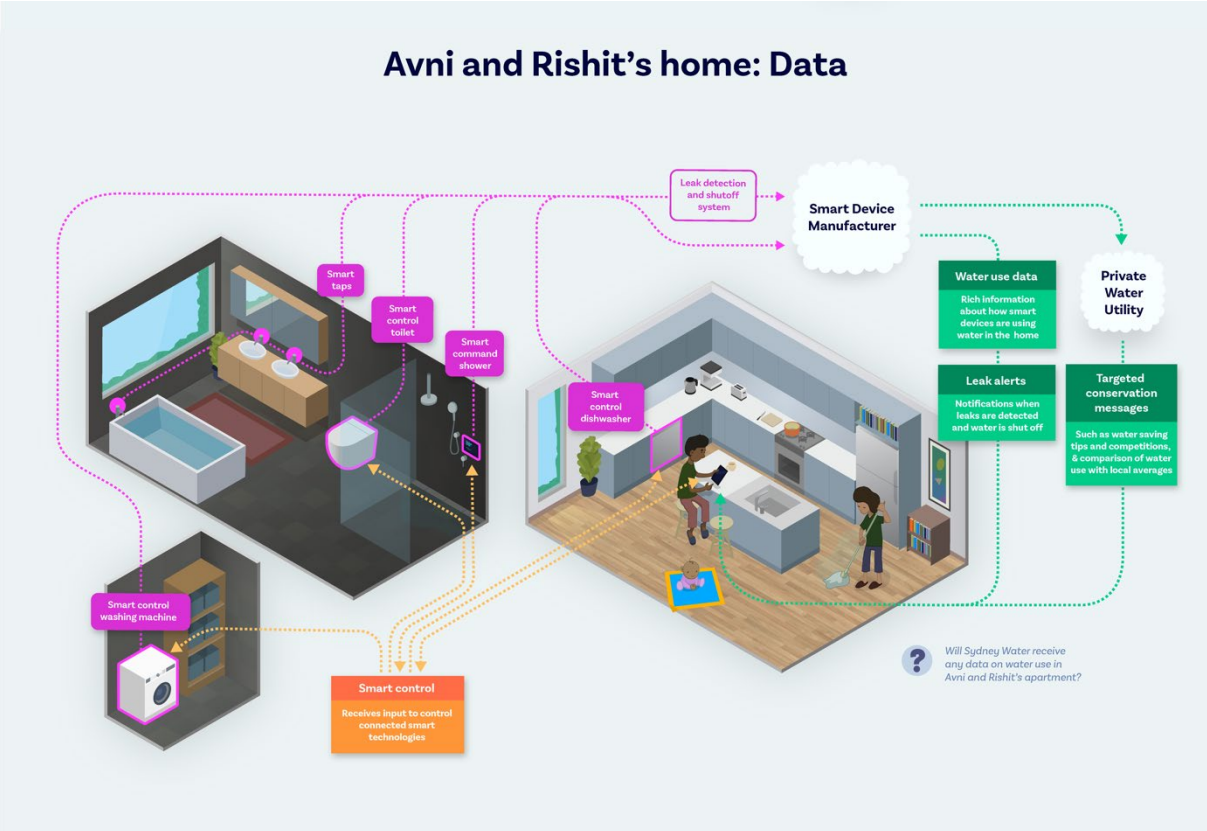

Figure 5: Eco-luxury apartment scenario – residential data flows

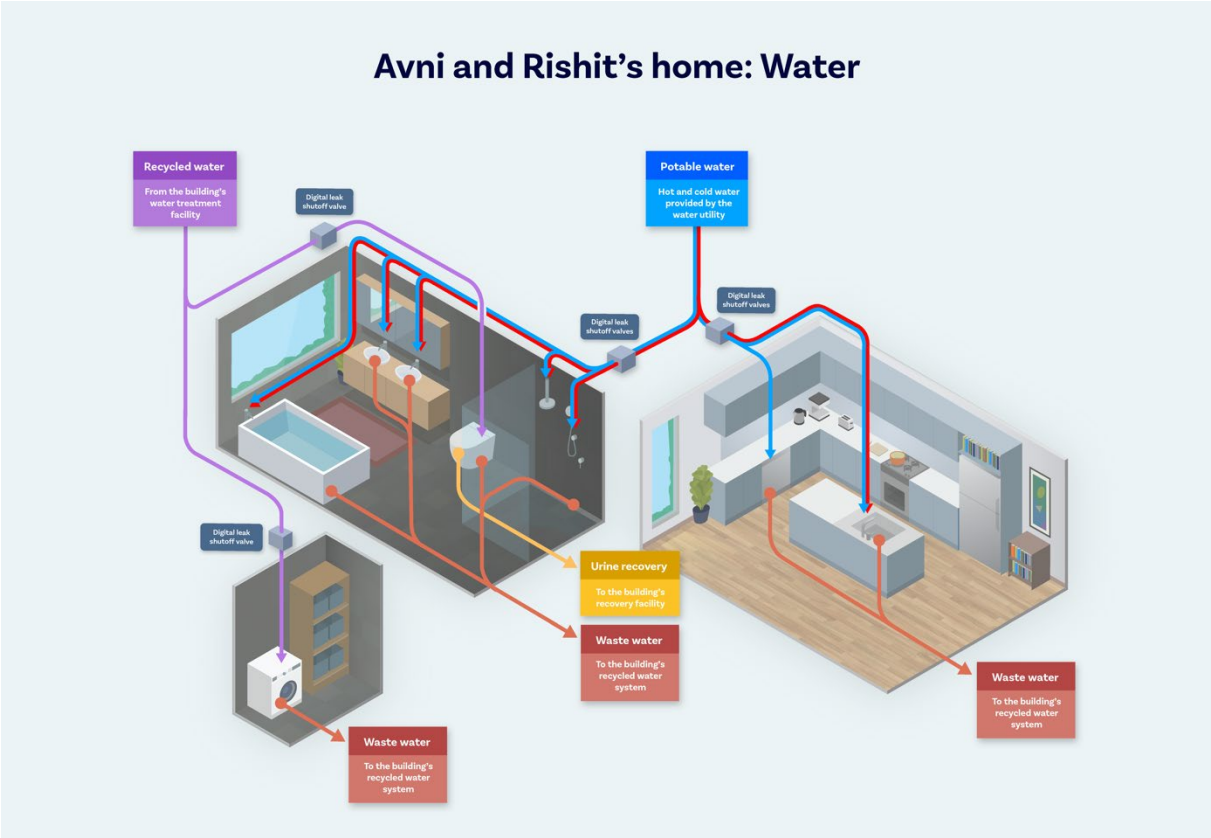

Figure 6: Eco-luxury apartment scenario – residential data flows

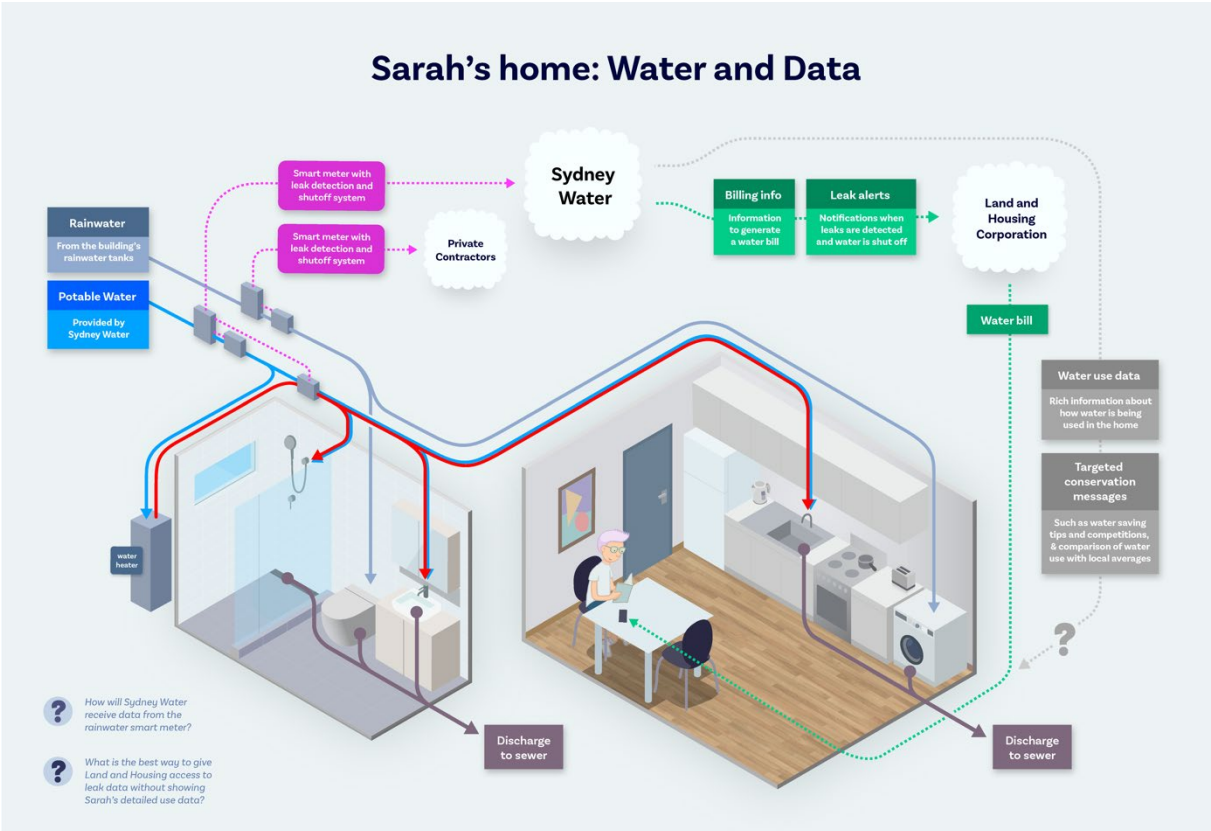

Figure 7 Social housing scenario - residential water and data flows

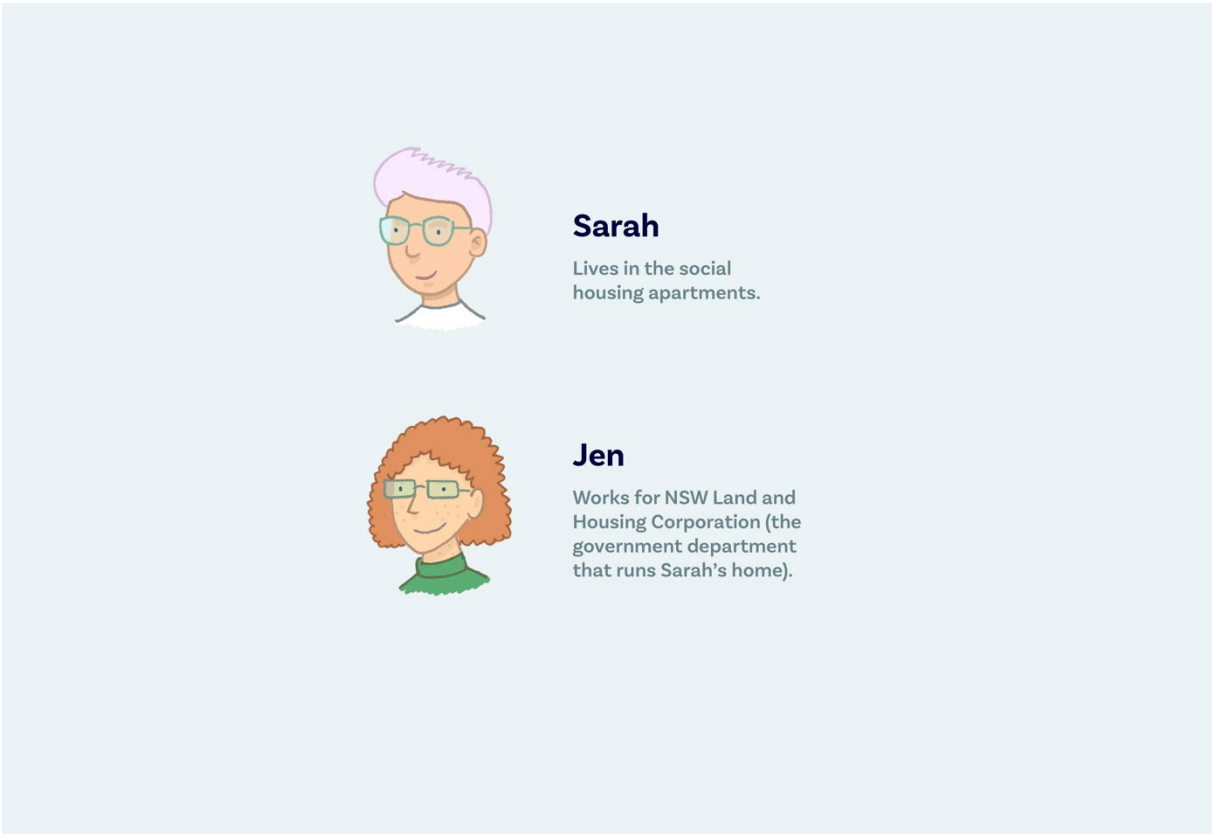

Figure 8 Social housing scenario -: Resident and Land and Housing's comments

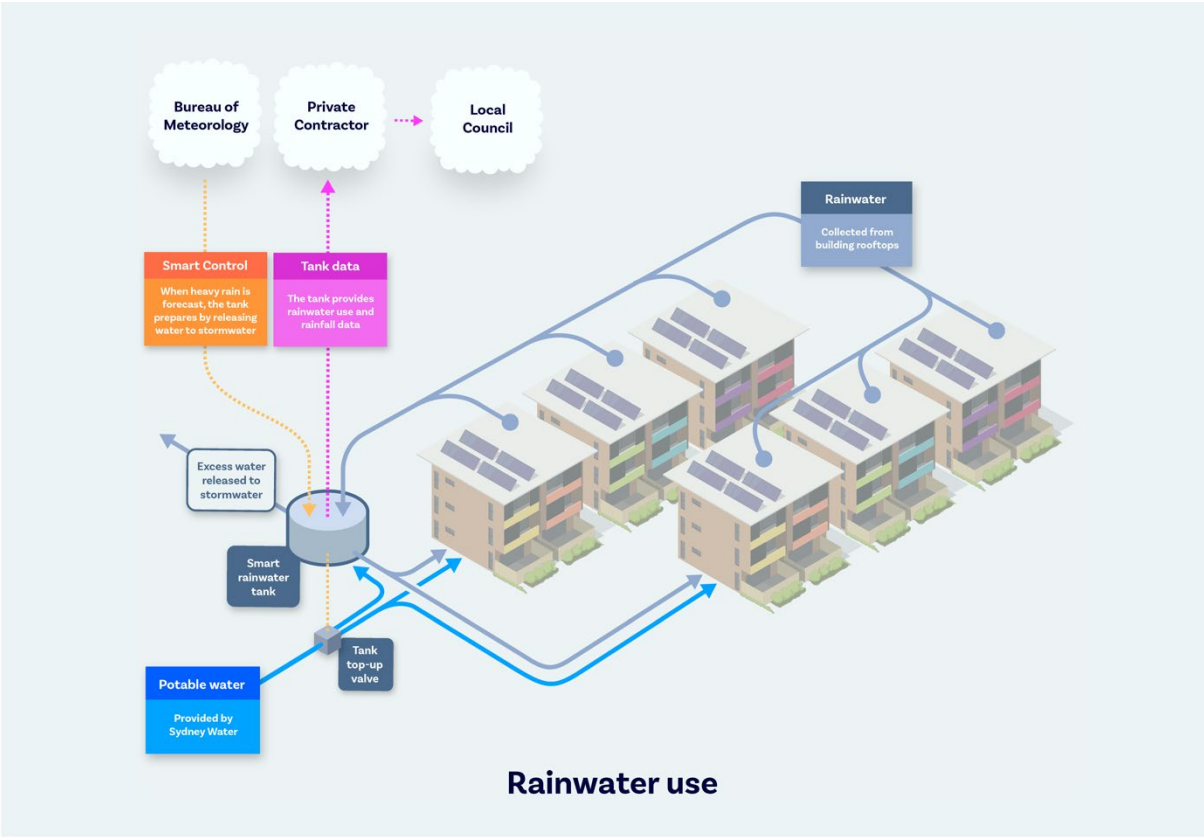

Figure 9: Social housing scenario - exploring smart rainwater use