Knowledge Series No. 4

SMART WATER SUPPLY

Application of Smart Technology in Water Supply

Smart Water Supply Workshop

September 2017

ADB

Knowledge Series No. 4

Digital Technology for Development Unit
Sustainable Development and Climate Change Department
Asian Development Bank

Contents

About the Workshop

The Workshop was conceived to share smart water knowledge gained by the government of Korea and K-Water (the Korean national water resources management agency and utility operator), other responsible agencies (City Governments), and the private sector in implementing Smart Water Systems to improve the efficiency and effectiveness of the National water supply system.

The workshop focused on three key aspects of Smart Water Systems:

1. Smart water treatment technologies
2. Smart water distribution and operations
3. Smart systems in data collection and data management

This report summarizes the workshop contents and the proceedings, including discussions on the applicability of Smart Water Systems in water supply, with a particular focus on the seven ADB projects, from which counterpart staff are participating.

The final workshop agenda, including each speaker, their presentation title, organization and role is appended. A final list of participants is also appended, including ADB project staff and Government counterpart staff from from Uzbekistan, Tajikistan, Pakistan, Sri Lanka and India.

G-Best Water Resources Centre supported the event and providing logistical oversight. The City of Daegu also supported the event and facilitated a site visit to their Moon-san water treatment facility. K-Water facilitated a visit their Goryong water managzement center, and provided numerous staff resources.

SY Yoon (Senior Public Management Specialist, e-Governance, ADB) initiated and managed the event. Niels van Dijk (Otak Inc.) facilitated the event and John Sutton (Otak Inc.) documented the outcomes in this technical summary.

At a Glance

Workshop Dates:
21-22 September 2017

Presenters/ Speakers:

Senior officials from the government of the Republic of Korea and the private sector

Workshop Participants:

Counterpart government staff in Uzbekistan, Tajikistan, Pakistan, Sri Lanka, and India, ADB project staff, and private sector participants

Workshop Organizers and Facilitators:

Asian Development Bank

G-Best Water Research Center, Korea

ADB

Participants

Counterparts from seven ADB projects attended the workshop. These participating projects all include urban water supply elements, and have been identified for potential application of smart water systems. The counterpart staff attending will cascade the knowledge they gained to apply to their respective projects.

Dushanbe Urban Water Supply and Sanitation Project, Tajikistan (ADB staff: Ms. Ramola Naik Singru)

The project covers source to user, including groundwater and surface water intakes, storage, simple treatment, distribution, as well as some sanitation components. There is interest in piloting a DMA (District Metered Area) for NRW (Non-Revenue Water) and demand management; and a modern billing and collection system, as well as a Geographic Information Systems-based asset management system, potentially administered through cloud computing.

Western Uzbekistan Water Supply System Development Project, Uzbekistan (ADB Staff: Mr. Hao Zhang)

The project covers water resources planning, including groundwater development, water quality management, transmission, treatment, storage and distribution. Smart water systems could be relevant for all components, including rainfall monitoring and prediction, groundwater level monitoring, operation of abstraction, transmission, water quality monitoring, treatment, pumping, pressure management, storage, a SCADA system for control and operation is expected to integrate some of these measures.

Punjab Intermediate Cities Investment Program, Sahiwal, Pakistan (ADB Staff: Mr. Kiyoshi Nakamitsu)

The project covers urban water supply, sanitation, drainage, and solid waste management. There is interest in smart systems related to the urban sector, particularly with respect to environmental water management, water supply and sanitation, and utility management.

Madhya Pradesh Urban Service Improvement Project, India (ADB Staff: Ms Jingmin Huang)

The project will supply water to 64 towns with a total population of around 2 million. It also includes some limited sanitation and wastewater components. The project will include 23 design, build, operate & maintain contracts, all with a 10-year contractual duration. Procurement and lending are currently underway, and the government responsibility will be to manage billing and collections and to manage implementation of the contracts.

"New and improved water supply technologies are required to meet MDG goals, and develop safe and affordable drinking water supply systems in Asia. ADB is currently investing around $2 billion/year for water related infrastructure. Exchanging knowledge between ADB's project operations is crucial to learn lessons and implement improved organizational and operational management of water resources and water supply. Further to this, learning best practices from countries such as Korea, who are willing to share their knowledge, is important to ADB, and can be achieved at this event."

Mr. Hao Zhang, Principal Urban Development Specialist, ADB

The interest in Smart Water Systems is in establishing measures to properly meter and bill water usage and collect revenues, as well as managing NRW in collaboration with selected contractors as well as operations and asset management (using a GIS based system) beyond the 10 year contract.

The Local Government Enhancement Sector project, Sri Lanka
(ADB Staff: Mr. Herathbanda Jayasundara, SLRM)
The project covers improvements in water supply, rural roads, solid waste management, drainage, and other municipal facilities. Water supply schemes include development of new water supply systems and expansion of existing systems especially in the areas affected by chronic kidney disease. Facilities such as raw water intakes, water treatment plants, overhead tanks, and transmission and distribution networks up to household connections are eligible for financing.

A total of 23 schemes will be developed or expanded, and will be implemented by respective provincial councils under the Ministry of Provincial Councils and Local Government. The National Water Supply and Drainage Board (NWSDB) will provide technical support for procurement, design and supervision of the sub projects. After completion, the assets will be transferred to NWSDB or local authorities (depending on capacity) for operation and maintenance.

Capacity development and training in IT systems and business processes will be provided to receiving local authorities.

The National Water Supply and Drainage Board (NWSDB) will generally be responsible for operating the distribution networks where Smart Water Systems will be applicable.

Jaffna and Kilinochchi Water Supply Project, Sri Lanka (ADB Staff: Mr. Kamal Dahanayake, SLRM)
The project includes development of water supply infrastructure and improved services in the Jaffna Peninsula; specifically, improvement of existing sources and increased storage, installation of a 24,000m3/day desalination plant, 700km of water mains and distribution pipes, and 60,000 new metered water connections. The desalination plant will be designed, built, operated and maintained by a single contractor using DBO and performance-based contract with a 7-year duration.

We look forward to bringing in Smart Water Systems under our upcoming Punjab Intermediate Cities Project. We are excited about exploring smarter opportunities in water management, as well as sewage management, traffic, street lighting and ultimately hope to implement a full city-scale MIS solution (the project has a focus on Sahiwal)."

Mr. Abid Hussainey - Senior Specialist, Strategic Management, Urban Unit, Government of Punjab, Pakistan

Project Relevance

The matrix below illustrates the importance of each Smart water component to the attending project participants:

	Smart Components								
	1	2	3	4	5	6	7	8	9
	Environmental data collection	Environmental analysis & prediction	Management of water resources facilities	Environmental water quality management	Water treatment optimisation	Water distribution & metering	Wastewater treatment optimisation	Centralised asset management	Billing & collections
Dushanbe, Tajikistan									
Western Uzbekistan									
Punjab, Pakistan									
Madhya Pradesh, India									
LGESP, Sri Lanka									
Jaffna & Kilinochchi Sri Lanka									

Smart Systems, Explained

Smart Water systems represent innovate technologies that can be applied across all aspects of integrated water resources management, including the management of environmental water, treatment and distribution of drinking water, and the treatment and discharge of wastewater effluents.

Smart systems are the application of information, data, and communication technologies to inform better decision making and enable better and faster responses which ultimately improve operation of water systems.

The illustration and descriptions below outline the IWRM system and smart applications:

1. **Remote sensing and environmental data collection.**
   Real-time collection of rainfall, groundwater level, river flow data (etc) through data loggers and telemetry systems – radio, cellular, Bluetooth, satellite or other wireless communication technology.

2. **Centralized data storage, management, analysis and prediction.**
   This includes real-time analysis and prediction of rainfall, drought, flooding, etcetera (to inform management of water resources facilities).

3. **Management of water resources facilities.**
   Gates, weirs, dams, pumps, intakes, storage, etcetera. Using real-time data and prediction, water resources management and operations plans can be developed to automatically operate water resources facilities to abstract, store, or release water depending upon existing and predicted conditions through SCADA systems.

4. **Environmental water quality monitoring and management.** Real-time collection of water quality in catchments and at water source points (rivers, springs, groundwater, desalination). This data can inform water safety plans and catchment management plans. For example, pollution events (or other water quality issues) can be observed in real time and water resources facilities can be managed to reduce impacts of pollution on water supply and ecosystems.

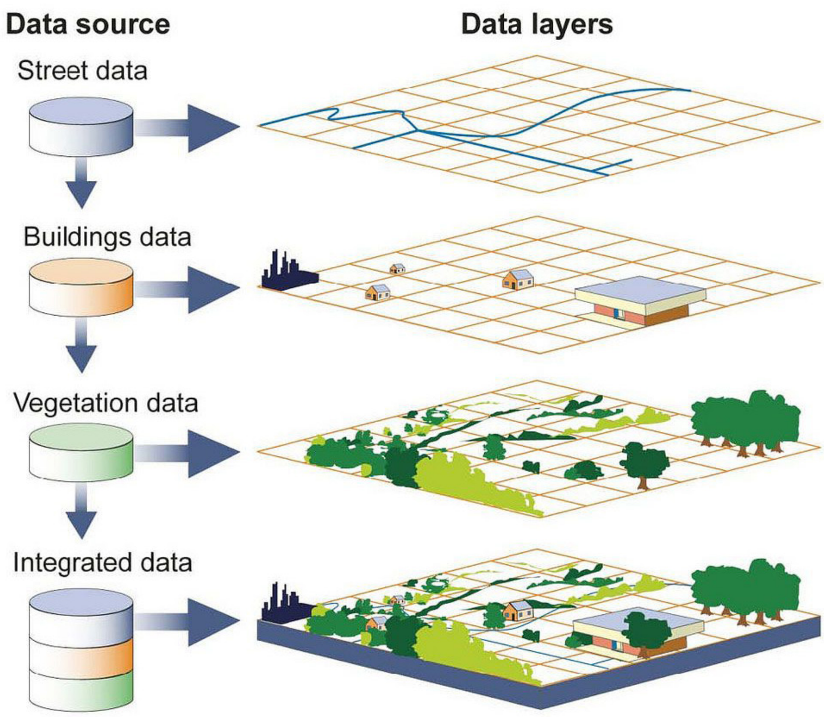
"Korea has been through a long process of water supply development and learned many learned lessons: from 17% coverage (of the population provided with treated water) in 1960 to 80% coverage in 1990. Through this time they have developed more efficient technology and organizational structures in water resources management. We now want to share the lessons that we have learnt and the technology that has been developed. Specifically, The Government of Korea has assigned $3 billion over the last 10 years to take care of replacing and rehabilitating aged water distribution networks. Smart technologies such as real time acoustic monitoring (for leakage detection) and pipe endoscopy (to check for pipe degradation) are being employed across the country."

Mr S.I. Choi - Chairman, G-BEST Water Research Center

5. **Optimization and operation of water treatment plant.** For example, blending of water from varying sources, based on real time water quality data, can improve WTP plant efficiency. Other operational processes can also be controlled such as chemical dosing, or backwashing filters when outflow water quality thresholds are exceeded. pollution events (or other water quality issues) can be observed in real time and water resources facilities can be managed to reduce impacts of pollution on water supply and ecosystems.

6. **Intelligent operation of water distribution network, pressure management, and metering.** This includes the creation of district metered areas (DMAs) and installing networks of remote flow, pressure and other meters reporting real time data, which can trigger alarms and actions. This can improve system diagnostics, leak detection, avoid pipe burst, monitor consumption by area and ultimately reduce non-revenue water.

7. **Optimization and operation of wastewater treatment plant.** Understanding the quantity and quality of wastewater inflows and treated effluent outflows to improve operational efficiency and potentially sludge management.



8. **Centralised asset management.** Geographic information systems *(sample shown above)* can be used to develop spatially registered asset inventories, including performance, ageing, etc. This enables utilities to meet service levels, reduce NRW, develop plans for critical assets and other risks, plan for overhaul, disposal and replacement, and calculate life cycle asset costs.

9. **Smart billing and collections.** This includes remote metering and billing (to cellular phones). Smart options for pre-paid water billing by phone can reduce NRW in certain circumstances.

Smart Water Treatment Technologies

Advanced membrane treatment technologies, which can enable desalination and water reuse, could be significant in finding solutions to global water scarcity. As SK Hong (Korea University) explained, 30% of the global population lives in water-stressed areas. In South Korea, membrane technologies are becoming more prevalent, but still only make up less than 1% of water treatment nationally. This tiny market share is due to the greater energy requirements and therefore higher operational costs of membrane technologies.

Membrane Technology Uses Less Area

Membrane technologies, however, do require less land footprint than conventional treatment through sedimentation and filtration. Such technologies then become applicable where land availability is an issue and/or where land costs are high enough that increased future operational costs are offset by reduced capital expenditure on land acquisition and development.

Heekyung Oh (Daewoo Construction Co.) presented a number of applications where large water treatment plants have been retrofitted with membrane processes and efficient operation systems *(see Box 1)* to increase treatment capacity without additional land take. This is particularly relevant in an urban setting. Through an EPC contract, Daewoo installed Korea's first pressurized membrane system with 25,000m3/day capacity in Yeongdeungpo, Seoul.

Small-Scale Package Treatment

Small-scale "package" membrane treatment plants become applicable in rural settings where treated water needs distribution over large areas. The cost of treated water losses (and maintenance) in such large distribution networks make smaller dispersed treatment plants, located closer to population centers, economically viable. They are also used in post disaster and conflict settings.

O2&B Environmental Engineering has developed a multipurpose mobile water purification system treatment plant which includes MF, UF, NF and RO *(see Box 2)* "cassette" modules which are interchangeable based on circumstances and for ease of maintenance.

TECH BOX 1: Daewoo DIMS & DIES

Daewoo integrated membrane system (DIMS) reduces energy consumption in water treatment by monitoring water quality and applying smart fouling and blending controls to meet performance criteria.

Daewoo Intelligent Energy Solution (DIES) evaluates real-time pump motor power and flow rate versus head to improve hydraulic efficiency at pumping stations. The system uses a monitoring network and fluid simulation and has resulted in a 3% reduction in energy consumption.

TECH BOX 2

Pressure ↑		Pore size ↓
	MF – Microfiltration – 0.01-1.0µm	
	UF – Ultrafiltration – 0.001-0.01µm	
	NF – Nanofiltration – 0.0001-0001µm	
	RO – Reverse Osmosis – <0.0001µm	

An in-built computer control module allows centralized remote operation of numerous plants. It is simple to transport and install, takes up limited space. A 'perfect' treatment system, including all modules, can be installed to mitigate the need for water quality testing and analysis pre-installation.

Innovations in efficiency of membrane technology

The global annual growth in the membrane technology market is 13%, driven by innovations in energy efficiency which improves the economic viability and thus widens applicability.

SK Hong (Korea University) presented the latest technological advancements in membrane water treatment, particularly in energy efficiency and energy recovery. Average energy consumption (per m3) of treatment of water from various sources is currently:

•	Lakes and rivers	0.37kWh
•	Groundwater	0.48kWh
•	Wastewater treatment	0.62-0.87kWh
•	Wastewater reuse	1.0-2.5kWh
•	Seawater desalination	2.58-8.5kWh

In the 2000s improvements, included recovering the hydraulic energy from the high-pressure brine (reject) effluent using various pressure exchanging devices. This technology is now fully commercialized.

Current research and development is focused on recovering energy through **forward osmosis (FO)** across the concentration gradient between saline feed water and a wastewater effluent. This has the added benefit of reclaiming wastewater.

Another developing technology is the utilization of **pressure retarded osmosis (PRO)** also in combination with wastewater, but against the brine effluent downstream of reverse osmosis.

Other advanced treatment technologies

Due to a number of infamous historic water quality episodes (in 1990s) there remains a national aversion to drinking tap water. There is an ongoing national program to socialize tap water consumption in Korean families. This is coupled with very high level of treatment. Numerous plants include Ozone Pretreatment and Activated Carbon (post treatment to consistently ensure high drinking water quality and deal with taste and odor issues (caused by algal blooms in Korea's rivers. Daegu City employs both ozone and Activated Carbon at its Moon-san pant as is described in *Box 3*.

TECH BOX 3:
Daegu City Water Treatment Plant (Site Visit, 22nd Sep 2017)

Workshop participants were hosted by the Water purification Team Leader, and a comprehensive guided tour of the facility was provided including an overview of the following processes (in treatment order):

i. Ozone contact
ii. Chlorination
iii. PAC (coagulant) injection
iv. Flocculation & sedimentation basin
v. Sand filtration
vi. Activated Carbon
vii. Chlorination

Water quality is monitored in real time through the treatment processes and upstream in the catchment.

Smart Water Distribution: Reduction of Non-Revenue Water

Q&A: Advanced Water Treatment

Can these technologies be applied in lower (technical) capacity environments around Asia?

- Advanced technologies may not always be applicable in low capacity settings, and energy supply (24 hours) is often a key constraint.

- Smaller plants can include smart control systems for unmanned, centralized operation. This has been applied to around 300 small plants in Korea. There are also solutions where the private sector is involved in O&M of higher technology plants (such solutions are already being implemented by numerous attending participant projects).

- Developing countries with lower technical capacity are actually the target market for O2&B package treatment. They are currently developing or have completed installations in Uzbekistan, Mongolia, Myanmar, Cambodia, Indonesia, and the Philippines.

What contaminants are membranes, Ozone, and GAC treating?

- Ozone is used to treat organic matter, algae, iron, and manganese.
- Activated Carbon is for treating disinfection by-products, bad taste and odor.
- Microfiltration and Ultrafiltration are essentially interchangeable with conventional sedimentation and filtration, reducing turbidity and removing pathogens.
- Nanofiltration and reverse osmosis are used for removal of ions and viruses, water softening, and desalination.

What is the capacity of the package treatment plant?
Currently each plant can treat up to 500m3/day. Multiple systems can be installed in parallel.

Every city in the world needs to manage inevitable water leaks in the distribution network as these can cause expensive losses of treated drinking water.

South Korea has an aging water distribution infrastructure: over 30% of pipes are over 20 years old and, in the last 5 years, it is estimated that it has lost almost US$3 billion in non-revenue water (as presented by Kwangsuhk Oh, USOL).

In 2005, a national RWR *(see Box 4)* Enhancement project commenced. Nationally, RWR has increased from 79% (2005) to 84% (2015). South Korea achieved this through a number of smart approaches to design, monitoring, management and operations of water distribution networks.

The approaches are underpinned by establishing water supply ‘blocks’ in distribution networks, otherwise known as district metered areas (DMAs).

TECH BOX 4: RWR vs. NRW

In South Korea, "revenue water ratio" (RWR) is used to describe non-revenue water (NRW). This RWR terminology is very simple, representing the percentage of water from which revenue is collected. This may be a more positive approach to defining this issue as it represents an opportunity to collect more revenue rather than putting the focus on reducing lost water (NRW).

Improving RWR is a doubly important operational target for water utility operators as revenue can be increased, and the cost per unit of treated & supplied water is reduced.

What are DMAs and How Are They Applied

DMAs are simply "blocks" in the water distribution network established by hydraulic isolation with water meters monitoring flows in and customer meters monitoring flows out. A simple water balance can then be used to understand leakage and other losses within the DMA.

With DMAs across a whole water supply network, utilities or operators can identify high loss areas and then target pipe replacement/ repair and leakage and pressure management projects to reduce NRW. The process is relatively straightforward and was piloted in Daegu (Korea) in 2005, following the approach outlined in *Box 5*. In South Korea, DMAs are usually applied to blocks of 500-1500 customers.

The levels of complexity can be increased across DMAs, introducing smart approaches, particularly with respect to mapping, flow and pressure monitoring, data collection, hydraulic analysis, leakage detection, and operations.

Mapping Distribution Networks

It is often unclear where existing pipes are due to the ad hoc nature of piped infrastructure improvements over time. Box 6 outlines a smart approach to mapping existing pipe networks as presented during the workshop.

Smart Monitoring of DMAs

Smart meters are installed like conventional water meters but can monitor and report flow and pressure remotely through wireless communication technology. Their installation allows real time monitoring of DMAs which assists in managing and repairing pipe bursts and leaks as soon as possible. Continuous pressure monitoring can also identify high pressure areas for pressure reduction, and highlight water hammer issues related to pumping.

Metering data can be sent to a central management center on a sub-hourly basis. The data can be georeferenced and integrated into a GIS based smart operating system. ICT enables more complex analysis, including 'virtual' isolation

"We need real time data collected through smart meters so we don't have to rely on ASSUMPTION and ESTIMATION. Smart water management is sustainable water management"

Imsu Park, senior researcher, K-Water

TECH BOX 5:
NRW Reduction Process Using DMAs

Presented by JK Choi, Dohwa Engineering

i. Survey of existing network.
ii. Planning block system.
iii. Installing flow meters on perimeters of each block.
iv. NRW determined, through water loss analysis in blocks.
v. Hydraulic analysis can help determine causes.
vi. Prioritize the target blocks and areas for NRW water management.
vii. Leak detection and pipe replacement in blocks to reduce NRW.
viii. Pressure management to avoid recurrence.
ix. Comparing NRW before and after block implementation.
x. Future reduced operational cost can cover outlay costs in pipe replacement.

TECH BOX 6:
Innovation in Pipe Mapping

Presented by Jinwon Kim, WARECO

WARECO has developed a multi-purpose pipeline diagnosis probe that includes buried pipe location and visual inspection.

The probe flows through pipes with 200-400 mm diameter. The device locates the pipe in 3 dimensions using gyro and accelerometers; the location is transferred to GIS system to map buried pipes. The probe also feeds back leakage detection data collected through acoustic device as well as a video feed from a camera to enable visual inspection of pipe condition.

K-water's smart meter

of complex networks which are difficult to isolate. This has been applied by K-water on a DMA pilot project in Colombo, Sri Lanka.

Smart meters can reduce manpower requirements of meter reading. This is particularly applicable in remote or unsafe regions.

Smart Leakage Detection in DMAs

Conventional leakage detection in Korea involves teams of investigators manually searching at night for leaks. Their coverage route is random so the opportunity to identify leaks as they occur is limited. This results in the potential for leaks to exist for over a year before identification.

A number of smart solutions have been developed to monitor leakage remotely through acoustic (sonar) monitoring devices, as presented by Kwansuhk Oh (USOL) and Hyungeu Cho (Seoyon Engineering – iLMS). Acoustic leakage detection devices can also be installed in the pipe couplings when laying new networks, as presented by Hyojung Kim (Cowithone).

Once again, the data received can be georeferenced and integrated into a GIS-based smart monitoring and management system for locating leaks spatially. The devices do not locate leaks exactly but monitor for acoustic anomalies, providing continuous high, medium and low leakage probability at each detection point.

TECH BOX 7: : K-water Case Studies of DMA Establishment and Smart Metering

Seosan City (K-water is utility concessionaire)
- Piloting smart metering of DMAs
- 6 small sub-DMAs established with around 300 customers per DMA
- 1 smart meter installed for every customer
- Hourly monitoring of RWR
- Losses identified remotely with smart meters
- RWR increased by 17% on average within 3 months!

Goryong City (K-water is utility concessionaire)
- Piloting smart metering of DMAs
- In 2006 61% of the population provided with water > increased to 91% by 2016.
- Installation of 217 smart meters across a number of DMAs.
- Establish GIS-based management system
- (K-Water Software: K-NSeries).
- Diagnose and repair leaks.
- Hydraulic analysis (software based) and pressure management.
- RWR increased by 32%
- Saving 34 Billion Won in 10 years ($30 million)
- Provide customers with up to date information on water flow, blockages
- Reduced manpower

To get a good indication of leak location before deploying technicians requires installation of a dense network of sensors, up to 400 in one DMA.

With this information teams can be deployed to manually locate the leak within a much smaller search area. The management system can send leakage alerts via smart phones to managers and technicians at certain risk thresholds so that large leakage events receive a rapid response. The ability to locate leaks and utilize staff more efficiently reduces manpower costs.

The case studies presented in *Box 7* illustrate that RWR can be increased very rapidly by applying DMA based smart leakage detection solutions. Once the infrastructure is in place leakage can be kept relatively low at little cost, particularly if more durable pipe quality is selected.

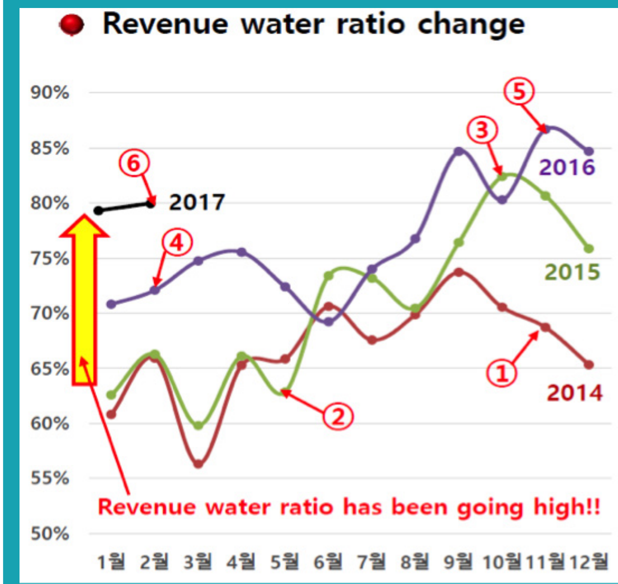
Mr HM Park (PPI Pipe) presented the ductile iPVC water pipe which is stronger than steel and has a 100-year design life. It has multiple applications:

- Corrosive/saline soils
- Heavy traffic / low bury depth
- Unavoidable high pressure variations
- Resilient to earthquakes (more than Richter scale magnitude 5-7).

TECH BOX 8:
Gonju City, Smart Leak Detection

Presented by KS Ho, USOL

- In 2013 RWR was at 64%.
- Deployed 6,945 leak sensors from 2014-2017.
- In 2015, they started to fix pipes, according to leak sensor data.
- By applying smart meters and leak sensors they can understand daily water usage, loss and RWR.
- By 2017, RWR has increased to 80%. See below:



TECH BOX 9: Promoting Smart Drinking Water Management in South Asian Cities

Presented by Daeik Son, K-Water

Bangladesh: Piloting smart metering in one DMA in Dhaka including 1 base station, 12 smart meters with transmitters and a GIS-based monitoring system (based on Google maps).

Sri Lanka: Establishing a virtual DMA with smart meters at DMA boundaries. Piloting smart flow and pressure meters and leakage sensors for NRW reduction, including 10 household connections.

Outcomes: No significant results yet but installations are now complete. The technical assistance is expanding to cover India, Nepal, Bhutan, and Maldives.

“The ability to have communication devices in our pocket can save time and improve efficiency. And we feel we should utilize this. It is important however to have a sensible plan for implementing appropriate smart technologies, step by step. Slowly building confidence in new systems.

"In Kathmandu, we are implementing a computerized billing and human resource management system. Currently, a database of customers is being developed — new connections are straightforward to add but old connections are more challenging. We are also establishing DMAs in new and old water distribution networks to manage leakage better as a significant new water source is diverted to the Kathmandu Valley. We will be implementing a SCADA system to remotely control raw water diversion and transmission of bulk treated water to numerous service reservoirs in Kathmandu. We also plan to continuously monitor water quality in service reservoirs, particularly residual chlorine.

We are also being ‘smart’ by coordinating pipe upgrades and installation with road maintenance.”

Laxmi Sharma, senior project officer, ADB, Nepal Resident Mission

Q&A: Smart Water Distribution and DMAs

Can DMAs and smart technologies be applied in lower (technical) capacity environments around Asia?

- The technology required in establishing simple blocks, metering usage (manually) and evaluating losses through water balance calculations can be applied to any system that can be hydraulically separated.
- Identifying such blocks and establishing DMAs should be the first step in any NRW programme. Further detail can be applied using smarter technology building up confidence and capacity slowly.
- A representative from Dhaka Water and Sewage Authority (DWASA) said by implementing a DMA approach and improving billing and collection ratios, NRW improved from 40% in 2008 to 22% in 2015. This has been supported by two ongoing ADB projects establishing DMAs, upgrading piped networks. Smart operation of DMAs is handed over to DWASA after construction. The projects have added 9,500 water connections and all DMAs now have 24-hour water.

What is the payback period for investing in smart systems?

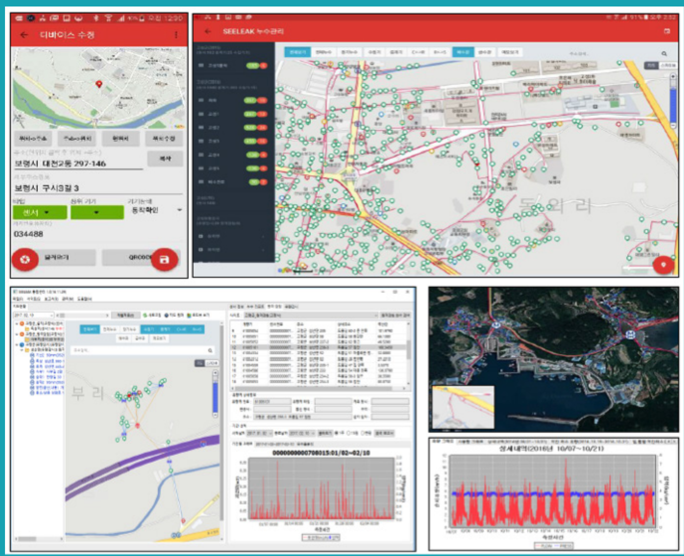
- Gonju City Government invested approximately US$2 million in leak detection sensors. In just 2 years, they recorded a NRW reduction of 16% equating to US$3 million in savings. *Box 10* illustrates densely deployed network of sensors in one DMA in Gonju and the ability to pinpoint and repair leakage using ICT platforms.
- In Busan, K-Water operates a 30-year water and wastewater O&M concession. Based on this model, K-Water reached breakeven point 8 years after commencing investment in DMAs, smart technologies, and pipe replacement. During this period, RWR increased from 68% - 91%.
- In Seoul, K-Water invested US$3 million in replacing 14000km of distribution pipe. In 10 years, the estimated water saving was US$5 million.

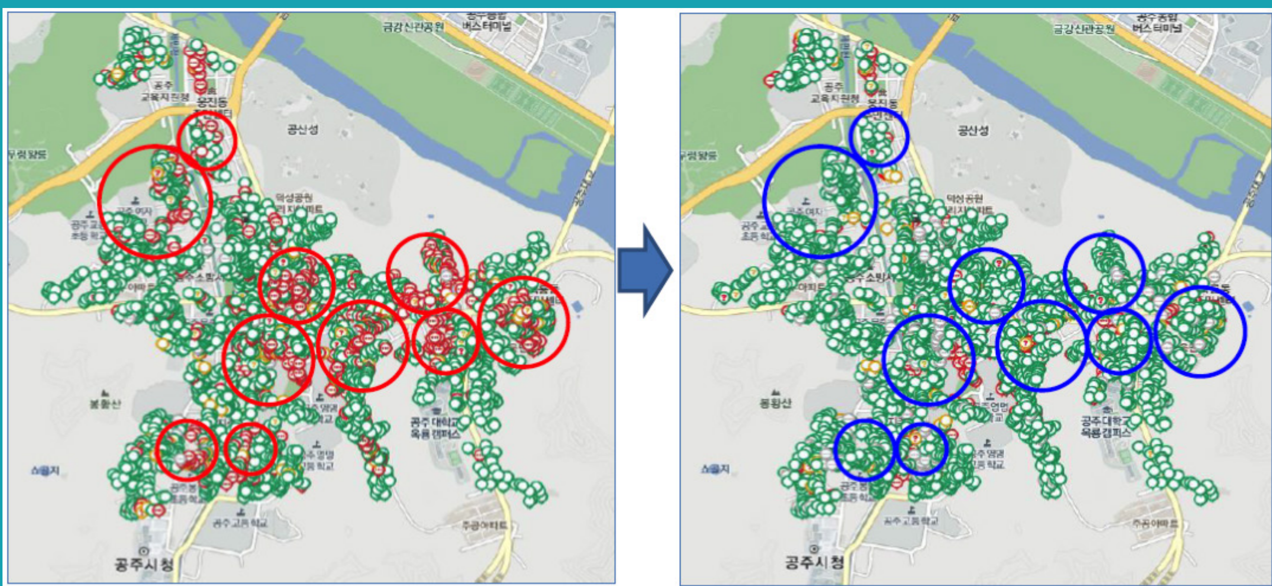
TECH BOX 10: Deployment of Leakage Detection Sensors in Gonju

After installation of a dense network of leakage detection sensors, numerous significant leaks were identified and repaired. This approach improved RWR for 64% to 80% from 2014 – 2017.

Adjacent (right) illustrates the visualization and analysis of leakage and other data through Seeall software on PC, tablet or smart phone, including:

- Device registration
- Interactive network map
- Leak monitoring result
- Leak position
- Water flow pattern
- Water flow quantity
- Customer water use quantity
- Customer water use pattern
- Block water supply quantity
- Non-Revenue water quantity
- Daily revenue water ratio





< 15 Aug 2015 >   < 8 May 2016 >

Q&A: Smart Water Distribution and DMAs *(continued)*

How should NRW reduction contracts be set up?

It was noted that contractors may not wish to reduce investment costs in maintenance/upgrading and may over estimate required works. How do we contract for NRW programs and ensure value for money?

- One approach is to use consultants to design the upgrades. This may not be satisfactory as contractors may not agree with the proposed works.
- A number of cities in Korea adopt a long-term concessionaire model engaging K-Water in utility operations. This has proved successful in reducing NRW. GS Engineering, Korea, are utilizing this model in Brazil where they have a 30 year concession for sewage and water operations, including integrated smart operations and collection of water and sewage fees.
- Another approach is water savings companies using the ESCO (energy saving contract) model where the private sector company invests in the efficiency measures and profits from the savings made (which are ultimately transferred to the owner at the end of the contract). Establishing an appropriate baseline from which savings are made is the main challenge for such contracts, but this approach has the added benefit of the private sector taking on the capital investment. This has been successful in Korea with contracting periods of around 6 years with return on investment up to 90% *(see Box 11).*

TECH BOX 11: The Application of Water Savings Contracts in Korea

Year Established	Contract Period (Months)	Works Undertaken	Investment Cost (USD)	Recovery Period (Month)	Expected Net Profit (USD)
2012	72	Water meter: 110 Pipe replacement: 1.78 km Reservoir management Leakage prevention	$1.6m	62	1.4m
	56	Water meter: 52 Pipe replacement: 1.28km Flow meter: 2 Leakage prevention	$0.9m	48	$0.8m
	85	Water meter: 131 Pipe replacement: 4.81km Flow meter: 2 Leakage prevention	$1.9m	72	$1.5m
2014	71	Water meter: 39 Pipe replacement: 1.53km Flow meter: 4 Leakage prevention	$2.0m	60	$0.8m
	56	Pipe replacement: 0.4km Inspection pit Leakage prevention	$0.5m	48	$0.2m

Smart Systems and Innovative Data Collection, Management and Analysis

The collection and analysis of data is crucial for operations, decision making, policy development, and commercial/financial management of integrated water resources management and supply. As was presented, efficiency of service delivery can be improved by automated real-time data-driven operational decision making. This can ultimately lead to positive impacts in service delivery, cost savings, environmental water management, and public health.

Importance of Data

In water resources management, data is necessary for forecasting and developing broad operational and investment plans (and policies) through analysis of historic information and trends. This is particularly important in terms of climate change adaptation/mitigation strategies with relation to drought and flood risk management in catchments and their respective human impacts. Melbourne Water implemented SRA Environment's Envirosys software to improve integrated water resources management *(see Box 12)*.

Data can also be used for optimizing processes to improve efficiency in:

- Reservoirs levels, releases, abstractions (including groundwater), raw water management and diversion, etcetera
- Blending of water sources for optimal treatment, dosing, optimizing backwashing and other treatment processes
- Managing treated water storage and distribution
- Leakage management and NRW reduction
- Billing and collections

Automation of the above can be implemented through SCADA systems (Supervisory Control and Data Acquisition) which gather data related to processes in real time and send control commands to field connected devices. This frees up staff time and the control software can generate automatic reports. This requires autonomous data capture, being made possible by modern wireless communications, sensors, and even drones. SunTech engineering presented their remote water quality monitoring products, including:

i. TU90 - High precision turbidity meter
ii. FCL - Free chlorine meter
iii. 5n - Multi-parameter water quality monitoring system (temperature, conductivity, pH, free chlorine, turbidity).

TECH BOX 12: Improved Data Collection and Management Across Melbourne Water

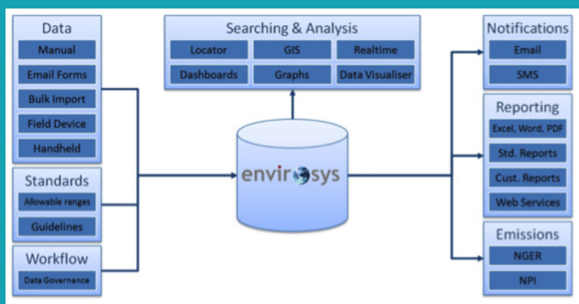
Presented by Andrew Hodges, SRA-IT

Over a 6-month period, SRA Environment supported Melbourne Water roll out its EnviroSys Software for improved integrated water quality and environmental data management throughout the organization. Lab or field test and monitoring results are sent directly to databases linked to a user friendly GIS enabled portal and dashboard. Automated reporting and other functions free up time for staff to do what they are trained to do and ultimately reduced costs by 11%, a saving which was passed on to customers.

EnviroSys software benefits include:

- Data integrity
- Reduce the risk of data loss
- Proactive monitoring of risks and trends
- Legislative and regulatory compliance
- Environmental audits and internal compliance
- Reduce the dependence on external data and service contracts
- Efficient environmental reporting
- Environmental incident responsiveness
- Continuous improvement in environmental management

EnviroSys Functions:



By collecting, storing and managing good quality data, information can be shared across agencies enabling standardized water accounting frameworks and analysis. This requires standardization of data collection and storage. International standardization of data collection and format will enable global water systems analysis. This will be underpinned by data sharing, open data, and transparency.

Big Data

Taking this a step further, Big Data has emerged as a game-changing presence in commerce. Coupled with the internet of things (IOT: the connection between and data acquisition from billions of global devices), Big Data is the collection and analysis of extremely large data sets to reveal patterns, trends, and associations, especially relating to human behavior and interactions.

While the scale of data sets in environmental and water resources management are more limited, by amassing data across sectors, improved analysis of trends may become possible. Data from climate, society, health, finance and other sectors could be usefully applied to solve problems and undertake analytics in the water resources sector.

"Data is often collected and used in separate 'silos'. Open it up, and think beyond your sector, because everyone is a water user. Interesting things happen when you 'open up' your data. Cloud is a wonderful enabler for this."

Andrew Hodges – SRA IT

Cloud Web Services

Bryon Wong from Amazon Web Services presented the benefits of integrating cloud web services with water technology. Cloud technology is the on demand deliver of IT resources over the internet, through public networks.

The benefits of cloud-based data storage include:

- On-demand delivery of IT resources
- No upfront hardware costs
- Easy to scale up and down to meet utilization
- Immediate setup
- Wider accessibility (potentially)
- Resilient to disaster, fire, power outage

Q&A: Data Management

Is data secure in the cloud?

- Amazon Web Services (AWS) data storage has been more secure than government data historically. There have been numerous recent government data security issues globally. Furthermore, government agencies core strength is not secure data management. This AWS's sole function and they have a significant (financial) motive to keep their clients data secure.
- AWS can store data in numerous locations, increasing its resilience to events such as fire and disaster.

Intergovernmental sanctions may result in blocking access to data stored outside of their territories?

- This is a real concern for countries like Pakistan.
- Amazon has data centers in more than one country and they have no commitment to any one government but each government where data is stored. Multiple locations could offset this risk. Often data will be more vulnerable in local data centers for numerous reasons.

Improving transparency improves fairness

One participant noted that increased transparency in data collection and in decision making is important in providing good quality service to all customers. A small example described is the manual operation of water distribution valves by field employees to remote communities. Without daily flow information in each branch, how can we be sure it is operated fairly on a daily basis? Sharing data between organizations and agencies can improve transparency as well as efficiency.

Summary and Lessons Learned

Investing in smart water systems can improve service delivery and efficiency, and future savings made through more efficient operations have been proved to offset investments over time.

Investments in smarter water treatment systems can provide benefits in the consistency of water quality in supply, but high-tech membrane solutions remain economic viable only in specific situations – where the cost of land is high, a small scale remote treatment plant is required, or if desalination or water recycling are the only viable water sources.

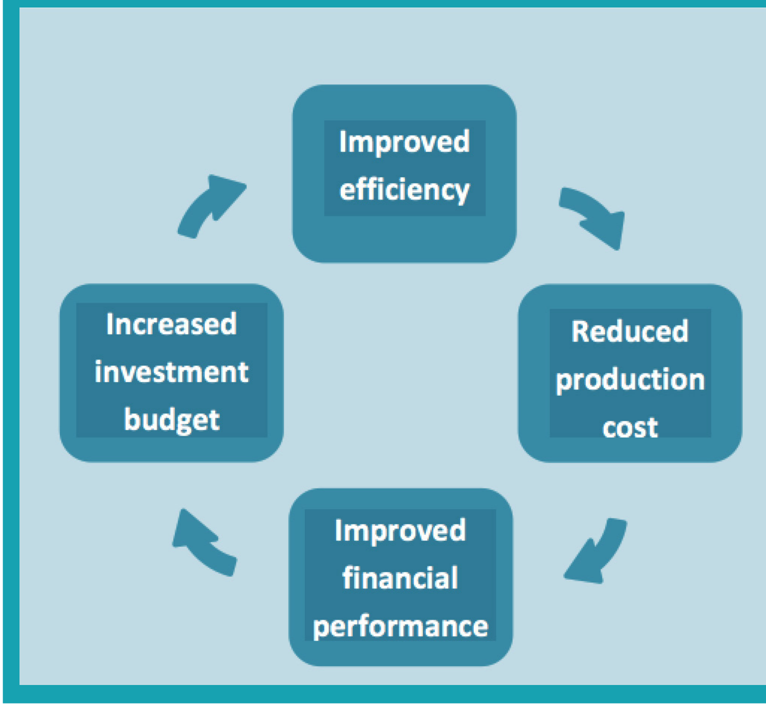
Current innovations in membrane technology will continue to reduce energy requirements and thus treatment cost per unit broadening the extent of viable applications.

Non-revenue water (NRW) reduction plans should include implementing the district metered area (DMA) approach. This can start with simple hydraulically isolated metered blocks. From this point, numerous smart technologies can be incrementally applied to improve water distribution efficiency and reduce water losses. Smart approaches to network mapping, flow and pressure metering, leakage detection, pipe installation, remote monitoring, spatial analysis, and automated alerting/reporting can be utilized to identify and resolve issues in water distribution networks and ultimately save water. In Korea, such savings have delivered a return on investment in relatively short time periods of around 2 to 5 years. These technologies are applicable to lower capacity environments across Asia, but should be introduced step by step in a phased approach before scaling up.

Improvement in data collection management and sharing, including standardization across agencies, allows transparency and better analysis of trends for planning. These data coupled with GIS-based software for analysis and operational management can improve water operations, particularly in management of water distribution. These investments also save money through efficiency and more effective use of staff.

Smart technology is implemented to improve efficiency, but high tech solutions may not always be most appropriate. Simple conventional technologies applied appropriately can provide the required data/knowledge to make appropriate efficiency improvements. Technology should be introduced incrementally to ensure it will be effective in the prevailing environmental, capacity, financial, social and other conditions. The virtuous cycle in *Box 13* illustrates how incremental improvements in efficiency (water savings, reduced leakage, better operations and management) can lead to the savings required to invest in the next level of technology or system gains.

TECH BOX 13:
Virtuous Cycle of incremental improvements



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