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Article

Planning for a Prosumer Future: The Case of Central Park, Sydney

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Abstract
Rapid convergence of utility and mobility solutions enabled by data and the Internet of Things is future-proofing economies around the world, delivering liveability, sustainability and resilience, and importantly decreasing pressure on utility bills and infrastructure costs. Australians cannot miss out on the many benefits brought to families and businesses by the digitisation of infrastructure and services, not just reduced household bills but also the ability to generate income as prosumers, not consumers. Localised sustainable Next-Gen infrastructure and services are growing from within communities, creating a new class of consumer—the prosumer: where customers are more than consumers but also producers. Prosumers have the ability to generate free energy from the sun at home or office and sell the excess, recycle water and waste reaping the financial benefit, avoid the second largest household expense of a car by sharing mobility, and access shared data networks to plug in and play at little cost. Planning frameworks play a critical role in enabling a new utility prosumer future in Australia and reform of planning gateway processes is essential. This article highlights Sydney's Central Park as a best practice urban infill development showcasing how the flows of water and energy are organised to provide enhanced sustainability, liveability and resilience for the local and neighbouring communities. Central Park proves the benefits of taking a precinct approach to utility and mobility services. It shows how these benefits can grow and be exported to neighbouring buildings and existing communities, in this case University of Technology driving inclusion and affordability. Central Park also demonstrates the opportunities to drive deeper socio/environmental benefits by enabling prosumer services through low-cost access to utility services and circular resource flows. Importantly, this article demonstrates that Central Park's phenomenal sustainability benefits can be replicated at scale in land release communities, but planning reform is required.

Keywords
Next-Gen infrastructure; prosumers; sustainability; Sydney; urban infill; utility convergence; water-energy nexus

Issue
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1. Introduction

The way water and energy are supplied to households has traditionally determined the level of sustainability. Under current traditional infrastructure, higher sustainability is delivered when as little resources are used as possible. That is because they are linked to non-renewable and inefficient centralised networks such as rainfall dependent water systems and coal-fired energy networks. Using Next-Gen Integrated Water Management (IWM) and precinct-scale energy utility approaches it is possible to use resources in a highly efficiently way that meets rapid urbanisation and climate change. It means it is possible to create flows in and through the city—an urban metabolism—that is sustainable. This approach means flows can stay within a precinct enhancing the liveability, vibrancy and ecology of that community, but can also be exported to neighbouring communities sharing the benefits and in fact creating abundance not scarcity. Taking this modern approach to utilities means there is a greater resource in wastewater, in organic waste, in solar and the use of water to heat and cool. A circular, not linear, approach can ensure waste streams leaving the city can be kept to a minimum reused again and again.

This (extended) metabolism model (Newman, 1999) is capable of describing the flows that run through the city and which parameters need to be used to increase sustainability. This model is used in urban planning and design to create the strategy of the two networks (Tjallingii, 2015), in which the flows of the transport network form the framework of higher dynamic functions and the flows of the water system are related to land use of lower dynamics. This way these flows have been separated and connect to each other in the residential area. Generally, the flow of energy is linked with the higher dynamic network. However, the recent technological developments, availability in next generation data (Cavallo & Cooper, 2015) and the development of the Internet of Things (IoT) places this approach under scrutiny. Smarter, more unexpected gains, more efficient use and exchange of production and consumption becomes possible when behaviour and demand of individuals can be collected, analysed and through algorithms be turned into precision supply, smart reuse and efficient waste management.

The circular economy decouples population growth from resource use (Webster, 2017) ensuring materials and resources are not exploitable but have continuous flows of reuse and reconnection within a city precinct: reshaping and transforming matter in a new context so that everything becomes a resource and creates reusable flows that are continuously available and in abundance. Scarcity becomes redundant, and citizens have the opportunity to harvest those circular resources, use them and trade them. This contrasts with current linear urban metabolism models that prelude circularity and struggle to embrace technological developments, such as IWM, local energy generation and IoT.

For residents in Next-Gen utility precincts, this means seamless change. While there is no physical difference to customers buying local energy and water—i.e., water and energy look the same at point of use, people are participating in circular systems that put downward pressure on utility bills. Recycled water is 10 to 30% cheaper than drinking water (Flow Systems, 2018a) and has a positive property investment impact, increasing property value due to self-sufficiency and resilience (Marsden Jacobs, 2013). In addition, sustainable utilities provide a platform for greater customer awareness and participation: making them more aware of the resources they use, providing them with more information, and greater control. Being informed about your usage and having an option to use sustainable water for non-drinking uses—since, according to the Australian guidelines for water recycling (National Health and Medical Research Council [NHMRC], n.d.), Australia does not drink recycled water—provides customers with the ability to make financial benefits compared to centralised utilities providing only drinking water. It can therefore be argued the decentralised utility has a bigger stake in connecting with their customers.

The use of water and energy can be measured and organised at different scales. Though it is often thought that larger scales make the flows more efficient in operation, precinct-scale utilities are proving that not to be the case. At urban precinct-scale generation, supply and consumption of water and energy could be well balanced and, because the resources are not transported over longer distances, this scale seems to be a good level to balance supply and demand. Keeping water local for greening, preserves drinking water supplies and removes upstream and downstream augmentation requirements, driving significant financial and broader sustainability benefits for the entire network.

In this article we firstly discuss the change IoT and Next-Gen data bring to the way energy and water is delivered to households. After this context is described we identify the problem and use the example of Central Park, Sydney, how a modern way of supplying, using and recycling water and energy can be operationalised, and, how residents benefit from sustainable, data driven utilities in their precinct and building. We present the development process of the precinct, the involvement of citizens/end users, and the technical aspects related to the flows of water and energy. We end with some recommendations and conclusions.

2. From Consumer to Prosumer

Big Data, algorithms and the IoT, and the translation of these data-technologies in propositions for smart cities is changing the way we look and plan our cities. It is also changing our utility and mobility models to be precinct scale and more sustainable. The siloed approach to utility infrastructure solutions and services is moving aside for converged solutions where waste and water are energy, they can heat and cool, and power mobility all within a single neighbourhood. Technological advancements enabled by IoT are also allowing people to own their infrastructure to be producers and consumers of energy, water, mobility and data. The rise of the prosumer: the consumer and producer will deliver big changes to our current utility markets. It is particularly important the vulnerable and disadvantaged who are most impacted by rising utility costs benefit directly from prosumer opportunities. This article looks at the consequences and opportunities these new technologies bring to the creation of more sustainable and user-beneficial flow-systems of water and energy. This is delivered by a new utility model that is precinct-scale not centralised and converging—bringing together water, energy, waste and transport, and has at its heart the prosumer (Figure 1).

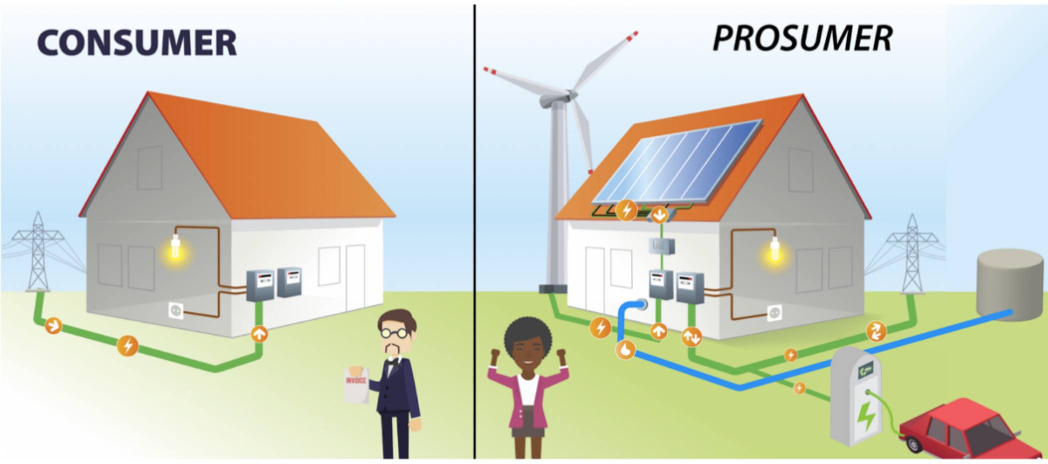

Figure 1. Consumer and prosumer (Open Cities). Source: adapted from US Department of Energy).

In water, there is now a growing movement—including industry, councils, research organisations, utilities and peak associations[1]—delivering critical transformation to decentralised precinct-scale sustainable water management (Watson, 2017). These decentralised water schemes embrace the principles of IWM (UNDESA, n.d.) and represents a new era for water in Australia.

In energy, the emergence of microgrids, Virtual Power Plants (VPPs) and local energy generation from trigeneration, solar with battery storage and organic waste to energy are driving a parallel shift to decentralisation. Unsurprisingly there are deep and significant benefits to people in being self-sufficient and not relying on costly, unsustainable coal-dependent energy. Retirees are Australia's fastest growing category of prosumers—as they rush to cover their homes in solar. Rooftop solar installations are at record highs. Almost $700 million could be saved annually by enabling decentralised standalone connections instead of the mandated conventional "grid connected" services (ENA & CSIRO, 2018).

Like the transition to decentralised water, decentralised energy is also challenging centralised thinking. Significant reform of policy, new regulatory arrangements are required. An unlevel playfield exists where all policy, legislation, regulation and tariff structures face and support last century centralised solutions. New regulatory arrangements are required as a matter of urgency to ensure communities, businesses, households and farms are able to be self-sufficient. Customers are exiting rapidly from the grid challenging the aging business models of centralised energy utilities which assume incorrectly all future growth belongs to them. If customers leave coal-fire powered networks in pursuit of their own free renewable rooftop solar, energy costs are immediately increased for the remaining customers to cover the deficit. This is clearly the wrong response and will only drive more people off the grid. More innovative and affordable network services that reward and incentivise prosumers to sell their own energy back to the grid and enable microgrids is a sensible outcome promoted by industry (ENA & CSIRO, 2018). The opportunity for the most vulnerable in the community to get free energy from the sun, to recycle their water and save on utility costs—is an important component of a transition.

There is no doubt new developments provide significant opportunities to implement Next-Gen infrastructure and services with the potential to embrace innovation and leap frog to new technologies. Urban infill and land release developments are driving different combinations of Next-Gen infrastructure and leveraging different financial drivers. For land release, deploying local renewable energy and recycled water is saving developers millions in upstream and downstream augmentation costs including upgrades to centralised drinking water and wastewater infrastructure or new substations. Here, these solutions can be deployed within the footprint of the development saving capital costs and land holding costs because they are faster to roll out and avoid the need for construction across multiple land holdings—as is required for centralised water or energy infrastructure. Importantly this demonstrates to planners how cost-effective Next-Gen sustainable water and energy is for new homes and developments—and why action now is required so another generation are not locked into high utility costs with no infrastructure or services to break away from rising costs.

In urban infill communities like Central Park where augmentation savings are limited there are growing examples of cost efficiencies from combining water and energy. For example, recycled water can extend the life of air coolers because the minerals and salts have been removed from the water as a result of Reverse Osmosis (RO; Saleh, Elhassan, & Abdalla, 2015). This practice occurs at Central Park Sydney—where the recycled water facility provides a mineral-free RO water quality specifically for air cooling. Local recycled water can also be used for heating and cooling, preserving rainfall dependent drinking water and removing the need for air conditioning units. Central Park is also proving the benefits of this approach and is now sharing both recycled wa-

[1] See, for instance: anz.smartcitiescouncil.com; www.asbec.asn.au; new.gbca.org.au; www.opencities.net.au

ter and chilled water for cooling with its neighbours—the University of Technology Sydney (UTS). See Central Park case study below.

2.1. Energy

IoT technologies deliver real time responses to energy generation and enable detailed mapping of fluctuations allowing for the deployment of more renewable energy for example in wind and solar. IoT technology is being integrated in utilities to effectively harvest solar energy locally (Nonnecke, Bruch, & Crittenden, 2016). It has a critical role to play in connecting infrastructure while cities wait for the deployment of 5G networks which will become widely available over coming years. IoT is enabling efficient management of energy sources that may be remote from each other by connecting and aggregating different energy resources for example microgrids and VPPs (AEMO & Energy Networks Australia, 2018).

Cities are readily making use of local renewable resources and not coal—or gas-powered power plants because "smart grids" are introduced as a distributed system with the help of IoT. When the demand for energy is high the normally used centralized power plants often use less efficient and polluting fossil resources. A distributed local energy system, with machine-to-machine data exchanges "decides" on the use of which local renewable resources, can provide the energy needed during periods of high demand or during a power outage and save energy because they are more efficient than a traditional grid. The data provided by such smart grids is more detailed than automatic meter reading, better known as AMR-systems hence can account for sudden consumption changes by residents and allows utility companies to manage their systems more accurately. A so-called smart meter in the house makes it possible to collect user data real time instead of reading out monthly totals and opens up the options to remotely disconnect a client and control the availability of the service in an area or even for a specific house (Oracle, 2009). Due to the granularity of the collected data through Internet, a utility company can raise its energy efficiency and savings. Home-owners can get access to their actual energy-use through an in-home display, better known as IHD, which shows precisely when and how much energy the people living in the house use. This could have a small but significant impact on the amount of energy people use. The Environmental Change Institute at Oxford found that direct feedback through a smart meter reduces the use of electricity by 5 to 15% (Darby, 2006). The utility company HydroOne in Ontario conducted a real-time feedback study amongst its customers and found a reduction of 6.5% of their aggregate use of energy (HydroOne, 2006). Another study focusing on people's behaviour found that the in-house display, providing real-time use and costs of energy, reduces the use by 11 to 14% (Jessoe & Rapson, 2014). It is therefore necessary that researchers, vendors and the utility companies collaborate to invent the most effective smart meters upon which consumers will base their actions.

These tools, to be used by individual consumers, carry the potential to reach a high level of energy savings hence deliver substantial improvements for the sustainability of urban neighbourhoods and their energy systems. The monitoring of heating and cooling, lighting and energy use in general facilitated by IoT technology is optimising energy efficiency and providing building managers with data on strange extreme usage patterns or local disconnects in the system making it easier and faster to act when there are system failures. Homeowners have the opportunity to track their current and possible reduction of energy used through "retroficiency"—making the benefits accessible to new and existing communities. Software programs can identify where and how energy is wasted through instant analytics of the data collected. The recognition of usage patterns when a building is heated or cooled can be automated using machine learning and make it possible to remotely adjust and customize the thermostats of customers. The use of intelligently placed sensors provides information on the times a building and its individual rooms are in use, the demand of lighting and the desired temperature in specific areas of a building and can automatically turn of lights and HVAC, reducing the costs on energy not spend in empty or unused spaces in a building. Consumers and companies can make use of hardware indicating the potential choice for different renewable energy providers, allowing them to switch to renewables more easily. IoT can also calculate the most optimal timing when appliances such as washing machines can be best used given the availability of renewables offered on the grid. For instance, the charging of electric vehicles (EVs) can be programmed to times when renewables are available.

2.2. Water

The 52,000 water utility companies in the US together lose about 2.1 trillion gallons of treated water because their infrastructure is leaking (Adler, 2015; Forer & Staub, 2013). Up to 15% of Houston's water was lost in 2013 as result of leaking pipes (Adler, 2015). Remote sensors, placed in water infrastructure can monitor waterflows and identify leaks, making the water pipes "smart". The IoT can reduce the water pressure in the system to the minimal required levels, resulting in less water being used. When the entire water distribution system connects these sensors with the central pumping station the water can be accurately regulated, minimizing the amount of water in the system, reducing the water lost through leaks and reducing the pumping electricity. Pipe bursts and other sudden fatalities in the system can be quickly identified and repaired as the sensors are distributed throughout the network (Adler, 2015). This way, the IoT can prevent loss of water and the amount of waste water and does so much cheaper than the reconstruction of a whole nations water network would cost (Tilley, 2015).

Similar to the smart meters in the energy system, the water consumption of individual customers can be recorded and offer both the home owner as well as the water utility company the opportunity to drive improved water management outcomes (Australian Government Initiative, n.d.). Water system managers in centralized water utility companies could easily identify leaks in homes or offices. Individual home owners gain access to the information of their water usage and can detect a leak when the smart meter never indicates zero use. Leaks in the water system in businesses can be found by applying algorithms provided by software vendors. Smart meters provide high granularity and real-time information about the use of water by which the water utility company can detect resource-wasting, illegal behaviour or non-essential use of water in sensitive climatic conditions (Finley, 2015). The higher granular data smart meters provide allow customers to understand their different water uses, give them the opportunity to adjust their consumption patterns, and reduce their costs of water use.

IoT has importantly enabled a new water management approach. Local, precinct-scale IWM systems, such as Central Park, can be run remotely from a laptop anywhere in the world. Complex water treatment approaches such as Membrane Bioreactor (MBR), Ultraviolet (UV) and RO are easily built and operated—for example in the basement of a residential building (Figure 2) or among a land release community. Technological advances are delivering smaller more effective kit that can be deployed in many more locations and integrated into the community. These systems are safer and more reliable because they are IoT-enabled and can communicate through SCADA systems from machine to machine, and to the utility operations manager. Wastewater management and drinking water management can all be brought together in a highly efficient and localized way thanks to IoT.

Centralised water utilities are struggling to meet the demands of rapid urbanisation in a cost-effective way. Next gen IWM utilities licensed under the Water Industry Competition (WIC) Act and councils are highlighting the limitations of ageing centralised water utility approaches (New South Wales [NSW] Consolidation Acts, 2017).

Building these systems in new developments can in fact speed up land release and ensure resilience and self-sufficiency—this has been demonstrated in schemes that implement pressure sewer systems instead of gravity sewer systems (Flow Systems, 2016) Pressure sewer systems utilise smaller more agile pipes that can be deployed in the footprint of the approved development at more shallow depths. Avoiding lengthy infrastructure and planning negotiations required to build centralised infrastructure and speeding up land release. "Local water innovation is providing cost-effective alternatives to BAU while driving more affordable housing in growth areas. The use of recycled water can reduce water bills by around 10 percent. IWM and recycled water are speeding up land release in NSW by 5 to 7 years. The Gables Estate in North Box Hill has commenced home completions this year when BAU delivery would have been post 2025" (IPART, 2018).

The costs of servicing centralised water infrastructure are impossible to quantify as Sydney Water, for example absorbs its costs across its postage stamp pricing and subsidies servicing for new growth. Industry has called for more transparent data from public utilities on both costings and locational servicing strategies. Meanwhile developers and utilities implementing Next-Gen solutions keep cost savings confidential. However, water augmentation for new land release can be as much as $AUS100M depending on the location—centralised drinking water and wastewater augmentation with upgrades to pumping stations and centralised infrastructure are costly and gold-plated. These costs are inflating

Figure 2. Central Park Plus: The world's biggest recycled water centre at the basement of a residential building. Source: www.centralparkplus.com.au

customer bills and putting unnecessary upward pressure on utility bills. Water and wastewater bills are set to rise to $2500 by 2040 simply due to the rising capital and operating expenses of centralised water utilities (Infrastructure Australia, 2017).

In the case of North Box Hill, the centralised water utility Sydney Water would not have been able to service the development for five to seven years—estimating land holding costs to developers over this time would sit in the millions. On the other hand, a recycled water centre could be constructed for $15–25 million in a land release development. The infrastructure on the ground can be installed within the precinct very quickly (12–18 months) and the local infrastructure required by the household to connect to a local recycled water centre is cheaper than a rainwater tank but delivers more resilient and reliable water supply (Flow Systems, 2018b). For urban infill IWM there are limited augmentation savings. Here regulatory requirements to connect to recycled water drives more innovative outcomes such a Central Park but also Parramatta City which has amended its Local Environmental Plan (LEP) to require high water savings (Parramatta City Council, 2016).

Reclaiming storm water is a necessity specifically for areas with increased or peak rainfall. The IoT is capable of combining information regarding the actual weather, short-term weather predictions and capacity analysis of available storage spaces to allocate the rain water surpluses real-time to different locations. In contrast, areas with a dry climate and less rainfall would need to store stormwater as much as possible. The IoT can provide the information to finetune sluice positions to increase the amount of water stored, based on accurate weather predictions and the current water levels in canals and creeks (Adler, 2015). The cleaning of wastewater and its reuse as well as sewage treatment, essential in areas with a limited freshwater resource can be upgraded using the IoT. Online data and information systems are able to identify and provide data instantly to operators in case of hazardous chemicals or the appearance of pathogens in the water. Because wastewater has both inorganic as well as organic components and pathogens mixed in its complex system, a quick response is needed to identify, adapt and respond to a progressing and constant changing of the water quality in the waterflow. Sensors and devices use machine learning algorithms to immediate adjust the treatment of wastewater whenever required hence increase its effectivity.

The IoT and the collection of Next Gen data is also delivering new utility models capable of bringing together previously siloed utility systems. The water energy nexus (US Department of Energy, 2014) is opening up exciting leaps in utility innovation that benefit customers. As a result, utilities are getting closer to households and households are liked to precinct networks. An intensive communication exchange occurs, at the household level and at a larger-scale where monitoring and real-time adaptation brings together previously siloed systems, and of course interpersonal contacts between utilities and customers. Prosumers are increasingly playing a more important role, which in turn is driving utilities to develop inclusive plans for participation which enables them to change their behaviour. This trust and reliability can be further enhanced as Next Gen data and IoT contribute to realising sustainability (Nonnecke et al., 2016).

3. Problem Statement

Despite the rapid developments in data-science and the IoT, many Australians miss out on the many benefits brought by the digitisation of infrastructure and services to people, families and businesses—not just significantly reduced household bills (City of Sydney, 2018) but the ability to generate income by being prosumers not consumers (European Commission, 2017). Localised sustainable infrastructure solutions and services are growing from within communities, creating a new class of consumer—the prosumer: where customers are not only consumers but also producing resources. For instance, they have the ability to generate free energy from the sun at their home or office and sell the excess, recycle water and waste reaping the financial benefit, avoiding the second largest household expense of a car by sharing their mobility instead, and accessing free shared data networks to plug in and play at no cost. Large siloed command and control centralised infrastructure approaches are more than 75 years old and not suited to the changing data-led economy. It is too expensive, it is inefficient and cannot deliver sustainability. Centralised linear approaches to water and energy remove resources from communities—stripping them of water needed locally to green and address heat island effect. For example, Sydney produces enough wastewater to fill Sydney Harbour every year while Western Sydney is dry and requires water for greening, for features and to mitigate heat island effect. Centralised utilities business is unable to make recycled water cost effective due to regulatory constraints such as ring-fencing which prevents revenues from drinking water or waste water to be used for recycled water infrastructure. Additionally, there is no incentive for centralised providers to reduce drinking water sales (Watson, 2017). Transitioning to 21st century energy, mobility, waste and water businesses and services is urgent and essential, moreover beneficial. Significant rethinking and modernising of government policy, legislation, regulation and market settings needs to occur. A vision for this future infrastructure state needs to be created and targets set to make the transition rapidly. It is essential that innovation and decarbonisation are placed at the core of this transition. Localised utility and mobility providers require a seat at State planning tables and competitive markets need to be established for new business models and solutions that better meet peoples' needs.

As the market seeks to embrace and implement new utility approaches, it has become apparent that a number of NSW potential development sites are being constrained due to the current Gateway and land release processes which only allow "public authorities" to participate in the planning proposal. Incumbent "public authorities" traditionally consider centralised non-sustainable utility solutions—big pipe in, big pipe out. Alternative decentralised and self-sufficient sustainable solutions by non-government utilities are currently not appreciated, understood or considered.

Increased participation by licensed Next-Gen utility providers in the planning and implementation of land use change across NSW is critical if the State is to reap the benefits of sustainable precinct servicing. Old thinking and servicing solutions for land release are locking out communities from achieving more innovative solutions that future proof homes and buildings and drive down costs.

By planning and developing in partnership with licensed utility providers, land and housing supply can be increased to the benefit of stakeholders and without burdening State finances. Innovation and change can be implemented in NSW through the development of strategy and regulatory changes (Flow Systems, 2018c). Amendments to the Environmental Planning and Assessment Act are necessary to provide "public authority" status to water and energy utilities providing decentralised solutions. At the moment, only centralised utility providers are given public authority status to provide services to new growth, so when more innovative outcomes are sought by developers or councils only Business As Usual (BAU) default servicing is enabled under planning gateway processes. Instead, Next-Gen licensed water and energy utilities should also be given public authority status. This change will open the market to urgent reform, enable greater competition and innovation and deliver significant prosumer benefits to families and businesses.

4. Central Park, Sydney

Central Park (Figure 3) has taken its many stakeholders with it in the creation of this world-leading sustainable precinct. This journey has always challenged stakeholders whether they be investors, developers, contractors, utilities, government or the community, to be more sus-

Figure 3. Central Park, Sydney. Source: www.frasersproperty.com.au

tainable and do things differently. In the end this approach has paid off: It has influenced the market, challenged linear, centralised utility approaches while delivering circular water and energy flows to the community that are now so efficient, they are expanding to neighbouring buildings and communities. Central Park in Sydney is showcasing how the local involvement of future residents and stakeholders can influence design, and how the flows of energy and water can be successfully organised at a circular precinct-scale, not the linear centralised approach of the past which fails to value our resources.

4.1. The Planning and Design Process

In 2004 Australand, the original developers of the former Carlton United Brewery site, were not granted development approval by City of Sydney Council following some negative community responses to the Master Plan. The site was then sold to Frasers Property who went on to deliver on the aspirations of the community and Council. The site was called in by the State Government under State Significant legislation and granted approval in 2009 with more open space, larger floor area, trigeneration and the objective of five green stars (De Manincor, 2014). Once development consent was achieved, the developers began partnerships to secure the higher sustainability aspirations including what is now the world's largest recycled water system in the basement of a residential building (Flow Systems, 2018d) and one of Australia's largest mixed-use tri-generation facilities (Figure 4)—now exporting energy to the neighbouring UTS (Clarke, 2016) to deliver Australia's first district energy sharing project. What was not known at the time was how this new approach to utility infrastructure would both set a precedent for best practice but also challenge centralised water management practices and regulations and market settings including the wholesale water prices.

4.2. Involvement of Citizens and End-Users

The City of Sydney's 2030 Vision provided Mayor Clover Moore with a sustainability mandate to push for higher community and environmental outcomes. Nine months of community engagement resulted in the City's flagship 2030 strategy (City of Sydney, 2017a) to create a more sustainable city and the conclusion of one of the most comprehensive community consultations in the City's history. Thousands of residents, businesses, community organizations have an overwhelming vote for a "greener more international and a better-connected city" (City of Sydney, 2013). This consensus-building approach won the City community buy-in to create a bold vision and set transparent targets to meet that vision.

The appointment of Flow Systems as the Central Park utility provider brought with it a more personalised approach to customer engagement. Flow's Central Park Plus customers became the first in the State to receive monthly water e-bills. Believe it or not, most States including NSW were still on quarterly paper water bills when Flow switched-on its services. The Central Park community benefitted from not only monthly bills to reduce bill shock but also paperless ones. They also learnt that a new circular flow of water meant they needed to be careful about what goes down the sewer, kitchen or bathroom sinks. This respect has fostered a new under-

Figure 4. Cooling towers of the Trigen-plant. Credit to Shane Lo.

standing of sustainability and resource use. Citizens have also seen enormous global interest in their precinct—it is winner of more than 30 awards and runner up or shortlisted for another 60—the precinct proves that money does grow on trees: the magnificent green walls are powered by recycled water and drive up property value (Central Park Sydney, n.d.)

4.3. Technical Features

To achieve the Green Star sustainability targets, Frasers sought a decentralised local energy solution in trigeneration, local recycled water solutions and green walls. It partnered with Australian leaders in sustainable utility solutions and green infrastructure, including Flow Systems, Enwave and Junglefy. In doing so, Central Park became Australia's first water and energy multi-utility supplying sustainable services to 5,000 residents, 15,000 workers and 65,000 square metres of retail and commercial space in the 14 buildings at Central Park, through the thermal energy, and embedded electric and recycled water networks. It has also since developed the ability to export the benefits to the neighbouring UTS buildings, with pipes constructed under the busy Broadway Road to a new UTS building, carrying chilled water for cooling and recycled water for air coolers. Central Park is not alone, as at the other end of Sydney city centre, developer Lend Lease has delivered the Barangaroo sustainable precinct and, working with Flow Systems, the City of Sydney has the same vision for its Green Square development (City of Sydney, n.d.) just ten minutes to the Sydney Kingsford Smith airport. Precinct-scale management of water and energy keeps resources locally for greening to reduce heat island effect, improve air quality and raise property prices, and for self-sufficiency: the ability to reduce utility costs with more efficient energy infrastructure.

4.3.1. Water

The Next-Gen approach to water management within Central Park was outsourced to Flow Systems who set about establishing a globally-leading innovative solution that was resilient, sustainable and would put downward pressure on the cost of water. It resulted in the construction of a 1ml/day sustainable water recycling facility and local water network spanning the site. This is an IWM approach collecting multiple water sources of varying qualities, whilst creating several water supplies to meet the needs of the community. Australian laws prohibit the drinking of recycled water in nearly all jurisdictions, although some indirect potable reuse schemes exist. Recycled water can be used for toilet flushing, clothes washing, irrigation, fire-fighting, use on vegetable gardens and water features (Environment Protection and Heritage Council, NHMRC, & Natural Resource Management Ministerial Council, 2008). This still represents an opportunity to reduce water consumption in a drought-stricken country like Australia by up to 70% (Flow Systems, 2017). A recycled water facility of that size had never been built before in Australia, or the world. It changes how Australia had managed and serviced its water for the past 100 years, it challenged industry's centralised thinking and along with it the 75-year-old business model of Sydney Water and the market settings, supporting those approaches.

The Central Park sustainable water centre required its own planning and design processes. Innovative State legislation, the WIC Act, licenses private companies and councils to be water utilities generating the highest quality water services including drinking water and wastewater. Introduced following the Millennium Drought (Bureau of Meteorology, 2015) as a drought-proofing measure in 2006, the WIC Act was set up to catalyse greater water innovation and to increase recycled water schemes in the State. The Central Park project was the first full-service WIC Act licence (IPART, n.d.) in NSW and many learnings were required to construct the water recycling facility tanks and filtration equipment in the basement of the Central Park One residential building and the precinct network.

The WIC Act regulations were passed by the NSW Parliament in 2008 and have resulted in the development of a number of world-leading recycled water schemes, including Central Park, Barangaroo (Barangaroo Delivery Authority, n.d.), Discovery Point (Discovery Point Water, 2018) and Pitt Town (Pitt Town Water, 2018). Flow Systems set up a local community utility Central Park Water which was granted a WIC Act licence allowing it to retail water and authorising it to operate a network. WIC Act companies are subject to the same licensing requirements as Sydney Water. IPART and the Minister for Natural Resources, Lands and Water oversees the administration and operation of private water licences. Flow Systems designs, builds, manages and operates its sustainable water centres, directly billing customers for all waste water services—drinking, recycled water and wastewater. It is a wholesale customer taking drinking water at the gate of the precinct. Precinct approaches take large water-using communities and reduce the water consumption dramatically. At the gate of Central Park, a 50% reduction of drinking water is realised.

At Central Park there are seven water sources, including (Figure 5):

1. Rainwater from roofs;
2. Storm water from planter box drainage and impermeable surfaces;
3. Groundwater from basement drainage systems;
4. Irrigation water from all green walls;
5. Drinking water from the public water main;
6. Wastewater from all buildings within the Central Park community (from sewage, bathroom, laundry & kitchen);
7. Sewage from an adjacent public sewer (sewer mining protocols were established with Sydney Water regulator).

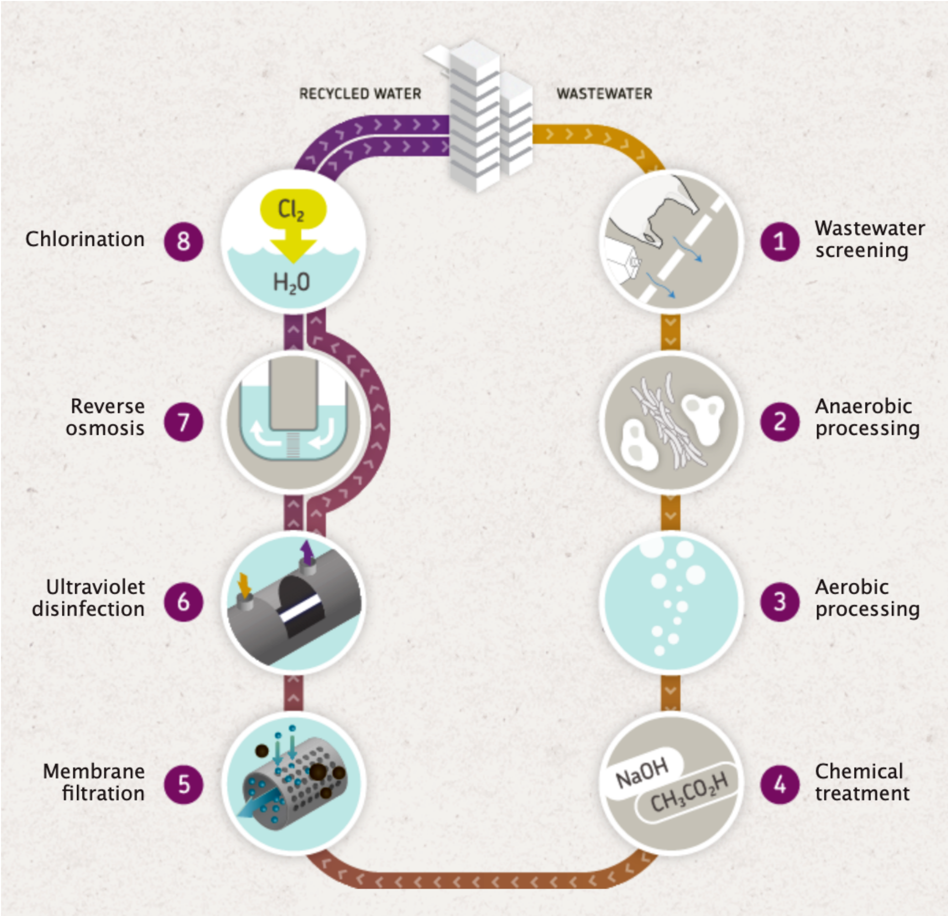

Figure 5. Central Park Plus 8-Step purification process. Source: www.centralparkplus.com.au

Wastewater is purified to the highest Australian standards undergoing eight purification processes including MBR, RO and UV treatment. Multiple sustainable water infrastructures within the precinct deliver three water qualities: recycled water and drinking water to households, shops and commercial space, and recycled water for air chillers. Given that Australia does not drink recycled water, dual reticulation is required to separately transport the drinking and recycled water. Households use up to 20% of water for drinking and cooking, another 30% for showering and bathing, and for the remaining 50%—toilet flushing, washing machine use, irrigation, green-wall watering and air cooling—it is possible to use recycled water. The sustainable water centre is built over four basement levels (Figure 6). Its technology can be completely controlled remotely from a laptop anywhere in the world. The facility requires minimal space, does not smell or make any disturbing noise. Every year water recycling technology becomes more efficient, smaller in size and more cost effective—confirming the need to shift to precinct-scale approaches.

4.3.2. Energy

Brookfield took over the Central Energy Plant at Central Park and it became operational in 2013. It is expected to produce 2mw of sustainable energy and reduce greenhouse gas emissions by 190,000 tonnes over the 25-year life of the plant—the equivalent of taking 2,500 cars off the roads each year for those 25 years (Central Park, 2013). Designed to run on natural gas (this technology can also use bio-fuels) it produces low-carbon thermal energy and also heats and cools the homes, offices and shops across the precinct, using water through heat exchanges. The centre also supplies low-carbon electricity to the multi-storey Clare Hotel and the mixed-use Brewery Yard building next to the Central Park precinct. Using water for heating and cooling can be 98 times more efficient than coal-fired power—with reduced emissions (Energy Efficiency Council, 2015). Apartments and shops no longer require air conditioners, as the highly effective network uses water to heat and cool. Since its construction in 2013, the facility has expanded, using thermal pipes to connect the central thermal plant to the neighbouring UTS, helping it reduce greenhouse gas emissions by around three per cent or 1111 tonnes annually (Clarke, 2016). Technologies such as solar are today more cost-effective in many cases in precincts than trigeneration. Coupled with batteries there is now greater accessibility for precincts to participate in a sustainable energy future.

There is also a significant potential role for organic waste to energy at Central Park. Flow Systems has part-

Figure 6. Central Park One. Source: www.frasersproperty.com.au

nered with the City of Sydney and UTS Institute for Sustainable Futures to quantify the benefits of aggregating organic waste from the recycled water process with food waste from restaurants and precinct businesses and apartments. The report has found apartments providing their organic waste to Anaerobic Digestion processes producing biogas could get as much as 20% of their electricity needs met or 50% of their hot water needs met. This trial, in its infancy, is demonstrating significant promise (Turner et al., 2018).

Central Park is also home to a superpod of car share vehicles. GoGet has Australia's largest car share depot with 44 car-sharing vehicles in under and above-ground parking lots (GoGet, 2018). As Australia transitions to fleet electrification the value of solar spill or local renewable sources such as biogas will increase to provide an affordable renewable local energy source for vehicles. These examples are proof of the convergence that is occurring between utility and mobility infrastructure and services.

4.3.3. Precincts

Exporting the benefits of precinct power and energy is a critical discussion for cities as they attempt to manage growth sustainably and ensure there is real downward pressure on utility bills. "If we are going to enable a low carbon future it will be critical that we learn how to transition existing urban systems ageing water and power infrastructure to flexible, resilient and sustainable networks" (Swinbourne, Hilson, & Yeomans, 2016). Existing communities that leverage new precinct developments with Next-Gen infrastructure innovations are expanding the benefits to their communities. Research and global best practices demonstrate that precincts with local water and energy solutions has lowered utility costs and carbon reduction. It's not just the technology, but the new business models that are allowing a transition to the future. The past decade has seen a shift away from single building water and energy innovations to precinct-scale. Here the ability to aggregate multiple revenue streams from water (drinking, waste, trade, sewage) and energy enables more creative business models that stack up in precincts of 1000 or more.

4.3.4. Green Finance

Finance for the trigeneration facility came through an innovative approach using an Environmental Upgrade Agreement (EUA; City of Sydney, 2017b). Frasers and the City of Sydney signed the $26.5 million agreement in 2013. It was the City's first agreement. Also known as Building Upgrade Finance, this approach to securing capital for commercial building improvement projects—and enabled owners and tenants to secure a benefit from operating buildings that are more sustainable and efficient. The City of Sydney offers EUAs to building owners with a lender who advances funds for the upgrade works. The loan is then repaid by the City's existing rate collection process. This is an environmental upgrade charge (City of Sydney, 2017c).

4.4. Role of the IoT and Next Gen Data

The rapid convergence of utility solutions enabled by new emerging business models, next generation digital technologies including the IoT, data analytics, AI and Blockchain, is enabling the transition to next generation multi-utility energy, waste and water businesses and services. It is driving new jobs, efficiencies and productivity, while decarbonising the economy. People will grow their own localised energy and water solutions from within communities using affordable sensors and participating in IoT use cases. They will get greater understanding of their water and energy usage through their own infrastructure—on the roof of their houses, their neighbour's community facilities and smart meters and apps. They will experience and see the benefits of local energy generation, recycling water and waste on their budget but also their environment. They will be able to do all this because of next gen data which can gather critical information about how utility services function, such as their costs and benefits.

5. Conclusions and Recommendations

Governance and market settings around the provision of precinct-scale water and energy need desperate reform. In all Australian States, legislation, regulation policy and tariff structures support and focus on last century centralised energy and water management. With 18,000 new dwellings constructed every month across the country (ABS, 2018), it is urgent governments mandate Next-Gen precinct-scale water and energy infrastructure and services in new growth areas. Centralised utilities unable to adapt their business models to the changing needs of communities have no place in the provision of services in new growth. Centralised water and energy infrastructure are gold-plated and the services lock families and businesses into ever-increasing costs, as their linear approach to resource use is unable to harness the value of reusing water or renewable energy options.

This is not just a question of cost. Home after home is currently built in communities facing higher temperatures (Webb & Hennessy, 2015), some with average 50-degree days, yet they are not equipped for these temperatures. Nearly every rooftop is without solar, and black in colour, absorbing more heat. Neighbourhoods lack established tree canopies, enabled and sustained by local recycled water. A failure to embrace Next-Gen infrastructure available now to the market will only lock families and businesses into an unsustainable and costly future—where quality of life and the value of property is diminished due to last century costly water and energy infrastructure.

Regulators and market operators need to show leadership and not engage in control fraud by supporting centralised energy and water business models at the exclusion of new innovative infrastructure and service solutions. Innovative regulation is urgently needed to position Australia towards a zero-carbon future by ensuring existing water and energy networks are resilient but also open to greater competition from circular economic approaches. This means valuing externalities such as reduced carbon, preservation of drinking water supplies, improved liveability and reduced ocean outfall. It also means considering the impact of new circular business approaches—for example the way EVs will use local energy networks is absolutely critical to the debate but absent from current policy settings, as is organic waste to energy and the potential for biofuels to provide sustainable alternative energy sources.

Innovative policy and regulation are transforming consumers to become prosumers around the world thereby achieving greater financial benefit, greater ownership and control by selling homegrown energy, recycling waste and water (European Commission, 2018). Next-Gen infrastructure approaches, such as those at Central Park, provide proof and inspiration for the prosumer future we must prepare for. Government has an unprecedented opportunity today to set a vision for the future, and targets to get there. Instead of looking at the past and replicating it. They need to look to the future and provide the infrastructure we need to succeed.

Conflict of Interests

The authors declare no conflict of interests.

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