USING AMI TECHNOLOGY TO REDUCE NON-REVENUE WATER AND ENHANCE CUSTOMER SATISFACTION

Eric Skowron (Jacobs New Zealand Ltd)

ABSTRACT (500 WORDS MAXIMUM)

By early December last summer, many communities across New Zealand were subject to water restrictions. Wellington and Hamilton City and Waipa and Waikato Districts banned or limited the use of sprinklers, whilst customers in Auckland, Canterbury, Wairarapa and many other areas were encouraged to reduce water consumption.

In contrast to regions like Australia and South Africa where droughts can extend for long periods, droughts in New Zealand typically last for much shorter durations. However, even short droughts can have significant consequences as storage facilities are often quite small and continued bore extraction during dry periods lowers aquifer levels which increases risk of salt water intrusion into aquifers.

Water efficiency is quickly becoming a topic of discussion countrywide. By some estimates, New Zealand is losing 100 billion litres of water annually through water loss. In some regions, many customers remain unmetered whilst some councils are expanding metering programmes but many are faced the challenge of creating a defensible business case.

This paper will discuss evolution of Advanced Metering Infrastructure (AMI) technologies, presenting examples from projects around the world relevant to New Zealand's unique water environment.

In one particular example, a 12-month AMI pilot study of a District Metered Area (DMA) with 500-homes has been established to use time-series data from customer meters to reduce Non-Revenue Water (NRW) before and after the customer meter. The study area is located in Gwinnett County (near Atlanta in the USA) and integrates AMI meters, network pressure sensors and weather data to identify NRW including pre and post customer leaks, water theft and meter accuracy.

Reduction of NRW, which averages 30% worldwide for utilities, can enable improved management of water supply during drought conditions and also the deferment of capital expenditure.

In addition to establishing NRW quantities, data from advanced metering can enable better understanding of network demands, demand patterns and network operation during drought or other disruptions to supply (including earthquakes) for improved operational response and community engagement.

Case studies of AMI projects will be presented illustrating benefits realised for improving water network resiliency including demand management, NRW reduction and enhanced customer engagement. Particular focus will be applied to outcomes relevant to improved potable water supply resiliency in New Zealand.

KEYWORDS

Intelligent Water Networks, IWN, Advanced Metering Infrastructure, AMI, Resilience, Internet of Things, IOT, Non-Revenue Water, NRW, Water Loss, Customer Metering

PRESENTER PROFILE

Eric is a civil engineer at Jacobs in Wellington, New Zealand with 18 years of engineering experience. As an Associate Water Engineer at Jacobs, his work includes development of capital infrastructure programs, planning strategies, pressure management programs and network optimization assessments for municipal and industrial clients. Eric manages delivery of technology projects for major water utilities, enabling clients to identify unexpected network behaviours early and optimise network operational efficiencies.

1 INTRODUCTION

Water metering and data collection technologies have evolved over the last several decades. Metering has been widely implemented in North America and many parts of Europe while in the Asia Pacific region, water metering has become more commonplace since the mid-2000s. Tauranga City Council (TCC), for example, began implementing Advanced Metering Infrastructure (AMI) with a trial in 2009.

Advanced Meter Infrastructure technologies have grown significantly in the past decade with metering data becoming readily accessible to customers to monitor their consumption and better understand their water footprint.

Drivers for implementation of AMI often include demand management, improved billing efficiency and accuracy, reduction of non-revenue water, deferment of capital expenditure, environmental benefits of reduced consumption and an improved customer experience.

Demand management, typically a primary driver for metering in arid regions, is also an important driver for metering and water resource management programs in New Zealand.

During the summer of 2017-18, many communities across New Zealand had experienced reduced water supplies as a result of drought and were subject to water restrictions. Wellington and Hamilton City and Waipa and Waikato Districts banned or limited the use of sprinklers, whilst customers in Auckland, Canterbury, Wairarapa and many other areas were encouraged to reduce water consumption.

Droughts in New Zealand typically last for much shorter durations than arid regions however, even short droughts can have significant consequences as supply, treatment and storage infrastructure are often not designed for long interruptions of supply. Continued bore extraction during dry periods can reduce aquifer levels which increases risk of salt water intrusion into aquifers.

Water efficiency is quickly becoming a topic of discussion countrywide. By some estimates, New Zealand is losing 100 billion litres of water annually through water loss. Metering can provide greater insights to councils and customers on how water is used. Data from AMI programs can provide greater understanding of water loss both upstream and downstream of customer meters.

While not all customers are metered in New Zealand, water metering is becoming more common, particularly for non-residential customers. As AMI, telemetry and data management technologies continue to evolve, there is opportunity for New Zealand to learn from the experiences of others and prepare for further advancements in technology when planning for metering programs.

2 AMI BENEFITS

Most benefits from implementation of customer metering are based on improved understanding of how water is used in within the network.

Traditional water metering typically collects customer consumption data three to four times per year. Data is sometimes collected manually (subject to increased error) or from drive-by systems which reduce risk of data collection errors. While this information is helpful for volume based billing and 'coarse' network water balance calculations for estimation of network losses, the benefits of using this data are often restricted.

AMI technologies enable collection of time-series consumption data. While hourly data intervals often provide adequate data for analysis of network demands and losses, data can be recorded in intervals as short as 10 to 15 minutes.

The value of data becomes exponentially less valuable over time for improving the operational resiliency of a utility. As an example, if a utility discovers a small pipeline break before it has surfaced instead of after the pipeline has burst and damaged the area above it, the cost for the utility to respond and mitigate is much less as shown in Figure 1: Relationship between value and time for response to network leak

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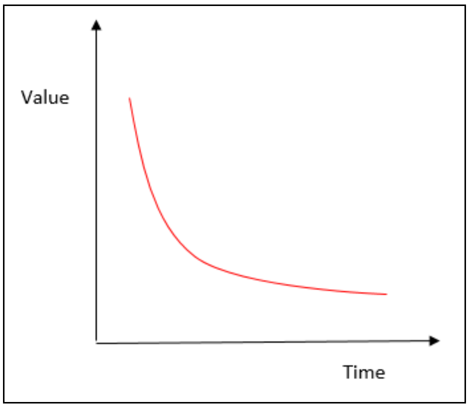
Figure 1: Relationship between value and time for response to network leak



Innovative technologies using time-series network data to create 'Actionable Information' for monitoring, analysis and optimisation of water and wastewater assets have been evolving over the past decade. Many of the tools and statistical approaches have been leveraged from other sectors (such as energy or banking) and applied to a number of utilities use cases.

'Actionable Information' is important for providing information for effective demand management programs. In addition to demand management and billing benefits, this information provides insights for implementing actions and responding to network events for reduction of non-revenue water.

2.1 WATER CONSERVATION

Water conservation is a primary driver for implementation of AMI programs. The two major components of water loss management are consumption and losses.

2.1.1 CONSUMPTION

The 2016/17 NPR (Water New Zealand, 2017) report indicated that the median average daily residential water use was 260 L/person/day (comparable to 275 L/person/day from the 2014-15 NPR). The 2014-15 NPR suggested that 275 L/person/day was the highest of all international benchmarks included in the review (average residential consumption from international benchmark studies ranged between 119 L/person/day in the Netherlands to 195 L/person/day in Australia).

Not all regions in New Zealand experience water demand above international benchmarks. In Auckland, where all residential and non-residential customers are metered, average residential demand between 151 to 157 l/p/d was experienced in 2010 and 2012 (Watercare, 2012). Residential demand in Auckland remained reasonably stable with average residential consumption in 2016/17 of 159 L/p/d (WaterNZ, 2017).

The Auckland figures are comparable to water consumption targets in the Asia-Pacific region. In Southeast Queensland, Australia, a 'Target 140' initiative was introduced following extensive drought in the mid-2000's with an aim of reducing daily residential consumption to below 140 litres per person (by applying strict water restrictions and other conservation measures). As the drought eased, permanent water conservation measures were implemented and a target of 200 L/p/d for average residential consumption was introduced.

Seqwater (bulk water authority in South East Queensland) monitors residential per capita water consumption on a fortnightly basis. Average residential water consumption figures have been gradually increasing since Target 140 was achieved however consumption figures remain well below the 200 L/p/d target. In the winter of 2017, consumption in Southeast Queensland averaged 175 L/p/d peaking at 189 L/p/d (Seqwater, 2017).

The Victoria State Government in Australia has implemented a public education campaign, 'Target 155.' It is a voluntary water efficiency program intended to encourage household water conservation and encourage per capita household water consumption within 155 litres per day.

AMI infrastructure, particularly when coupled with a customer accessible web-based interface, provide important information for customer awareness of how they use water and the outcomes of demand management initiatives.

Average residential consumption is difficult to quantify for many New Zealand water authorities because many do not meter all residential customers. The 2014-15 NPR assessment indicated that of study participants, only seven had implemented metering of all residential customers and 22 have not implemented residential meters (or had implemented 'very low levels' of residential metering). While this number is slowly improving (12,000 residential water meters added to participant systems in 2016-17), there are a significant number of residential customers in New Zealand that remain unmetered.

Yet according to the NPR study, two-thirds of participants issued water restrictions in the 2014-15 financial year and nearly half of participants issued water restrictions in the 2016-27 financial year indicating that water availability is of concern in New Zealand (Water New Zealand, 2015). It is expected that these numbers will increase substantially for the 2017-18 financial year as the summer presented very dry conditions resulting in communities such as Tauranga introducing water restrictions in late 2017 for the first time in 17 years.

2.1.2 NETWORK LOSSES

According to the 2016-17 NPR report, approximately 90 million cubic meters of water was lost in the 2016-17 financial year from participating utilities. The 2016-17 NPR report presented Infrastructure Index Figures (ILI) for participating utilities.

The ILI is a widely recognized metric for comparison of the water loss performance of water utilities by dividing the current annual real losses (CARL) by the unavoidable annual real losses (UARL). Ratios greater than 2 are considered to have moderate water loss with figures above 4 to have high water loss. According to the 2016-17 NPR report, of 29 participants, only six utilities had an ILI less than 2. Further, approximately 80% of participating utilities had moderate water loss or higher, and almost 30% had high or very high water loss. These metrics indicate that there is opportunity to reduce losses in New Zealand water networks.

AMI programs provide a significant amount of information related to individual customer meters. When combined with additional network information, such as network pressure, flow or external data (weather, major events where changes in demand are expected, etc), the benefits to the utility for evaluation and resolution of events contributing to network water losses, or Non-Revenue Water (NRW) are increased.

The network monitoring plan and monitoring data should be reviewed for consistency, completeness and accuracy to evaluate what can be used with the IWN technology being considered and where the gaps are to achieve the long term vision.

In the event that additional network monitoring is anticipated to support the long term IWN architecture, advancements in monitoring and telemetry technologies should be considered carefully to select current technologies that can provide more functionality and longevity in compatibility (and in some cases lower cost options).

For example, advancements in ultrasonic metering technologies can enable additional flow monitoring points for 'virtually' segmenting a large distribution zone or District Metered Area (DMA) into smaller areas for greater monitoring resolution without further physically segmenting the network (important when leveraging AMI for evaluating and reducing non-revenue water in the network).

Advancements in pressure sensor, flow meter, customer meter and water quality probes are enabling collection of higher frequency data at lower cost.

Advancements in customer metering and battery technology enable customer meter collection of high frequency data and higher transmission frequencies (every 4 to 6 hours) under battery power. This enables collection and transmission of data at frequencies that can be used for advanced network analytics.

In some cases, water losses due to leaks or breaks occur downstream of the customer meter, often unknown to the customer. AMI can help identify where post meter leakage or breaks are occurring, reducing unnecessary water loss and expense to the customer. AMI metering can also enable water utilities to notify customers when unusual activity occurs, raising awareness of a post-meter leak early and minimise leak related damage. The City of Martinsville in Virginia, USA reported that customers appreciated receiving notification right away "rather than have issues go unnoticed that might end up costing them hundreds of dollars in excess water charges or — worse yet — causing significant water damage." (Wateronline, 2018)

2.2 CUSTOMER ENGAGEMENT

Results from an online survey of 940 water, gas and electric customers with AMI in the US suggested that customers were generally accepting of AMI technologies and health, safety and privacy risks were not of great concern to survey participants (Mulki, 2018). The study suggested that utilities may be overestimating customer concerns with AMI and emphasised the importance for early and frequent community engagement to address perceived risks of AMI and share benefits.

In Waikato, implementation of water metering in Huntly, Ngaruawahia and Raglan regions was preceded with a public awareness campaign including issuing trial meter reading statements to newly metered properties to familiarise customers with what to expect from the metering program. Information sessions, titled 'You're your Meter' were held at local council offices to give customers opportunities to learn about the program and talk with council staff. Through public engagement, Waikato District Council emphasized how water meters enable customers to increase awareness of their use and outcomes of conservation measures.

In New Zealand, public sentiments around water consumption and metering are diverse. Where volumetric consumption based charging for water may be unsavory in some communities, the benefits of providing insights to household consumption and outcomes of conservation measures should be highlighted.

Public engagement is an important step in planning for a metering program and should be integrated in pre-planning, implementation and operation stages.

2.3 DEFERMENT OF EXPENDITURE

AMI data can enhance demand management campaigns by enabling customers to view their consumption and compare to their neighbourhood, community and other cities.

Typically, after implementation of water restriction programs the per-capita water consumption increases after conclusion of water restrictions but often remains below pre-restriction levels as customers adopt more water-wise behaviours.

AMI data can increase the effectiveness of demand management programs by providing consumers more awareness of how they use water. Sustained water-wise behaviours can reduce requirements on water supply, treatment, storage and distribution infrastructure and can result in deferred (or avoided) capital and operational costs.

3 CASE STUDY: AMI TRIAL

A case study with the Gwinnett County Department of Water Resources (GCDWR) is presented to highlight the objectives, approach, implementation and outcomes of an AMI pilot study for identifying losses before and after customer meters.

Gwinnett County (near Atlanta in the USA) is a rapidly growing region in the United States. A zone in the GCDWR network was selected for the study with approximately 500 homes and two discrete sections of network. Approximately half of the zone had older, ductile iron distribution network and the other half had newer, polyvinyl chloride pipe network. This was important to enable comparison of leakage observations between discrete areas of the network with different material type and age. AMI meters were installed on all customer connections.

The trial was set up to generate insights and enable reduction of (NRW) before and after the customer meter by integrating data from the AMI meters, network pressure sensors and weather data to identify NRW including pre and post customer leaks, water theft and meter accuracy.

3.1 PROJECT OBJECTIVES

On average, utilities around the world lose 30% of treated water from distribution networks. These losses, typically referred to as (NRW) are comprised of Real Losses (physical losses of water from the distribution network including leaks, unauthorised consumption or theft, unmetered consumption) and Apparent Losses (metering inaccuracy and measurement error of figures used in network water balance calculations).

In 2016, CH2M (now Jacobs) collaborated with industry telecom partners (AT&T and Qualcomm) on Smart Cities projects to fund and establish a water focused Internet-of-Things (IoT) pilot project using cellular communications. The cellular communications network was used to transfer data from the water network and AMI infrastructure. The AMI data was expected to enhance available information for demand forecasting and development of diurnal consumption patterns for modelling and network analysis.

As part of water security and resiliency investigations using AMI, the United States Environmental Protection Agency (USEPA) Water Security Division provided additional funding to include assessment of backflow events and unauthorised consumption to study objectives.

3.2 SELECTION OF AREA FOR PILOT STUDY

The ideal network for the AMI pilot study would have discrete monitored areas within the network where inflows are measured.

Segmentation of water supply networks into DMAs for monitoring and pressure management has been widely adopted in parts of the world including Europe and Asia-Pacific regions. While customer metering has been widely implemented in the US by 2016, adoption of DMAs in the US are is slowly growing.

GCDWR, located in located near Atlanta, Georgia (USA) had implemented DMAs within much of its network. Gwinnett County is metropolitan area with approximately 895,000 residents. It is one of the fastest growing areas in the USA and is subject to severe droughts (the last occurring in 2016 to 2017).

A DMA with approximately 500 homes supplied from a single DMA meter was selected for the study. Approximately half of the zone had newer polyvinyl chloride water mains and the other half had older ductile iron mains.

3.3 IMPLEMENTATION

After commencement of the project and confirmation of approach with GCDWR, installation of AMI meters began in 2017. The pilot study is scheduled for completion in July 2018.

Customers were retrofitted with new AMI meters (450 Neptune ultrasonic meters and 27 Neptune disc meters and 25 Badger disc meters). All meters were equipped with a Neptune Cellular Meter Interface Unit (CMIU), programmed to collect readings every 15 minutes and transmit data every 6-hours. The existing cellular infrastructure is being used to transmit the data from each meter.

Through advancements in AMI and battery technology, a power supply was not required for each meter as batteries were able to provide a five to ten year operating life (depending on data transfer frequency). Transmitting data at a greater frequency does reduce battery life.

3.4 DEVELOPMENT OF ANALYTICS TOOL

Business Intelligence Architecture (BIA) was developed by the project team for the pilot study. The BIA collects and processes the data and presents summaries and visualization of network performance in a web-based dashboard (Figure 2).

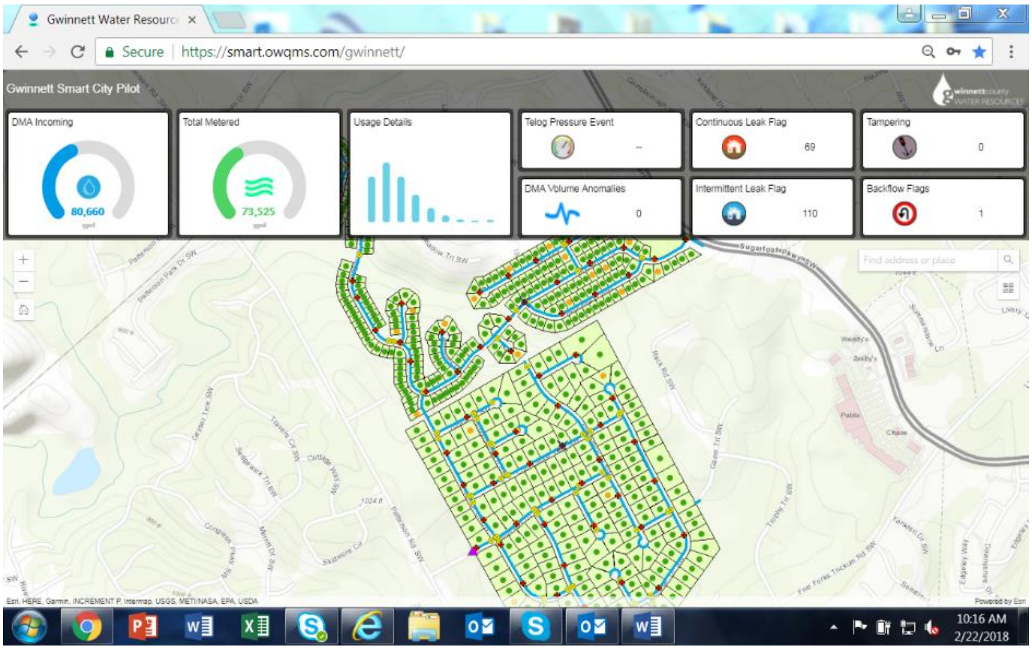


Figure 2: Example of tool dashboard developed for Gwinnett County AMI pilot study

The dashboard presents a navigable map illustrating the water network, monitoring locations and customer meter locations. It graphically summarises incoming DMA flow, total metered flow and customer usage patterns. Changes in network performance behaviours are identified through 'big-data' analytics processes developed in the BIA. Network performance events including pressure events, continuous leak events, suspected meter tampering, DMA volume anomalies, intermittent leak events and backflow events are summarized on the dashboard.

3.5 PROJECT OUTCOMES

The pilot study is ongoing (scheduled for completion in July of 2018) and is on track to deliver the following outcomes:

- Demonstrating positive community impact;
- Enabling early detection and correction of customer leakage (demonstrate commitment to reducing customer bills);
- Steady reduction in length and size of customer leaks over time;
- Providing insights to system operation and integrity;
- Identifying volumes of NRW on customer's side of meter;

- Developing relationships between pressure and customer continuous leak reduction, and
- Demonstrating NRW improvement from pre-trial levels for full scale deployment.

As the trial study has not yet concluded, the project outcomes summarized above have not yet been quantified. However, the Gwinnett County trial study example qualitatively illustrates how AMI can be used to provide improved insights for reduction of water leakage when compared to traditional metering technologies.

It is expected that the project will continue (and possibly expand) after the conclusion of the pilot study in July 2018.

4 CONCLUSIONS

Advancements in monitoring, telemetry and data analytics technologies are increasing opportunities for water utilities to increase understanding of the performance of water networks to optimise operations and maintenance, reduce losses and increase network efficiency and resiliency.

Whether implementing AMI infrastructure, IWN solutions or a combination of both, real-time monitoring can enable utilities to identify changes in network behaviour quickly, reducing total water loss and reducing risk of larger, failures through early intervention.

The Gwinnett County example presented an AMI pilot study which has demonstrated benefits in addition to accurate measurement of customer demand including identification of customer leaks, identification of leaks within the DMA and changes in DMA performance to identify increasing leakage or other events. These additional benefits can improve business cases for metering programs.

In New Zealand, customer metering is increasing yet many customers remain unmetered despite a high number of water restrictions and security of supply concerns.

Further metering programs are planned however some have been questioned by local communities over need and cost.

Public education campaigns will be an important part of communicating benefits to customers, communities and the environment to gain public endorsement of benefits and justification of costs and purpose of metering programs.

AMI programs typically have greater cost than traditional metering however the gap is narrowing as metering, telemetry, data storage and analytics solutions continue to become more cost competitive. Further, metering business cases and public education campaigns should also consider long term expenses of traditional metering programs (particularly data collection) in addition to additional benefits to customers, communities and the environment.

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