Renew Nexus: stormwater management through urban water trading

Renew Nexus: gestion des eaux pluviales grâce au commerce de l'eau en milieu urbain

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RÉSUMÉ

La conception des systèmes d'eau urbains exige de plus en plus d'attention pour l'efficacité et les stratégies de réutilisation afin de fonctionner de manière harmonieuse et durable avec les services écosystémiques offerts par les eaux souterraines et les eaux pluviales. De nouveaux outils et technologies relatifs aux eaux pluviales pour des systèmes d'approvisionnement en eau urbains résistants au climat et efficaces sont nécessaires pour réduire la dépendance des gouvernements vis-à-vis de nouvelles infrastructures coûteuses. L'essai RENew Nexus en Australie occidentale examine comment des bases de données et / ou des registres distribués en ligne peuvent établir un système intégré d'énergie, d'eau et de mobilité comprenant la production d'énergie renouvelable, le stockage sur batterie, la récupération d'eau recyclée et d'eaux pluviales et la recharge des aquifères. L'essai intègre la technologie de comptage intelligent, la participation des ménages et l'analyse de données. L'introduction d'un nouveau système de commerce des eaux urbaines, sous la forme d'un système de crédits de récompense, aux résidents qui économisent activement de l'eau de consommation et des eaux usées à forte intensité énergétique tout en gérant de manière optimale la recharge des eaux pluviales et des aquifères devrait avoir un impact positif sur le déploiement , sources d'eau hybrides à l'échelle résidentielle.

ABSTRACT

Urban water system design increasingly demands better attention to efficiency and reuse strategies in order to work harmoniously and sustainably with ecosystem services offered by groundwater and stormwater. New stormwater tools and technologies for climate resilient and efficient urban water systems are necessary to reduce dependency on expensive new infrastructure by governments. The RENew Nexus trial in Western Australia is investigating how online distributed databases and/or ledgers can establish an integrated power, water and mobility system comprising renewable energy generation, battery storage, recycled water and stormwater harvesting and aquifer recharge. The trial integrates smart metering technology, household participation and data analytics. The introduction of a new urban water trading system in the form of a reward credit scheme to those residents who actively save energy-intensive mains water and wastewater, whilst optimally managing the stormwater and aquifer recharge, is expected to positively impact on the rollout of localised, hybrid water sources at residential scale.

KEYWORDS

Stormwater infiltration, groundwater, metrology, hybrid water system, urban water trading.

1 INTRODUCTION

Urban water system design increasingly demands better attention to efficiency and reuse strategies in order to work harmoniously and sustainably with ecosystem services offered by groundwater and stormwater. In the southwest of Western Australia the impact of climate change has severely reduced rainfall (McFarlane *et al.*, 2009, 2012, 2016). This has led to the construction of expensive, energy intensive seawater desalination plants using reverse osmosis for urban water supply to the capital city Perth, as has become the practice around other Australian coastal cities and some other parts of the world. Accordingly, new stormwater tools and technologies for climate resilient and efficient urban water systems are necessary to reduce dependency on such expensive infrastructure by governments.

The RENeW Nexus project (Resilient Energy and Water Systems) is a federally-funded initiative being delivered under the national Smart Cities & Suburbs program. Operating within the local government area of the City of Fremantle in Perth, Western Australia the RENew Nexus trial is investigating how online distributed databases and/or ledgers can establish an integrated power, water and mobility system comprising renewable energy generation, battery storage, recycled water and stormwater harvesting and aquifer recharge.

The water side approach in the trial integrates smart metering technology, household participation and data analytics with the aim to understand and manage the implementation of hybrid water systems at the residential scale within the traditional centralised urban water network. Similar trials on metrology, data analytics and end use studies are underway in various parts of Australia, for example, Nguyen *et al.* (2016), but little that also involves urban water trading, for example, McColl *et al.* (2007). In this paper methods and results of the trial are presented.

The project demonstrates the benefits of integrating stormwater technologies and tools towards sustainable cities via new approaches to stormwater infiltration, evaporation, collection and treatment.

1.1 Aim

The aim is to achieve sustainable urban stormwater management through urban water trading. The objectives of Renew Nexus towards sustainable urban water management and smart cities are:

1. Deploy smart water meters to participating households;
2. Monitor the contribution of hybrid water systems including mains, grey, storm and ground water supplies;
3. Develop a water balance model to urban the data collection and analytics platform;
4. Develop an online system of credits and debits within the existing centralised water infrastructure;
5. Provide a reward credit system to those residents who actively save energy-intensive mains water and wastewater, whilst optimally managing the aquifer recharge with stormwater runoff.

2 METHODS

The project sought expressions of interest (EOI) from residents within the local government area of the City of Fremantle who had hybrid water systems (i.e. plumbed rainwater tanks, pumped greywater systems, garden bores) and/or rooftop solar PV (photovoltaic) and were willing to have these systems metered, free of charge, over a 12-month period. To promote this phase of the project a poster was distributed, a website launched and public meetings advertised and held.

The following methodology was then deployed during the first six months of the project:

- Undertake site assessments at each EOI participant household;
- Assess and select advanced (smart) metering technology;
- Install water smart-meters;
- Set up data transmission, collection and analytics platform;
- Develop a conceptual modelling framework of a system of water credits and debits and test the framework on a case study data set;
- Collect and apply analytics to both water and energy use data.

Smart meter selection: In order to select the most appropriate smart meter, six current or imminently

available smart meters were assessed against a range of criteria. The NUmeter from the Water Group was selected. This is a 20mm ultrasonic, revenue grade smart meter that is configured to operate on Telstra's narrow band Internet of Things (NB-IoT) network and on its Cumulocity platform (Telstra, 2018). NB-IoT is a LPWAN radio technology standard to enable a wide range of cellular devices and services and this platform went live across all Australia's major cities in 2018. A key factor that will emerge from the trial is the trade-off between sampling frequency, meter battery life and density of data that can be collected on this platform.

Data analytics: Smart water meters were installed at about 40 residential premises within the City of Fremantle, with a total of about 80 meters installed on the various hybrid water systems. Each meter communicates with the Cumulocity platform via the NB-IoT network and water volume data is recorded every 30 minutes. Through a system of automated API (Application Programming Interface) calls to the Cumulocity IoT platform, the water usage data recorded by each metering device is imported into the computing software to proceed with data analytics and modelling. For each metered household (whether it is a single lot house or a strata apartment), a water balance will be calculated at a time interval equal to the meter readings (e.g. 5, 10, 30 minutes depending on the metering configuration selected). The objective of the water balance is to quantify the volume of water used, the volume of wastewater produced and water source (e.g. rainwater, groundwater, greywater, mains water) as well as abstraction and recharge to aquifer.

The volumetric quantification of each water source represents the first step towards the identification of mains water savings, reduced discharge to sewer, and abstraction/discharge relationship to the aquifer. A system of water credits and water debits was developed based on the water inflows and outflows quantified at the household-scale.

3 RESULTS AND DISCUSSION

Data from all meters is now streaming to the Cumulocity platform and analysis using the raw data has commenced. An example of the various water sources and flows at half hourly intervals provided by the smart meters over a one week period in September for a single residence in Fremantle with four occupants is provided in Figure 1. This residence has sound on-lot stormwater management with effective aquifer recharge of runoff, plumbed rainwater for all internal potable demands plus a greywater treatment system for toilet flushing, cold water inlet to the washing machine and all irrigation. The residence showed no mains water demand over this period.

Integration of three centralised UWM networks (i.e. water supply, sewerage, stormwater drainage) with the decentralised systems installed at the household scale (i.e. rainwater tanks, greywater recycling systems, groundwater bores) was achieved in the model developed. The presence of a shallow aquifer that is freely accessible by the consumers represents a fourth network where ecosystem services and residential water supply interlock. The centralised and decentralised (i.e. hybrid) water solutions were holistically integrated and accounted for in a modelling framework where volumetric and financial credits/debits are quantified and related to the consumers' home system of practice (Eon *et al.* 2018).

The credit-debit modelling outcome is a quantification of volumetric and financial water credits and debits that each consumer develops towards the water supply, sewerage and stormwater drainage networks, as well as the aquifer as a consequence of the consumer's usage of mains water, rainwater, ground water and recycled greywater. The new tariff scheme, developed in collaboration with the Western Australian water utility and regulatory agency, associates a fit-for-purpose financial value to all the water sources the consumer interacts with. Whilst the credits/debits towards the water supply network fully rely on metered streams, the largest source of uncertainty is related to the modelling of stormwater runoff, aquifer infiltration and blackwater generation.

Accounting for a net water credit/debit that considers the presence of water efficient measures and quantifies the impact of the household practices on the centralised water networks represents the first step towards recognizing the multi-attribute value of all water sources society interacts with. Importantly, this model places value on the stormwater infiltration to shallow aquifer as the often exploited groundwater resource for its ecosystem service offerings. Integration of the credit/debit model with distributed ledger technology results in a new urban water trading system where all water sources are valued, uncertainty accounted for. A trading system of water credits and debits between consumers and the water utility is developed.

4 CONCLUSIONS

The introduction of a new urban water trading system in the form of a reward credit scheme to those residents who actively save energy-intensive mains water and wastewater, whilst optimally managing the stormwater and aquifer recharge, is expected to positively impact on the rollout of localised, hybrid water sources at residential scale. The highlights to date are as follows:

- The deployment of over 70 ultrasonic smart water meters across 40 participating households;
- The volumetric measurement in 30 minute intervals of hybrid mains, grey, rain and ground water supplies;
- A water balance model underlies an online system of credits and debits within the existing centralised water infrastructure;
- A reward credit scheme to those residents who actively save energy-intensive mains water and wastewater, whilst optimally managing the stormwater to aquifer recharge.

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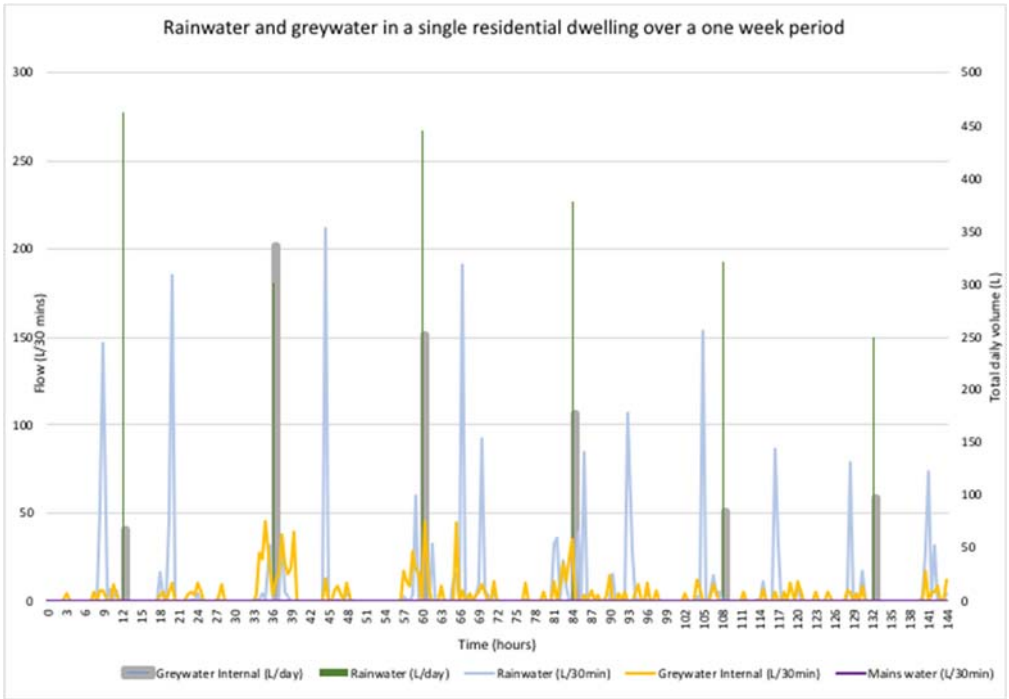

Figure 1. Example of smart metering output from a Fremantle residence maximising alternative water sources