SEPTEMBER 2014
VOLUME 9 ■ ISSUE 3

water utility management
INTERNATIONAL

ENERGY EFFICIENCY

Saving energy and cutting water treatment costs on the US-Mexico border

TARIFFS

Incorporating marginal costs in water supply tariffs: prospects for change

CUSTOMER SERVICES

Improving utility customer services: the case of Eau de Paris

PLUS ...

A new data paradigm for water management

Research finds common coagulant could corrode sewers

A research team at the University of Queensland has discovered that a common coagulant used in drinking water treatment can be a prime contributor to global sewer corrosion.

Aluminium sulphate (alum) is widely used as a coagulant as it is relatively cheap and widely available. The paper, published in the journal Science, reveals that the coagulant is the main source of over 50% of the sulphate found in wastewater, which in turn is indirectly the primary source of hydrogen sulphide. This gas is well known as the cause of rapid degradation in concrete sewers, sometimes reducing their life by up to 90%.

The mechanism for the degradation is the presence of microbes on sewer walls that take up the hydrogen sulphide and oxidise it to form sulphuric acid.

The team, led by Professor Zhiguo Yuan, concluded that to reduce sulphide formation, it was necessary to reduce either the sulphate or the organics in wastewater, the latter not being a viable option. They recommended that utilities move to sulphate-free coagulants, in order to reduce concrete corrosion by 35% after just ten hours and up to 60% over a longer period of time, generating potentially large savings in sewer maintenance.

The research also discovered that the production process for desalinated or recycled water normally eliminates sulphate from the final produced water, creating a potentially valuable protective effect for sewers downstream.

The researchers undertook a two-year sampling programme in South East Queensland, conducted an industry survey across the country, and undertook a global literature review and a comprehensive model-based scenario analysis of the various possible sources of sulphate to reach its conclusions.

The team also recommends a more fully integrated approach to urban water management to identify other interactions, noting that the main reason the connection had not been realised earlier is the institutional separation of the urban water system into water and wastewater services, often run by separate organisations. ●

Opponents go to court over Israel fluoridation ban

A group of public health experts and senior dentists opposed to health minister Yael German's decision to end fluoridation in Israel have filed an appeal in the country's High Court.

The group allege that the decision will 'cause harm to public health and significantly increase the gap in dental health between the well-off and the poor'.

German is a long-time opponent of mandatory fluoridation – in 2002 she headed one of a number of local authorities attempting to end fluoridation of the country's drinking water, a stance opposed by the health ministry at the time.

Fluoride has been added by law to the public drinking water supply in Israeli towns since the 1980s, and until the ban around 70% of the country's water was fluoridated. The decision to halt fluoridation came in a 2013 Supreme Court ruling that established a deadline of a year to end the practice following a report by the Adin committee, which recommended ending mandatory fluoridation but also suggested allowing local decision making on whether to fluoridate.

A ministry of health press release at the time of the ban argued that 'only some 1% of the water is used for drinking', and cited scientific evidence that fluoride in large amounts can damage health.

'When fluoride is supplied via drinking water, there is no control regarding the amount of fluoride actually consumed, which could lead to excessive consumption. Supply of fluoridated water forces those who do not so wish to also consume water with added fluoride. This approach is therefore not accepted in most countries in the world,' the ministry said.

The lawyer for the public health group, Joseph Havillio, told press: 'Fluoridation must be a scientific decision and not a political one, so it is absolutely unreasonable that the minister decided it on her own, in contravention of the advice of the professional level in her office and of the medical and academic establishment in Israel and abroad.' ●

ADB approves $49 million loan and grant for Armenia's ageing water system

The Asian Development Bank has approved a $49 million loan and a technical assistance grant of $900,000 to support the sustainability of Armenia's road and water sectors, which have deteriorated due to limited investments and public management system challenges.

Half of the country's water system needs to be upgraded, and many rural areas lack access to clean piped water. The programme will promote more efficient service delivery through a clearer focus on results and joint work on more effective and timely ways to achieve them.

The programme blends expertise and resources from government planning, finance and sector agencies with civil society, user groups and development partners, who together will help to ensure a realistic course of action.

The programme is intended to produce a more integrated approach to road and water management, with deeper reforms in both sectors. ●

UK gives $252 million to fund Tanzania water and sanitation initiatives

The UK has announced funding of $252 million for Tanzania's water and sanitation sector programmes for the period 2014-2019. The UK's Department for International Development (DFID) acting head for Tanzania, Ros Cooper, said the funding will support the country's Big Results Now initiative and also complements the second phase of the Water Sector Development Programme (WSPD).

The Big Results Now initiative is a plan developed to aid Tanzania to transition from a low to middle-income economy.

WSDP on the other hand, whose DFID funding by 2019 will go up to $113 million, is a four-component water and sanitation development initiative focusing on water resources management, rural water supply and sanitation services, urban water supply and sewerage services and finally sector institutional strengthening and capacity building. ●

New Zealand review gives clean bill of health to fluoride

The addition of fuoride to drinking water is also being keenly debated in New Zealand, where a review into the health effects of water fluoridation has found 'no adverse effects of any significance' from adding fluoride to public water supplies.

The report, commissioned by the New Zealand chief science advisor Sir Peter Gluckman and Royal Society of New Zealand president Sir David Skegg, was the work of an expert panel that looked in particular at the claims that fluoride contributes to the risk of a spread of illnesses and conditions.

The report concluded that fluoride 'does not pose appreciable risks of harm to human health', including in particular cancer, bone fractures, effects on cognition, reproduction, endocrine function, cardiovascular and renal effects, and effects on the immune system.

The report found that the only side effect from fluoridation at the levels used in New Zealand (between 0.7 and 1mg/l) was mild dental fluorosis, which can cause minor mottling on teeth. It was found that this was as prevalent in non-fluoridated areas as in fluoridated ones, suggesting it was caused by other sources such as children swallowing toothpaste.

It dismissed a much-publicised review from China that claimed fluoridation could reduce children's IQs by up to one point as not having considered other sources for the issue and suggested the low observed decrease was 'likely to be a measurement or statistical artefact of no functional significance'. An extensive study in New Zealand found no link, the report added.

The review found 'compelling evidence' that fluoridation at established and recommended levels produced 'broad benefits' for dental health. It also cleared the use of fluoridated water for making up baby milk.

Fluoridation in New Zealand, which is being undertaken by 21 of the country's councils and is not used by 44, has met with vocal opposition from protest groups, which led the councils to call for the federal government to take charge of fluoridation policy earlier this year.

Anti-fluoride group Fluoride Action Network NZ spokesperson Mary Byrne voiced concerns to press about the scope of the review, and said of the panel that she 'would imagine it was just going to be very pro-fluoridation.' She also voiced concerns that the review did not address the 'broader philosophical issues' surrounding fluoridation. ●

Suez signs framework agreement with La Caixa bank

Suez Environnement has announced that it is signing a framework agreement to acquire the remaining 24.1% of its stake in Spain's Aguas de Barcelona (Agbar) from Spanish savings bank La Caixa, in exchange for 22 million new Suez shares and €299 million ($404 million) in cash.

The move will give La Caixa a 4.1% holding in Suez, making it the company's second-largest stakeholder – there is also an intention to reach up to a 7% stake 'in the near term', Suez says.

La Caixa will reuse the money from the sale to purchase a 15% stake from Agbar in Aigues of Barcelona, which manages water and sanitation in Greater Barcelona and is 70% owned by Agbar, and a 14.5% share from Suez in Aguas de Valencia.

Suez says the transaction will strengthen its shareholding structure with La Caixa, reinforce its position in its Spanish and Chilean water activities, and rationalise the group structure. ●

FEATURES

Cover photo credits: Frontpage / Shutterstock and Eau de Paris. See features p5 and p8.

California water bill gains legislative approval

California's legislature has finally agreed a compromise $7.5 billion Water Bill covering a wide range of water infrastructure, supply and ecosystems projects to be put forward for a public ballot in November.

The pared-down bill is the largest investment in the state's water infrastructure for decades. It is also a compromise between the state governor's preferred $6 billion bill, which removed significant amounts of 'pork-barrel' – patronage – projects, and the original $11.1 billion 'pork-laden' bill, which had been delayed twice and was thought unlikely ever to gain voter approval.

The funds consist of $7.12 billion in new money and appropriated an unspent $425 million from previous bonds, which will be redirected to the water priorities – a move that requires voter approval.

Governor Jerry Brown told press: 'We've got a real water bond, and we've got Democrats and Republicans that are more unified than I've ever seen, probably, in my life. It was an amazing convergence over a big idea, and the big idea is that the future of California needs a lot of water and we've got to use it in the best way possible.' ●

Jakarta proposes extra effort for water and sanitation

Jakarta's Public Works Ministry is proposing a budget allocation of $10.4 billion to improve infrastructure and facilities next year. Around half will be spent on roads and bridges, with 20% of the remainder going to the directorate that oversees utilities, clean water and waste facilities.

Nigeria receives funding for water supply upgrade

Nigeria's Bauchi state is to receive a $65 million loan to upgrade its water supply infrastructure. The money will fund an upgrade to the Gubi dam, provide 50km of pipeline and an additional 100km of pipeline within the urban metropolis. The state will provide $6.5 million in counterpart funding.

EBRD offers funds for Romanian watsan improvements

The EBRD is extending a new €10 million ($13.4 million) loan to SC Raja SA Constanta, one of the largest water utilities in Romania. The company operates in the counties of Constanta and Ialomita with a growing presence in Calarasi, Dambovita and Ilfov. The EBRD loan is being provided alongside EU Cohesion Funds worth €47.5 million ($63.6 million). The investment will increase access to clean water and improve sewerage services in the region, enabling 10,000 people to receive access to a safe water supply through extended water networks and nearly 20,000 to be connected to wastewater networks in 17 towns and villages across Constanta, Ialomita and Ilfov. The project will also support investments to ensure that quality water supply services are available for smaller locations in Ilfov county.

South Australia rejects pricing report recommendations

South Australia's treasurer Tom Koutsantonis has signalled that the state government is unlikely to adopt recommendations from a draft report on water and sewerage pricing issued by the Essential Services Commission of South Australia (ESCOSA). The report makes 28 recommendations, among them lower charges for water, a more cost-effective water pricing scheme and a move away from property value-based sewerage charges. Koutsantonis said that the suggestions would increase water bills overall, generating a much higher connection fee.

ADB agrees services funding for Bangladesh

The ADB has agreed a $125 million loan to improve services and governance in pourashavas (municipalities) across Bangladesh, with a focus on potable water, sanitation, solid waste management and drainage systems. The new project, part of an existing programme to support improved services, will help 30 pourashavas with a total population of 2.2 million, including 20 district headquarters. The funding will be used to upgrade infrastructure and services, including water, wastewater and drainage networks, and solid waste collection and disposal. The money will also be used for municipal capacity building in urban planning, financial management and service delivery.

Ecojustice report warns of flaws in Canada's drinking water standards

Green pressure group Ecojustice has issued a report, titled 'Waterproof: standards', which claims Canada's drinking water standards continue to lag behind international benchmarks and are at risk of falling further behind. Ecojustice says that while Canada has, or is tied for the strongest standard in 24 instances, it has, or is tied for the weakest standard for 27 substances. And in 105 instances Canada has no standard, where at least one other comparator does. Ecojustice's criticisms are based on what it calls 'a patchwork of standards' that are in place across Canada, which vary from province to territory with no overall binding national standards for drinking water quality.

water utility management INTERNATIONAL

EDITORIAL

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Water Utility Management International focuses on the interests of utility executives, policy makers and advisors around the world engaged with the key management issues faced by water and wastewater utilities. As well as senior utility managers, WUMI will be of interest to regulators, consultants, contractors, academics, and financial, technical and legal professionals.

Utility reform and achieving efficiency are central themes of the publication, encompassing topics such as benchmarking, investment planning, consolidation, public / private sector roles, leadership, IT, and human resources. Other regular themes include financing, regulation, charging policies, procurement, corporate governance and customer issues.

PUBLISHING

Publisher
Michael Dunn

Water Utility Management International is published four times a year by IWA Publishing. Statements made do not represent the views of the International Water Association or its Governing Board.

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W: www.iwapublishing.com

Design & print
Layout: IPL Print & Design Ltd
Printed by Hobbs the Printers, UK

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T: +44 (0)20 7368 7145
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SUBSCRIPTIONS

Water Utility Management International is available as either a print or an online subscription.

2014 price (4 issues):
£256 / €387 / $511
(IWA members: £209 / €314 / $397)

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www.iwaponline.com/wumi/default.htm

ISSN (print) 1747-7751
ISSN (online) 1747-776X

Improving utility customer services: *the case of Eau de Paris*

For many years, Paris's water supply was handled by two major companies. In 2010 a new utility was formed, Eau de Paris, to unify the supply of water, but the decision had to be made whether to outsource customer services or build it up in-house. **XAVIER FANCHTEIN** discusses the transfer process, the decision to insource customer services and the challenges Eau de Paris faced.

At the beginning of 2010, Eau de Paris took over Paris' water supply and as well as the challenge of bringing together two water supplies previously controlled by two separate companies, the new utility also had to face the challenge of what to do regarding its customer service activities.

Eau de Paris did not have the human resources or IT infrastructure for this and especially did not have the skills. So, when the consulting firm assisting Eau de Paris through the process of remunicipalisation advised the utility to outsource this activity, it was clearly the best option.

Before 2010, customer services were managed by the two companies who had been in charge of supplying Paris with water: Veolia and Suez Environnement. Each company managed its own customer services for its own side of the river Seine, which meant that there were two call centres, two sets of staff and two invoice providers. This, despites all efforts, implied a differing quality of service for customers.

Eau de Paris decided to wait for the implementation of its new information system before unifying the customer service. Therefore, the utility outsourced this activity for an 18-month period to the original operators, Veolia and Suez.

A period of transition

At the end of the original delegation contracts, the technical staff from Suez and Veolia were transferred to Eau de Paris, but not the billing and customer management staff. Nevertheless, it was clear that customers could not wait until the new software had been installed, hence these activities were outsourced. However, the utility's customer director thought that it was important to keep a part of the customer service department in house to help Eau de Paris to understand the activities taking place. So while the management of the call centre and the billing process remained outsourced to the former operators, the team who handled the complex claims was insourced.

As customer expectations increase, customer services have to continue to improve. Credit: Eau de Paris.

During this period, Eau de Paris installed a new way of working with the former delegators, setting up weekly meeting with key performance indicator (KPI) reviews. At the same time, Eau de Paris took advantage of these exchanges to specify its new customer relationship management software. After six months the city council decided to stop outsourcing and brought all customer services in-house.

Customer service insourcing: an easy decision?

Different options

Eau de Paris succeeded in maintaining the quality of the water service with no problems, but, according to some, the remunicipalisation was not totally completed. The municipal council decided in July 2010 to insource customer service activities because to their mind it is a core business: 'how can you listen to your customers if you're not close to them'?

At that time the customer director was preparing a call for tender to find a provider capable of unifying the customer services from the two previous companies as well as capable of handling all interactions with customers (phone calls, mail and invoices). This decision was unexpected as it had only been six months since Eau de Paris had developed its customer department and it is quite different to manage a contactor rather than managing customer services yourself.

As the deadline of the new software drew closer, the insourcing project was launched rapidly in September 2010. There were many things to do, starting with finding a company to implement the new customer services department.

A two-phase transfer

In order to simplify the transition, it had been decided in accordance with the IT department to separate the transfer of the left side of the Seine from the right side

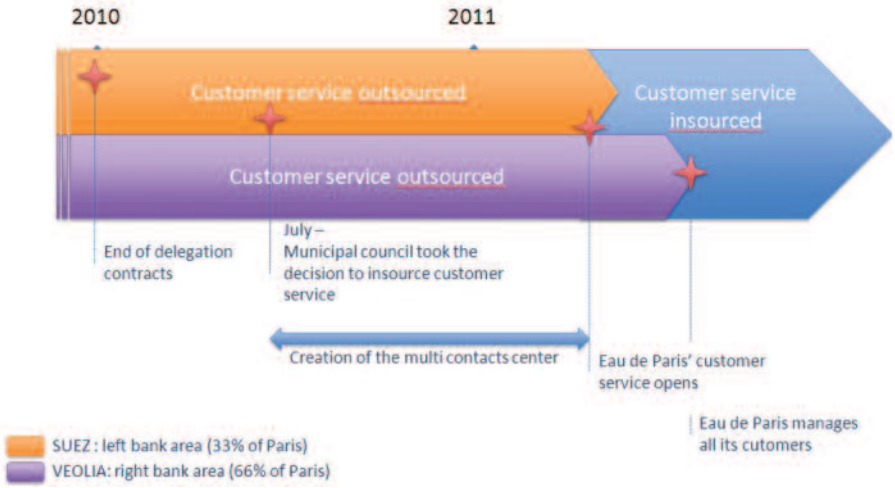

Figure 1: Unifying and insourcing the customer service

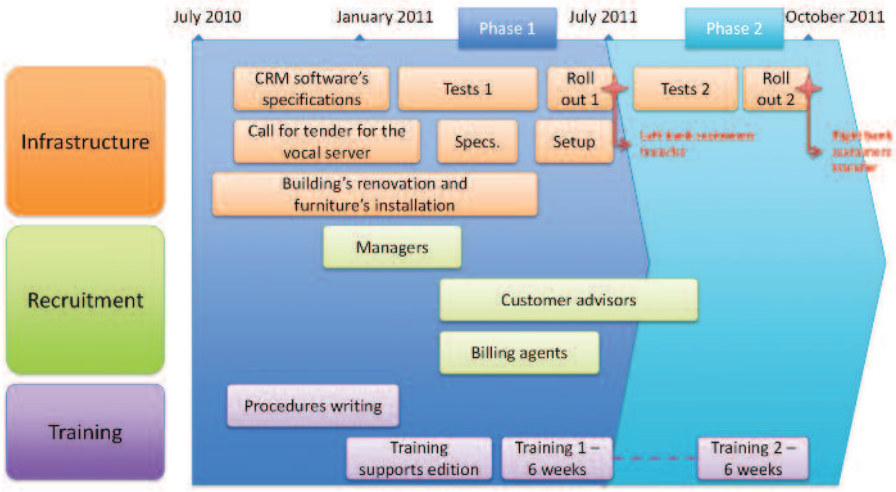

Figure 2: The macro planning of the insourcing project

one. Therefore, Veolia's contract was extended by three months to manage customer services for the right side of the river, while Eau de Paris handled the customer service of the left side (Figure 1).

This choice was made considering both contracts and the fact that the left side was smaller with less activity. Looking back it was maybe not the best choice as it took the Eau de Paris team six intense months instead of three and included two phases of tests, two data migrations and two training sessions. This was also hampered by the fact that Eau de Paris did not have a good command of its new information system.

Installation

Once the place to install the call centre had been found, it became an urgent matter to hire managers in order to help with recruitment, procedures and training.

To estimate the number of staff needed, Eau de Paris referred to the activity the former operators managed during the first six months. The activity was flat over the year, which simplified the evaluation. It took six months for Eau de Paris to recruit agents, purchase the vocal server, write down unified procedures, test the new CRM software, build the training support and eventually train the future customer service agents.

From the beginning Eau de Paris decided to focus on quality. It took six weeks to train customer service agents with regards to water supply activities and customer relationship management, and to organize technical visits. The timescale can be seen in Figure 2.

Customer services

Eventually, in October 2011, the customer service department of Eau de Paris was in charge of the whole area of Paris. The procedures were unified and the service was operational, but it took several months to become fully efficient. It took time to control the new software, to learn procedures, and fix bugs and work with all departments involved in providing customer service.

The customer department was set up with different assignments (Figure 3):

- Managing relationships with both contractors and end-users. This required a platform of a range of contact points, composed with a front office and a back office, which handles customers' calls, mails and emails and handles complex claims.
- Billing customers. The department had to bill customers quarterly and there had to be an engineer in charge of computing and managing water meter readings using software which can compute bills and analyze water consumption.
- Offering new products and services. A marketing team was developed dedicated to creating and developing new products and services, such as

Customer Service operator at work: Credit: Sofièn Haddaji, Eau de Paris.

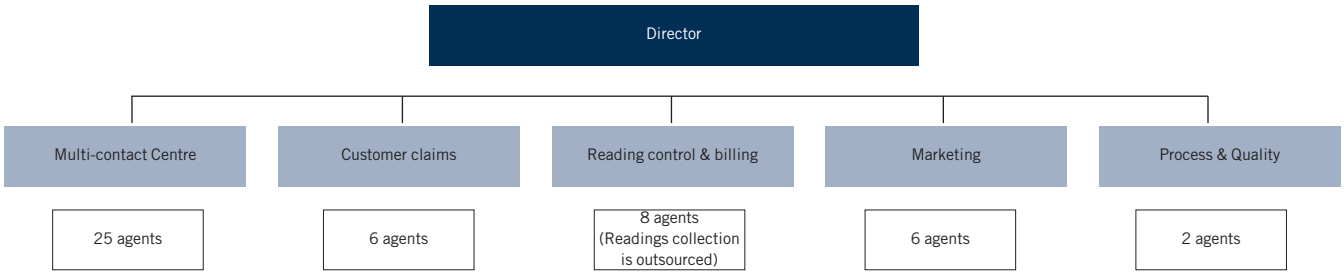

Figure 3: Eau de Paris customer department's organization

online customer care, water leak alerts and unique invoices. There were also fountains to manage and the website and a key accounts team was developed, dedicated to handling relationships with customers who use a lot of water or who have many buildings. There is also a solidarity representative who is in charge of proposing financial help to customers who have difficulties in paying water invoices.

- To support these services, a process & quality department was formed, which is in charge of optimizing processes and measuring customer satisfaction

The end result

After a year, Eau de Paris' customer service department succeeded in maintaining the quality of service delivered to its customers and was presented with an award for 'Customer Service of the Year' by VISEO conseil.

Besides insourcing the customer service, the unification of both customer services enables Eau de Paris to make significant improvements with regards to reporting, standardising customer services and increasing public education with regards to water consumption.

Most of all, insourcing allowed the utility to save a lot of money as the price per contact and per invoice sent have been significantly reduced (Figure 4). This saving has enabled Eau de Paris to lower the price of drinking water by 8%.

Conclusion

Insourcing the customer service was certainly not the easiest choice to make, especially when larger companies prefer to outsource this activity to more specialised companies.

But the will of the municipal council to get closer to its end-users drove this transformation and it has been a success. The quality of service is excellent and customers are satisfied: 72% customers interviewed found that the quality of service has improved since 2010. The price of the water has diminished and it has directly benefited Parisians.

However, some challenges remains. Customers' expectancies are growing higher and Eau de Paris is not at the cutting edge of the customer service compared to other companies, for example in the telecom industry. Eau de Paris could develop its online customer care and social media to enable customers to interact with the utility 24/7. Eau de Paris must continue to develop new services such as a leak alert, but it is also necessary to improve its knowledge of customer habits in order to better meet their needs.

These improvements must not just focus on customers, however. Eau de Paris also has a responsibility towards its Parisian end-users by being a public service, in order to help them to lower their consumption and help them realize that water is a resource to protect. ●

This paper was presented at the 7th IWA International Conference on Efficient Use and Management of Water (Efficient 2013), Paris, France. 22-25 October 2013.

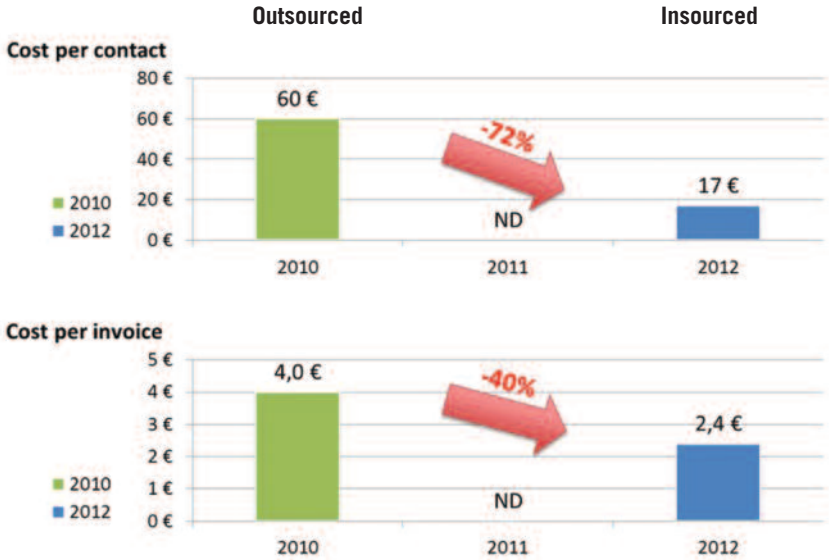

Figure 4: Evolution of the costs per contact and per invoice sent

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Saving energy and cutting water treatment costs on the US-Mexico border

The Border Environment Cooperation Commission has become a key promoter of efforts to reduce water utility energy costs in the US-Mexico border region. **ROBERT LONERGAN, ROBERTO MOLINA, RENATA MANNING-GBOGBO, FRANK BRACAMONTE** and **GEORGE HUNTER** look at how energy auditing of treatment facilities can help identify opportunities to make cost savings.

Aerial shot of the US-Mexico border with the Mexican city of Agua Prieta at the top and the US city of Douglas at the bottom. Douglas was chosen to receive technical assistance funding to support the development of its wastewater infrastructure. Credit: Frontpage / Shutterstock.

Water and wastewater treatment and distribution systems account for an estimated 75 billion kilowatt-hours (kWh) of overall US electricity demand (EPA, 2008). In addition, around 4% of the nation's electricity use goes into moving and treating water and wastewater, and electricity accounts for approximately 80% of municipal water processing and distribution costs (Goldstein and Smith, 2002).

Generating electricity requires the burning of fossil fuels: in the US, electricity generation accounts for 35% of all emissions of carbon dioxide (a major contributor to global warming and climatic change), 75% of sulphur dioxide (a respiratory irritant and a component of acid rain), and 38% of nitrogen oxides (a contributor to smog and component of acid rain) (Arora and LeChevallier, 1998).

Historically, energy efficiency was rarely considered to be an important metric when designing water and wastewater treatment plants. However, in recent years, federal, state and local governments have started taking steps to mandate, support, and / or incentivise efforts to increase energy efficiency and alternative energy production in such plants nationwide.

This is largely due to a range of factors. Wastewater treatment costs are expected to increase by 20% over the next 15 years (EPA, 2008), and budgets are tight due to the weakened state of the economy. Electricity costs continue to rise, and less energy use means a reduced impact on the environment.

Tetra Tech has taken a proactive position in facilitating energy conservation and promoting renewable energy production at water and wastewater treatment plants by performing energy audits, implementing energy conservation measures (ECMs), and installing renewable energy at municipal treatment facilities. The Tetra Tech team has completed more than 50 comprehensive energy audits for plants.

Border Environment Cooperation Commission

One vehicle that Tetra Tech is using to complete energy efficiency projects is a service contract with the Border

Environment Cooperation Commission (BECC). The BECC is a bi-national governmental organisation established in 1993 by the US and Mexico to preserve, protect and enhance the environment and human health in the region that lies between 100km north and 300km south of the US-Mexico border through project certification, technical assistance and capacity building.

The US EPA's US-Mexico border water infrastructure programme (BWIP) uses US EPA grant money together with funds from other sources to create affordable, high priority water infrastructure projects that otherwise could not be implemented. The BECC, in coordination with the US EPA, seeks to ensure the environmental and economic sustainability of BWIP projects in the region. To that end, the BECC and US EPA are incorporating energy and water audits into the development of projects being implemented on both sides of the US-Mexico border.

The BECC administers service contracts for energy and water audits for water and wastewater treatment plants, as well as value engineering (VE) reviews of plant design projects in the border region. To date, these efforts have been supported by funds administered by BECC from the US EPA (BWIP and Border, 2012), BECC's technical assistance programme, and funds from the US Agency for International Development (US AID), the World Bank and private sector partners.

As of June of 2014, BECC had certified 236 environmental infrastructure projects: 126 in Mexico and 110 in the US, with an estimated total cost of approximately $8205 billion. Figure 1 shows the locations and associated costs of these projects.

BECC has made an effort to perform a US border region needs assessment focused on defining the lack of access to centralised water and wastewater services, and to evaluate service needs in the solid waste and air quality sectors within the 100km border region. The needs assessment identified that providing adequate drinking water and wastewater services continues to be a need for residents in US border counties. While the primary gap in centralised service coverage largely exists in a rural setting, an investment would likely be required whether connecting to a centralised system or making improvements to address drinking water quality or adequate on-site wastewater disposal. Table 1 summarises the US needs and investment estimates for water and wastewater services in the border region throughout the states of California, Arizona, New Mexico and Texas.

Figure 1: Certified projects (1995 to date) - 236 projects with an estimated total cost of $8.205 billion

Based on the extent of this existing need and the rising costs of energy burdening the operational costs of utilities, the energy audit efforts are expected to identify opportunities to relieve some of the demand on financial resources, which can then be reallocated to address new capital investment needs. These resources can be used to fund projects directly or leverage resources from other sources, e.g., loans and grants.

Willcox WWTP energy audit

The city of Willcox is about 99km north of the US-Mexico border and encompasses an incorporated area of approximately 15.8km^2. The city population is about 3757 residents according to the 2010 US census, and it is located in Cochise county, in the southeastern corner of Arizona.

As a task order under the service contract, Tetra Tech recently completed an energy audit of the existing Willcox wastewater treatment plant and collection system, as well as a VE review of the 60% design of the proposed upgrade to the plant. The city of Willcox, Arizona was selected by EPA Region 9's US-Mexico BWIP to receive project development assistance programme (PDAP) technical assistance funding, managed by BECC, to support project development tasks such as planning, environmental analysis and design for wastewater infrastructure projects.

The energy audit was divided into two separate tasks, the first of which was to establish an energy baseline. This included a review of energy usage, evaluation of rate structures, field testing of major equipment and considerations for operational changes during the evaluated time period. The team performed wire-to-water efficiency tests on all 11 of the pumps to determine how efficient they were at utilising grid power in pumping

Table 1: Access to centralised municipal services – US needs and investment estimates

State	Number of counties	Drinking water – unserved	Estimated investment – drinking water ($)	Wastewater – unserved	Estimated investment – wastewater ($)	Total estimated investment ($)
California	2	38,864	287.6M	70,803	849.6M	1.14B
Arizona	4	133,491	987.8M	138,359	1.67B	2.65B
New Mexico	5	11,826	87.5M	38,669	464M	551.5M
Texas	25	87,377	646.6M	289,609	3.48B	4.12B
Total US border region	36	271,558	2.01B	537,440	6.45B	8.46B

Table 2: Willcox WWTP Energy Conservation Measure (ECM) list

Energy Conservation Measure	Estimated Annual Savings
ECM 1: Replace inefficient influent lift station pumps	4600
ECM 2: Replace inefficient Magic Circle lift station pumps	150
ECM 3: Replace inefficient effluent lift station pumps	2800
ECM 4: Replace inefficient Wood Street lift station pumps	300
ECM 5: Replace inefficient Railroad lift station pumps	450
ECM 6: Install solar photovoltaic energy	N/A*
ECM 7: Install flowmeters on lift station discharge lines	TBD**
ECM 8: Develop an asset management plan	TBD**
ECM 9: Improve pre-treatment requirements	TBD**

* Not applicable ** To be determined

wastewater. The wire-to-water efficiency tests were performed on the existing pumps in an 'as is' scenario, and the resulting metric is a product of the motor efficiency and pump efficiency. This was achieved by measuring each pump's flow rate and electrical demand simultaneously to provide the data required for the efficiency calculations.

The second portion of the scope included a review and analysis of opportunities to reduce energy consumption and demand and / or generate renewable energy. The energy audit deliverable was a report identifying the baseline energy usage, as well as each ECM and its associated technical and economic feasibility.

As part of the energy audit, the team identified five ECMs related to pump station efficiency upgrades and evaluated the preliminary feasibility of installing solar photovoltaic renewable energy at the plant. The team also performed a detailed process evaluation in order to identify opportunities to reduce the aeration, mixing or pumping energy required for biological nutrient removal. Table 2 lists the ECMs identified along with the estimated annual savings associated with each.

Note that due to small pump sizes and limited run times, the team determined that ECMs 2, 4, and 5 were not economically viable for implementation based on energy savings alone.

Willcox wastewater treatment plant value engineering review

In 2011, the city initiated a plan to upgrade the plant treatment processes while maintaining a plant capacity of 2.27MLD. Based on the technical evaluation performed by Tetra Tech in 2012, the recommendation for upgrading the treatment plant was to install an activated sludge process incorporating oxidation ditches. Subsequently, a design consultant was retained to complete the detailed design for the upgrades to the existing Willcox wastewater treatment plant.

In accordance with funding programme requirements, BECC procured and contracted a value engineering task with Tetra Tech for the Willcox plant design. Tetra Tech's four-day VE review was conducted following the 60% design phase, with final design scheduled for completion in the third quarter of 2014. Information provided during the VE review indicated that the project was scheduled for completion of construction and start-up in the second quarter of 2016. The VE team included an electrical engineer, a process engineer, a civil / structural engineer, an energy/biosolids engineer, and a Certified Value Specialist (CVS). A subconsultant, Value Management Strategies, provided the CVS team member.

The objectives of the VE study were to:

- Improve the overall plant process control
- Investigate ways to reduce O&M costs incurred by the city of Willcox
- Review alternative biosolids disposal processes
- Increase value by optimising the relationship between project scope, cost, and schedule

During the course of the VE review, a number of analytical tools and techniques were applied to develop a better understanding of the baseline concept. A major component of this analysis was Value Metrics, which seeks to assess the elements of cost, performance, time, and risk as they relate to project value. The key performance attributes identified for the project were operating costs, regulatory compliance, plant operations, constructability and expandability.

Below is a summary of the major observations and conclusions identified during the evaluation of the baseline concept, which led the VE team to develop the alternatives and recommendations presented in the final report. The key cost drivers for this project were the oxidation ditch, residuals holding tank / solids dewatering / residuals storage, clarifiers and the O&M building.

From a performance perspective, the key drivers were operational costs, regulatory compliance and plant operations. The VE team was interested in maximising the quality of the effluent to benefit the city. A key focus of the VE review was to investigate ways to reduce O&M costs, in particular for transporting biosolids and the costs of the plant's electricity consumption.

The VE review generated 24 VE alternatives, each of which would result in increased value and a reduction in capital costs and / or operating costs if implemented. Several of the VE alternatives would result in a significant reduction in annual electricity and / or fuel consumption if implemented.

The VE alternatives included solids drying onsite followed by land application in lieu of landfill disposal, adding anaero-

Figure 2: Comparison of value – baseline concept and VE strategies

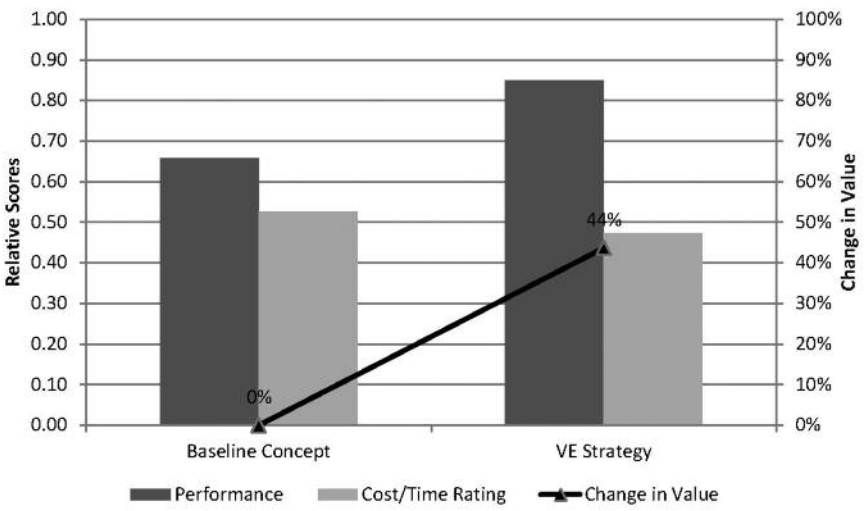

Table 3: Summary of VE strategies

Strategy description	Initial cost savings	LLC savings*	Change in schedule	Performance change	Value change
VE strategy: VE alternatives 1,3; 2,0; 3,0; 4,0; 5,0; 6,0; 7,0; 8,0; 9,0; 10,0; 11,.0; 12,0; 13,0; 14,0; 15,0; 16,0; 17,0; 18,0; 19,0; 21,0.	$1.072.600	$4.061.000	-2 months	+29%	+44%

* Life Cycle Cost (LCC) savings are based on the sum of the Capital Costs + Net Present Value (NPV) of the O&M costs. The baseline concept has a capital cost of $9,553,000 (using a blended rate of 11 cents/kWh for the electrical utility rate). The baseline concept has NPV for a 20-year term of the O&M costs = $9,413,000.

bic selector tanks and eliminating the effluent filters, installation of oxidation reduction potential (ORP) probes in the oxidation ditches to improve process control and avoid excessive aeration, eliminating the waste activated sludge (WAS) pump, eliminating the cover over the WAS storage tank, installing aeration control for the WAS storage tank, installing two electrical feeds into the plant instead of one, and using driven piles in lieu of drilled piers, among others.

A summary of the recommended VE strategies (combinations of VE alternatives) is provided in Figure 2 and Table 3. The chart illustrates the relative trade-offs between performance versus cost and schedule. The line indicates the net percentage change in total value relative to the baseline concept.

The implementation of the VE strategy could result in an 11% reduction in the initial (capital) cost, a 43% reduction in operating costs (LCC), and could reduce the construction schedule by two months while providing significant improvements in regulatory compliance, plant operations, constructability and expandability.

At the end of the project, the results of the energy audit and the VE review were presented to the city of Willcox. The stakeholders in attendance either in person or via conference call were BECC, the US EPA, the North American Development Bank (NADB), the Arizona Department of Environmental Quality (ADEQ) and the city of Willcox.

Douglas energy and water audits

The city of Douglas, Arizona is in the southeastern corner of the state in Cochise county. Douglas is on the US-Mexico international border, adjacent to the city of Agua Prieta, México, and is approximately 190km southeast of Tucson, Arizona.

Douglas was chosen by EPA Region 9's US-Mexico BWIP to receive PDAP technical assistance funding managed by BECC to support project development tasks for planning, environmental analysis and design of wastewater infrastructure projects, including the expansion and upgrade to the wastewater collection system in the Bay Acres Colonia and improvements to the Douglas wastewater treatment plant. The preliminary engineering reports and the environmental information document have been completed, and the National Environmental Policy Act (NEPA) authorisation process is underway. A scope of work is currently being developed for the final design of the project.

To support identification of additional improvements to increase the sustainability of the project and the utility, the BECC retained Tetra Tech to perform an energy audit of the existing wastewater collection system, as well as water and energy audits of the drinking water system. The recommendations of the water and energy audits may be integrated into the proposed project final design or implemented independently by the community.

Conclusions

These projects are just two examples of the numerous water and wastewater energy projects in both Tetra Tech's and the BECC's portfolios, but this is just a drop in the bucket. The industry is saturated with similar, untapped opportunities.

It is going to require a significant departure from current practices for the wastewater treatment industry and the general public to view wastewater as a valuable energy resource, instead of a nuisance that must be disposed of. It is essential that governments promote and provide incentives for energy efficiency and generation in order to reduce our carbon footprint and negative impact on the environment. Energy audits complemented by value engineering offer a good way to achieve these efficiencies. The US and Mexico have set an important precedent that other nations should follow. ●

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The original version of this paper was presented at the IWA Water, Energy and Climate Conference 2014, held in Mexico City, Mexico, 21-23 May 2014.

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Incorporating marginal costs in water supply tariffs: prospects for change

There are two main methods used for incorporating marginal costs into tariff setting so costs are recovered and consumers are encouraged to be efficient in their water use: Turvey and Average Incremental Cost. **GEORGE ANSTEY** and **TOM GRAHAM** discuss the advantages and disadvantages of the two methods and examples of their application.

Academics and policy makers have widely acknowledged that the price of water has been substantially below the cost of providing water services (Rogers et al, 2002). Pressure on utilities' budgets has led to a growing acceptance of the need for full cost recovery (FCR). Today, in most developed regimes at least, customers are expected to pay for their water services.

The widespread acceptance of FCR has brought with it a new pricing challenge – not just ensuring that customers pay for the services that they receive, but that customers consume an efficient quantity of water. Utilities adopting more expensive technologies at the margin (such as the expansion of desalination plants in Australia) may have incremental costs far outstripping their historical average costs of service and the prices they charge to customers. Moreover, rising water scarcity, increasing bills and economic pressures on the population as a whole have resulted in an increasing scrutiny of tariffs, even in water-rich jurisdictions like the UK.

Economic theory suggests that marginal cost pricing is the key to ensuring customers make efficient consumption decisions. In the water industry, which requires significant upfront investment for long-lived assets, the marginal cost concepts can be difficult to apply. Two main methods for incorporating marginal cost signals into price setting have emerged in the literature, which we shall call the 'Turvey' approach (also known as the 'perturbation approach') and average incremental cost (AIC) approach.

These long run marginal or incremental cost concepts are not purely theoretical approaches for setting prices favoured by economists; regulators internationally, particularly in Australia, have begun to adopt these marginal cost concepts as a method for setting tariffs and encourage efficient consumption. Although the Turvey approach has stronger theoretical underpinnings, regulators have mostly implemented AIC approaches for reasons of computational simplicity.

The distinction between marginal costs for the purpose of setting prices and cost concepts used more widely is important here. The forward-looking Turvey approach and AIC approach may not be the only relevant cost standards for calculating marginal costs, for example in other contexts, where specific legal standards may apply. This article focuses its attention on tariff setting and the implications of marginal cost concepts for economic efficiency. We begin by outlining the need for long run marginal costs in setting prices, go on to discuss how to calculate each of these approaches and finally describe how these approaches have been implemented in practice.

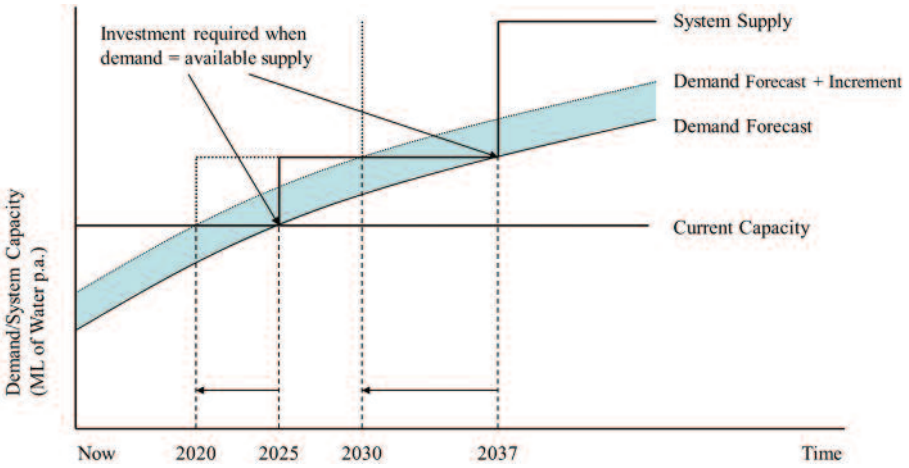


Figure 1: Turvey approach to estimating LRMC

Why use long run marginal costs for the water sector?

Economic theory, roughly speaking, states that that markets are efficient mechanisms when prices are set equal to the cost of producing one more unit of output, known as 'marginal cost' (this result, the First Fundamental Theorem of Welfare Economics, requires a number of caveats and assumptions, excluded here for brevity – for reference, see any standard micro-economics textbook).

The cost of producing one more unit of output depends on the time period concerned. Short run marginal cost (SRMC) describes the cost of meeting an additional unit of water demand, keeping capacity constant, whereas long-run marginal cost (LRMC) relaxes this constraint and allows supply-side capacity to be varied.

In principle, prices could reflect either SRMC or LRMC. Indeed, if capital expenditure (capex) could be split into very small projects, SRMC and LRMC would converge (see Turvey, 2000). In practice, in industries like the water industry, capex tends to be 'lumpy' and consist, at least in part, of significant upfront investments. In such circumstances, SRMC and LRMC may not be equal and SRMC may not be a reliable basis for setting water tariffs, because:

- SRMC is more volatile than LRMC: SRMC can rise as high as the costs of cutting off (the value of lost load). High and volatile prices may not provide a credible method for charging consumers / financing water utilities.
- Costs of reflecting SRMC in prices are higher than LRMC: in order to reflect SRMC accurately in prices, prices would have to vary on a short run basis. That would require a wide roll-out of smart water meters, which, in the first instance, are not there, and in the second instance, may not justify the investment costs.
- SRMC pricing may incentivise fewer

investments to reduce consumption than LRMC: Many methods of reducing consumption of water take the form of long-term investments such as households' investment in water-using appliances, such as dual-flush toilets, or industrial users' locations. If consumers are not fully rational or have limited access to credit, they may not make investments to reduce exposure to volatile peak-time prices.

Accordingly, regulators and companies in the water industry use long-run cost concepts, such as the 'Turvey' and AIC approach to provide marginal cost signals through tariffs.

The Turvey approach to long run marginal cost

The Turvey approach, named after Ralph Turvey (Turvey, 1969), estimates the cost of serving an additional increment in demand. The analyst takes the following steps (see Figure 1):

- Step 1: forecast supply and demand under the optimal expansion plan for the water utility
- Step 2: hypothesise a permanent increment (or decrement) to the expected demand forecast and estimate a new optimal expansion plan in light of that increment (or decrement)
- Step 3: calculate the LRMC as the change in the present value of expenditure in step 1 and step 2, divided by the present value of the hypothesised increment (or decrement) in expected demand

If the underlying investments undertaken do not change between step 1 and step 2, the Turvey approach boils down to calculating the additional interest costs of bringing investments forward (back) over time to meet demand at lowest cost. Of course, it may be possible to reduce the cost of meeting the additional demand further by optimising the types of infrastructure investments for the higher demand level.

The Turvey approach is very close to the marginal cost concept and has economic theory on its side. However, in practice, the Turvey approach can be data intensive. For example, the results are sensitive to the forecast of demand and defining two optimal expansion plans into the future. If demand does not materialise as forecasted, then the prices calculated could be significantly out of line with the actual marginal costs incurred.

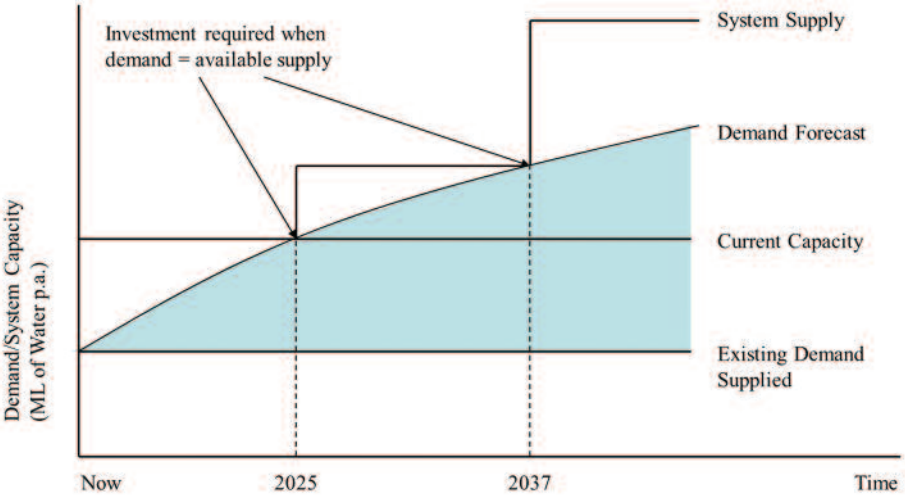


Figure 2: AIC approach to estimating LRMC

Similarly, marginal costs under the Turvey approach can be very sensitive to the hypothesised increment to demand. In some instances, where the hypothesised increment has a natural interpretation, such as the water demand of an additional customer of a particular type, it may be simple to decide on the increment. In other cases, the increment size may be subjective and the choice of that increment may have a large impact on the estimated marginal costs.

The AIC approach

The AIC approach estimates the average cost of meeting future demand. The analyst takes the following steps (see Figure 2 below):

- Step 1: forecast the costs of serving demand including anticipated growth under the optimal expansion plan for the water utility (i.e. the same as under the Turvey approach)
- Step 2: forecast costs without demand growth
- Step 3: calculate the LRMC as the change in the present value of expenditure in step 1 and step 2, divided by the present value of additional demand served

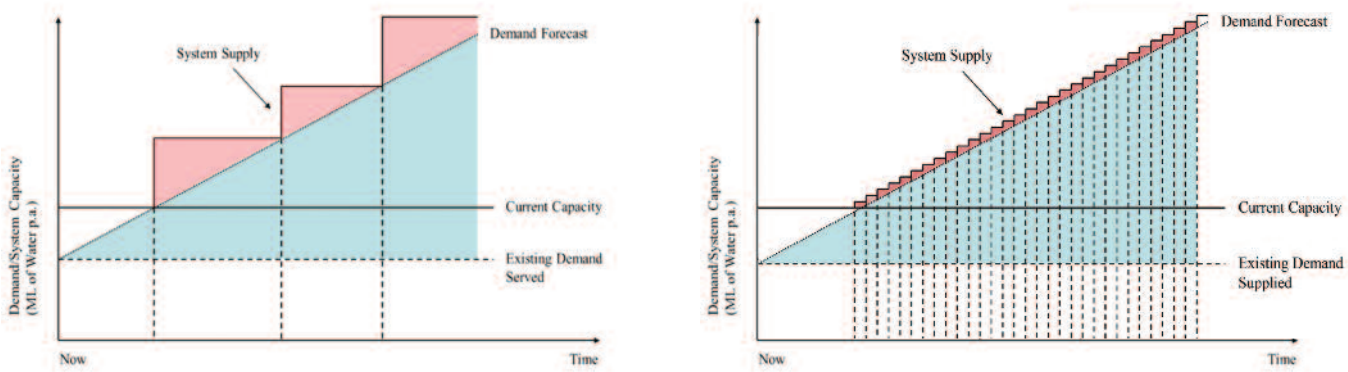
The principal shortcoming of the AIC approach is that it uses average capital costs to approximate the likely marginal costs associated with a change in demand. Specifically, the AIC approach does not explicitly consider the water supply capacity associated with marginal capital projects. Rather, the AIC approach averages the cost of future projects by dividing by the present value of the change in demand supplied by them without discriminating between the 'size' of individual projects. The implication of this is that the estimates of LRMC under the AIC approach can depart quite significantly from the 'true' underlying LRMC.

Turvey and AIC in the water sector

There are no established rules regarding which of the two methods results in higher or more volatile cost estimates and no general 'equivalence' theorem of convergence for the two approaches. In practice, the choice between the Turvey approach and the AIC approach requires consideration of a number of factors:

- Theoretical robustness and stability: both approaches seek to estimate the incremental cost of output. From a theoretical standpoint, the Turvey approach has the edge over the AIC approach because it estimates the marginal cost of incremental output, whilst the AIC approach estimates the average cost of incremental output. On the other hand, as an average cost concept, AIC may offer greater stability in prices.
- Informational intensity and subjectivity of inputs: both the Turvey and AIC approaches require the choice of subjective parameters, including the reliance on expectations (i.e. demand forecasts) and unknown parameters that have to be estimated such as the appropriate private or social discount rate. The Turvey approach requires an extra degree of subjectivity in that it requires the utility or the regulator to forecast additional optimal expansion plans, with and / or without a hypothesised increment to demand.
- 'Lumpiness' of capex: in circumstances where the marginal capex for a system is relatively 'lumpy', the AIC approach leads to a large amount of 'spare' capacity entering into the marginal cost calculation under the AIC approach. In circumstances where system capacity is

Figure 3: AIC approach to estimating LRMC under 'lumpy' (left) and 'smooth' (right) capex



expanded more 'smoothly' as demand increases, the AIC serves as a better approximation of the underlying marginal costs than when capex is lumpy. This is because the extent of 'spare' capacity is significantly reduced (as illustrated by the red triangles in Figure 3). The Turvey approach often largely consists of the interest costs of bringing forward capital projects, and may therefore be less sensitive to the 'lumpiness' of capex.

International precedent

Both the Turvey and the AIC approaches have been implemented internationally. Despite the theoretical benefits of the Turvey approach, regulators have mostly chosen to use the AIC approach on the basis of computational simplicity. Some of the most developed and interesting examples are in Australia, where there is a rise in the need for desalination and periodic water shortages, but we also refer to the largely abandoned workstream implementing LRMC in England and Wales. We summarise these case studies in Table 1.

Western Australia

In Western Australia, the Economic Regulatory Authority (ERA) conducts periodic inquiries to recommend tariffs to the state Minister for Water, who approves tariffs for the water companies (ERA, 2009). The ERA has applied a mixed and somewhat inconsistent approach. As part of the ERA's 2005 price inquiry into the tariffs of the Water Corporation, the company used a Turvey approach to estimate the LRMC of supplying water and an AIC approach for estimating the LRMC of wastewater services as part of its regulatory submissions (Allen Consulting Group, 2005). In a contemporaneous inquiry, the ERA selected an AIC approach to estimate the LRMC for Aqwest and Busselton Water. The ERA provides no material explanation for its mixed approach in the 2005 inquiries or in the 2009 inquiries that followed.

New South Wales

In New South Wales, the Independent Pricing and Regulatory Tribunal (IPART) is responsible for determining the maximum prices that can be charged for metropolitan water, wastewater and stormwater services as well as for services related to bulk water services, including water resource management. IPART first used LRMC estimates as part of its 2005 metropolitan price determination. At the time IPART decided to use the AIC approach on the basis that it provided simpler estimates that were less susceptible to small changes in assumptions (IPART, 2005). IPART has continued to use the AIC approach to calculate LRMC for the Sydney Water determinations in 2005 and 2008, the recent 2009 determinations for the Central Coast councils as well as the 2009 determination for Hunter Water Corporation (IPART, 2009).

Queensland

In Queensland, the Queensland Competition Authority (QCA) has wavered between the Turvey and AIC approaches. In December 2000, the QCA published its pricing principles for the water sector, concluding that volumetric charges should be set equal to AIC (QCA, 2000). As part of its final report on the pricing practices of the Gladstone Area Water Board (GAWB) in September 2002, the QCA changed its mind in favour of the Turvey approach on the grounds that it more closely reflects incremental costs (QCA, 2000). During its investigation into the pricing practices of the Gladstone Area Water Board in March 2005, the QCA changed stance again on the most appropriate methodology for estimating the LRMC. Noting its earlier conclusion that the Turvey method provided a more appropriate estimate of LRMC than the AIC, the QCA advocated using the AIC approach on the basis that it would provide more stable prices that were more transparent and on the grounds of computational simplicity (QCA, 2005).

Overall, as part of the 2005 investigation into the pricing practices of GAWB, the QCA recommended that LRMC be estimated using the AIC methodology. The QCA has retained this approach at all subsequent pricing investigations.

South Australia

The Essential Services Commission of South Australia (ESCOSA) is the economic regulator in South Australia for the monopoly supplies of urban water and sewerage services. ESCOSA has, perhaps, used the least sophisticated calculation of LRMC in setting prices of the Australian regulators we reviewed. In its 2009-2010 pricing decision, ESCOSA stated that it set charges consistent with SA Water's own estimate of LRMC, based on an AIC approach (South Australian Government, 2009). SA Water estimated the AIC of a single future project – the potential expansion of the planned Adelaide desalination plant from 50GL to 100GL. SA Water has used the same methodology at subsequent reviews. ESCOSA has complained about the lack of transparency in SA Water's calculation, but has not gone so far as to propose moving to the Turvey approach (ESCOSA, 2010).

Melbourne, Victoria

The Essential Services Commission of Victoria (ESC) is responsible for the economic regulation of the water sector in Melbourne. As part of its review of water and wastewater prices to be charged from 1 July 2005, ESC empha-

Table 1: Regulators have mostly used AIC rather than Turvey in practice. Source: NERA Research

Jurisdiction	Marginal Cost Principles	Commentart on Marginal Cost Concepts	LRMC Estimate
ERA, Western Australia (Perth)	Turvey (water), AIC (wastewater, 2009)	No material explanation for mixed approach	AU$1.90 ($2011/12)
IPART, New South Wales (Sydney)	AIC	IPART argues AIC approach provides simpler estimates that are less susceptible to small changes in assumptions	AU$2.18/kL ($2011/12)
Queensland Competition Authority (Gladstone Area)	Turvey and AIC	QCA swithced from advocating Turvey to AIC in 2005 on the basis that it would provide more stable prices that were transparent and computationaly simple	NA*
ESCOSA, South Australia	AIC of expansion of Adelaide Desalination Plant (50Gl to 100Gl)	ESCOSA adopted SA Water's favoured approach	AU$2.32/kL ($2009-11)
Essential Services Commission, Victoria (Melbourne)		Unlikely to consider AIC approach adequate signal of marginal costs	NA*
OFWAT, England and Wales	AIC and LRMC reviewed, neither used	Ofwat pointed to wide variety of LRMC's identified	£0.09-1.32/m³ (Nov 2003) water only companies with steady demand

*Theoretical approach discussed, but no values published.

sised the importance of setting variable prices according to estimates of the LRMC of supply, but noted that the businesses were not doing so at that stage (ESC, 2005). ESC consulted with water businesses on the methodological issues associated with estimating LRMC and released an Information Paper in September 2005, the purpose of which was to serve as a manual to which businesses could refer to when demonstrating that they had estimated the LRMC of their various services and had had regard to those estimates in setting their variable prices (ESC, 2005). The Information Paper was couched in relatively high level terms, but stated that the ESC 'would be unlikely to consider LRMC estimates based on the AIC approach to be adequate for the purpose of proposing prices in the next review' (ESC, 2005, p15). However, no common approach to estimating LRMC was adopted between water businesses subsequently.

England and Wales

In England and Wales, the regulator, Ofwat, has considered using both approaches. Ofwat launched a review in 1997 investigating methods for using LRMC in water tariffs. Following the review, it required the water companies in England and Wales to submit LRMC estimates, including annual updates from 2001. The water companies were able to use either the Turvey or AIC approaches to calculate their LRMC estimates and most, but not all, opted for the AIC approach. Ofwat responded to the initial estimates the companies provided with scepticism, partly due to the wide range in LRMCs calculated by different companies and issued detailed guidance on how the approach should be implemented in 2002. Nonetheless, the LRMC estimates were not used to set the tariffs for end users, which in part may reflect the lack of metering for many household customers. Although never implemented in practice as the basis for widespread pricing reforms, the England and Wales case illustrates the sensitivities of the LRMC

Conclusion

While achieving efficiency in the procurement, treatment, transport and consumption of water is almost universally considered to be a desirable outcome, regulators and water utilities do not always price water services in line with this objective, i.e., by reference to LRMC. Moreover, regulators and utilities have adopted inconsistent approaches for estimating the underlying LRMC.

Of the two commonly employed approaches to estimate LRMC for setting prices, the Turvey approach most closely approximates the marginal costs because the cost estimate represents the change in costs as a result of a specified change in demand. The AIC approach, on the other hand, uses the average costs of future increases in demand as an approximation for the costs of providing an additional unit of the service. Turvey's conceptual superiority comes at a price: the process of calculating the Turvey approach is more resource and data intensive than the AIC approach. There can also be additional subjectivity associated with the Turvey approach due to the need to pick an increment to demand and forecast additional optimal expansion plans with and without that increment.

In practice, where regulators have attempted to introduce LRMC signals in prices, they have tended to use AIC to estimate LRMC in the water sector for reasons of computational simplicity. It may be that, as experience with using LRMC to define tariffs grows, more regulators will follow the ESC in Victoria and seek to move away from AIC to more marginal concepts, such as the Turvey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Tom Graham

approach.

In any case, where the marginal technology is increasingly expensive and / or where existing assets are largely depreciated, AIC will tend to be higher than average historic cost and closer to the marginal cost of providing water services. It follows that either the AIC or the Turvey approach is likely to provide better signals for efficient consumption than relying on average historic cost. Irrespective of the calculation method chosen in future regulatory decisions, rising water scarcity will continue to put pressure on tariff policy and encourage the use of more marginal cost concepts in prices. Industry observers should expect to see increasing use of marginal cost concepts and increasingly marginal cost concepts employed in setting end-user prices. ●

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DATA MANAGEMENT

A new data paradigm for water management

Using software to integrate data sources and create a holistic 'system of systems' management approach is an innovative new approach with advantages for the water industry. IBM's **NITIN KAPOOR** and **GAUTAM MENON** report.

The water industry is undergoing a dramatic shift. Tremendous challenges are forcing the industry to adapt and reshape itself. Population growth, urbanisation, ageing infrastructure and constrained budgets are forcing utilities to rethink the way they operate. On a larger scale, increasing water stress, pollution and sustainability have become critical imperatives for regional and national governments – driving renewed interest in integrated water resource management (IWRM).

This article will set out some key themes that will be critical to the transformation of utilities and agencies that deal with water management, from the local to the national level. It sets out a concept for the holistic application of information technology (IT) to potable water distribution system management, based on the greatest possible use and integration of data and optimisation techniques.

We believe this to be a new paradigm for water management – we label it the 'information engineering' paradigm, and intend it to be contrasted with the traditional 'water operations' paradigm. The approach we are taking here is more a comparative study between the existing paradigm (of IT within water distribution systems) and what we are proposing for the future – 'information engineering'. This article will lay out the current components of a water utility and how the new paradigm will impact such utilities across the world.

We believe that four themes will typify the water organisation of the future: continuous monitoring of operations, a single point of truth, listening to assets, and using insights from all of these to drive the optimisation of operations and decisions. The unifying thread behind these themes is data – data that usually already exists in some system somewhere within the organisation. The data usually (but not always) comes from instrumentation of some kind, but it could also come from people. Data by itself is of little use until it is used in some fashion to drive business insights.

This is where IBM comes in. Our strength is that of 'information engineers' – we are not water engineers, nor do we want (or claim) to be. With the help

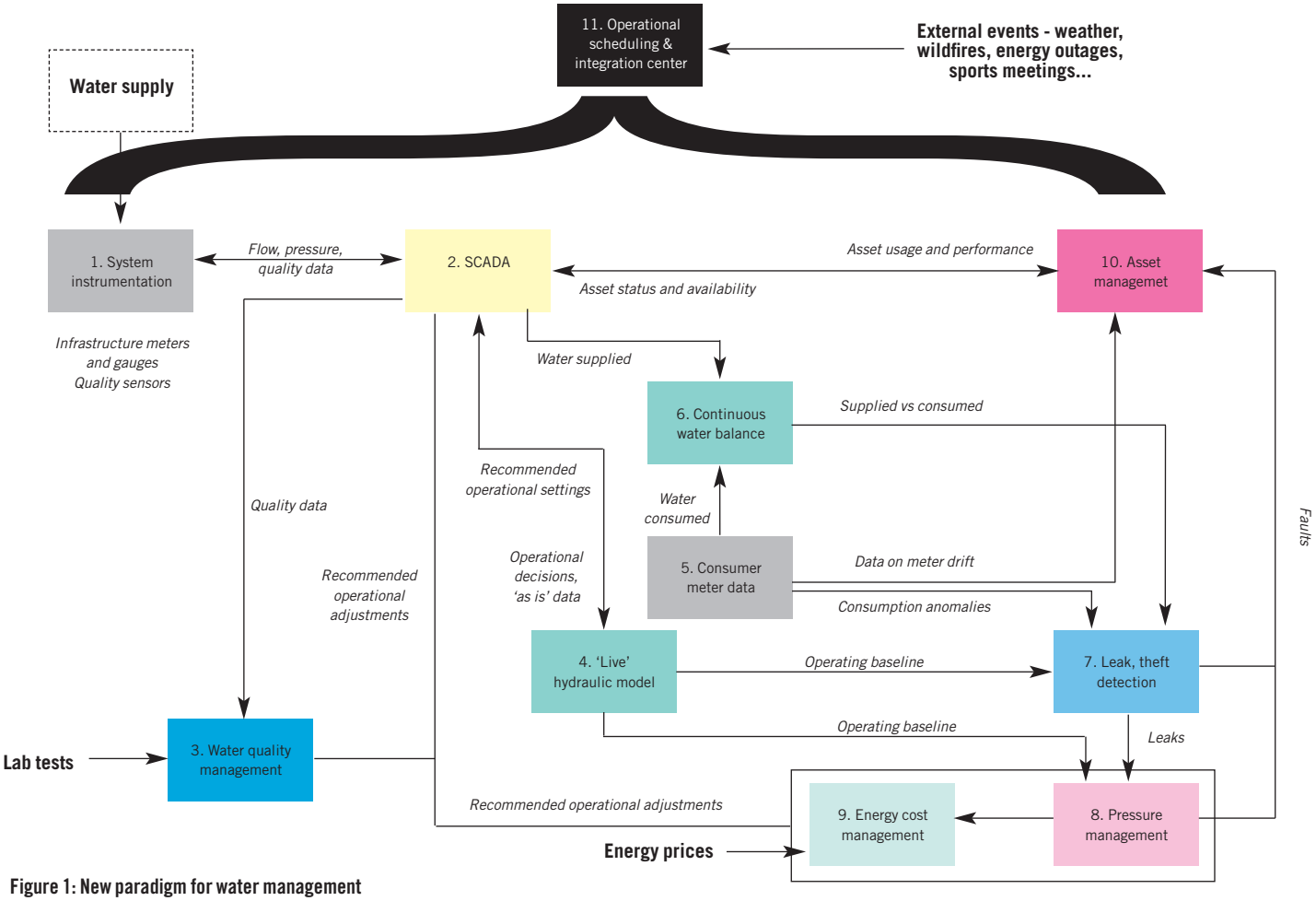

Figure 1: New paradigm for water management

of partners, we are able to marry our industry-leading technology with expertise in water to deliver integrated solutions that can make a real dent in the challenges that water participants face today.

The notion of using software to integrate data sources and create a holistic 'system of systems' management approach is not yet well understood or considered. It is an innovative view held by a few forward thinkers in the industry, requiring a paradigm shift from relying solely on traditional engineering problem solving to using data to help address operational challenges.

The benefits of this new 'smarter' paradigm are compelling – moving from a reactive operational stance to a proactive one, reducing costs and improving quality of service while minimising the need for large capital investment.

Note that we have not included water or wastewater treatment at this stage, although analogous principles could also be applied to those domains. We have also excluded billing, customer relationship management (CRM) and other 'back office' systems.

A new paradigm for water management

Ageing water infrastructures and non-revenue water (NRW) cost public and private water utilities billions of dollars every year. Other challenges – like traditional processes that lack real-time responsiveness – make it challenging to adequately detect leaks, act proactively or manage water pressure. So when leaks or pipe bursts occur, a water utility is forced to spend its limited budget on emergency repairs and associated costs.

The water and wastewater industry is built on a physical infrastructure of pipes, pumps, storage tanks / basins and treatment plants. These are long-lasting investments. Change is slow. The basic commodity, water, is under-valued and priced, so there is little incentive to invest. Regulatory restrictions and risk aversion also contribute to slow change.

Because of the complex, expensive physical infrastructure, change is something considered primarily when legislation changes and action is required for environmental compliance and ultimately, to avoid penalties and fines. In addition, the traditional approach is likely to be civil engineering-oriented – fix what we have and build more – which involves capital expenditure projects that must be carefully considered against utility and city budget constraints.

But these costs can be mitigated through a flexible, standards-based platform that monitors the entire water infrastructure in near real time, which is exactly what the IBM Intelligent Water software delivers. It unites and correlates data collected from multiple sources for an integrated view that enables rapid, coordinated action; providing insight and control over every facet of water management.

Our concept addresses the needs of the water transmission and distribution systems through to end customer connections, and it would embrace pressure management, energy optimisation, NRW management, certain aspects of water quality management and integration with asset management. These areas are chosen because they are interrelated and because from an information engineering point of view it is evident that effective management often requires optimisation of some or all of the many variables involved relative to each other.

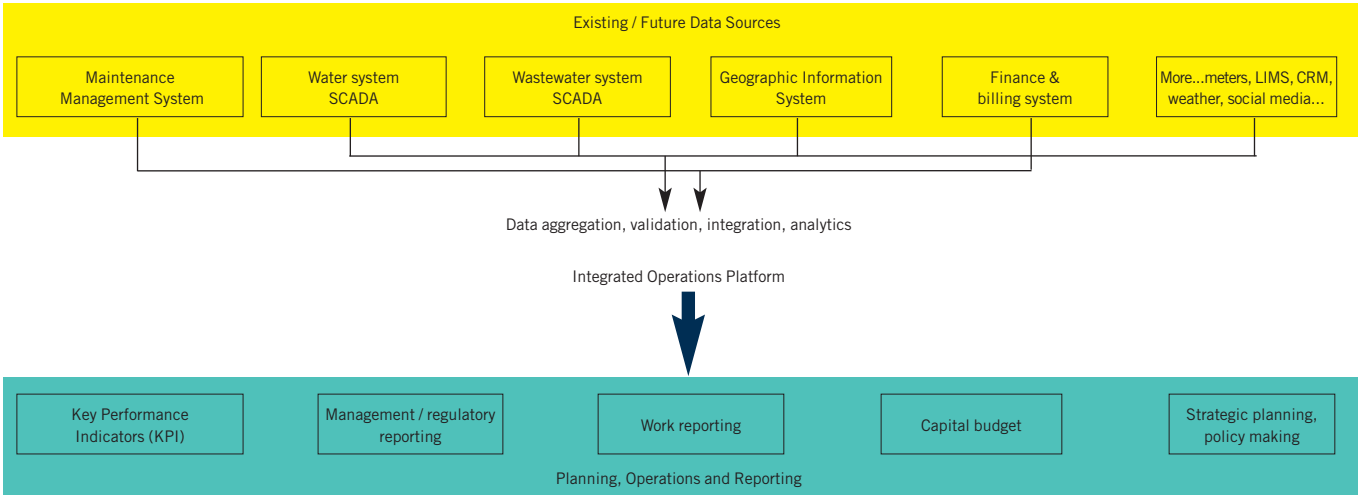

Figure 2: Getting started with 'smarter' water: the concept of an integrated operations platform

A new paradigm for water system management can be achieved by capturing detailed data about the system, applying that data via several continuous processes of optimisation and analysis, and enabling the maximum degree of integration between those components. This is important because it will enable the management of operations at a much finer spatial and temporal resolution than the current norm, which in turn allows greater extraction of efficiencies from the system, continuous scanning for anomalies such as leaks, and detailed accumulation of asset performance histories, which enables better maintenance practices. In turn these all enable reduced costs, and a switch from reactive management to a more predictive – and thus proactive – management model.

Maximum integration will also enable a much better basis for longer-run adaptation to deal with such factors as replacement of ageing physical infrastructure, rising energy costs, rising scarcity (and cost) of water supply, changing regulatory requirements, climate change impacts and population changes. It will also provide a greater level of system resilience in the face of extreme events such as storms or floods, high temperatures or earthquakes, or in the face of major malfunctions.

The new paradigm will entail the logical components shown schematically in Figure 1. As stated, the individual components in Figure 1 may be used in some form in leading water agencies today, but few water agencies have all of them, and fewer still have them fully integrated with each other. This integration is the key to the new paradigm. The major components from Figure 1 are described below. Let us look at the aspects of the new paradigm

Continuous versus Periodic model

Most hydraulic models today are run intermittently, often to explore scenarios for planning purposes. In contrast, running the hydraulic model continuously would provide the 'ought to be' picture that then offers an analytic counterpoint to the 'as is' data from the SCADA system. Anomalies between the two data sets become powerful information for pressure optimisation and NRW management.

To set up a hydraulic model in this way requires careful initial calibration, which can be time-consuming – but the calibration process itself offers an excellent way to execute a 'health check' on the water system, as it uncovers previously unknown issues such as jammed or leaking valves, under-recording instrumentation, under-filling tanks and so on. Once the model is calibrated, in continuous operation it will then be easy to keep calibrated, as system malfunctions will become immediately apparent, which is itself a benefit. Hydraulic modelling products that are designed to operate continuously are now becoming available (including a version of the well-known open-sourced EPAnet), and are sometimes embedded in pump optimisation tools.

A single version of the truth

The key to the information engineering paradigm is the integration of the different components, both with other individual components and collectively. All of the foregoing should come together in one summary computer tool, shared by all those contributing to the performance of the system (sometimes referred to as 'one version of the truth'). For example, if one were to ask the question, how much water was delivered to users last month?, often there could be one number from the billing system, a different number from metering systems and a third number from the SCADA control systems.

The visualisation in the operational scheduling and integration centre would be structured at the highest level around a set of key performance indicators (KPIs), with data represented geographically or in system schematic (or tabular) form as required.

As Figure 1 shows, these would be supplemented by data on critical external factors such as the weather, public events, fire-fighting needs and so on. Alerts would be provided to enable the user to 'drill' into problems that the tool reports. These would trigger workflows to ensure a closed loop in following them up. While there would be a single summary screen, lower level screens would then cater to the needs of different functions (operations, maintenance, planning, and so on).

Your assets are talking – listen to them

All of the foregoing will provide valuable data that allows maintenance issues to be identified and, over time predicted and responded to before they become major problems. At one level this will be a matter of, say, identifying small leaks before they become major blow-outs; at another, it is now possible to analyse meter data and detect under-recording consumer meters before the problem becomes apparent from just reading consumption or billing data.

Moving beyond that, while some

water agencies already practise a form of leak risk assessment, we believe that the input of accumulated pressure histories could greatly improve that process, as an aid to maintenance planning and capital budgeting. Similarly, as in other industries that use predictive maintenance, it may be possible to predict pump and other equipment failures and gear maintenance scheduling to these predictions, with major savings in asset lifecycle costs

Another critical asset for water systems is meters. Advanced Meter Infrastructure (AMI) data is reported, usually via a wireless network, every 15 minutes, hourly or half-daily. In addition to its billing and demand management function, and customer education, this data offers significant additional value in water system management. The data will usually be captured from the meter data management (MDM) system.

While AMI systems are gaining momentum in the water sector, the value of migrating from analogue to digital meters is often assumed to arise only from reducing the cost of meter data collection. We have encountered utilities that struggle to find business justification for investment in more advanced meters, especially (but not only) in low labour-cost economies. Unfortunately, this has led many agencies to opt to replace their analogue meters not with AMI but with Automated Meter Reading (AMR) technologies that report wirelessly, but only via a monthly drive-by.

This is certainly cheaper than manual reads, but loses the real value that the greater frequency of AMR can bring: first, detailed insight into water consumption patterns over time, enabling the provision of information to consumers to help them conserve water more effectively; and second, enhanced network operations, support for leak detection, customer management, network and capacity expansion planning, and so on.

In some parts of the world, instrumentation is poor or absent, leading to a dearth of data on which to base decisions. One way to avoid this is to get creative – many parts of the world that have poor instrumentation have a high penetration of mobile devices. Innovative solutions can use this to turn citizens into a form of sensors – have them take pictures of water bodies and infrastructure and report problems to the water agency. IBM recently used this idea, to great effect, in South Africa.

Using insights to optimise

Insights from continuous monitoring, asset information and a holistic, integrated view of operations can be used to optimise the business as never before. Simple correlations of failures with assets and, say, temperature information, can help identify which assets are most prone to break and at what times of the year.

Predictive analytics can help identify which part of the infrastructure is most at risk of failure. The continuous hydraulic comparison identifies opportunities to reduce pressure while maintaining an acceptable pressure at consumer premises and for fire hydrants.

Integration with external sources such as river levels, tides weather events and more can drive better preparedness and planning during large-scale disruptions such as floods, surges and storms. Integrating, analysing and understanding data and relationships across a disparate set of sources such as land use, water levels, water allocation and demand, forestation, pollution and more can guide IWRM policies and decisions. Contextual knowledge about the network that resides in people's minds or in scattered documents can be captured and embedded into structured processes and operating procedures, thus avoiding a 'brain drain' when older workers retire or leave the workforce.

Data to optimise operations need not be limited to internal systems – there is a wealth of external data, that, when used in the right way, could further drive business value. One obvious external data source is weather information. From flooding and coastal surges to sewer flows and watershed pollution, weather has a large impact on water management. The better the weather prediction, the more efficient the planning and the disruption to operations and infrastructure can be mitigated. IBM's Deep Thunder capability delivers a high resolution (down to a square mile), highly accurate weather prediction capability that helps utilities, private entities and government agencies make more informed decisions and minimise weather-related risks and costs.

No water agency known to us has implemented in its entirety the information engineering paradigm just described, so the precise level of return on investment is difficult to predict at this time. However, there are success stories that we can share around this paradigm.

For example, a US water management utility is reducing its leakage and proactively managing issues with a first-of-a-kind, analytics-driven management solution. There has been a greater than 16% reduction in leaks and bursts in first year of deployment, compared to the previous year (19% compared to the previous three-year average). The number of pressure spikes was also minimised by moving from a reactive to a proactive management approach.

A water department in Asia serving seven million people is using predictive models to identify and proactively replace the pipes at highest risk of failing. There has been a greater than 300% increase in forecasting precision compared with the previous approach, and a 24% reduction in failures, achieved by replacing the riskiest 2% of pipes.

Where to start

The best way to get started is to take stock of the numerous and often disparate or fragmented data sources that exist within the organisation. Understanding what data is available, in what form and where is fundamental – once this is done, it becomes easy to validate (or 'clean') the data and integrate it. This exercise also helps discover gaps in information and in business processes.

Data integration may sound simple but in reality it takes industrial strength enterprise software and a solid understanding of data to pull it off well. It is important that data is not integrated for its own sake – the data should drive real value based on the business requirements and industry challenges that the organisation is facing. We have found that the contextual understanding of data is also very important – that is, the relationship between different data elements is just as important as the data itself. For example, being able to easily visualise which pipes are associated with which customer accounts is invaluable in figuring out what impact there could be from a pipe burst or maintenance work.

Complementing this internal data could be external information from social media, weather, citizen-driven data, inter-agency data sharing and much more. These external data are an often overlooked part of driving business value.

Once the data is integrated and the solution is able to show patterns, its important to have a flexible and scalable platform that allows the user to take actions on the insights coming from the continuous modelling and from assets. These actions could include collabora-

tion, executing alerts and operating procedures, viewing correlations, trends and patterns and much more.

Such an 'integrated operations console' (see Figure 2) is the first step in making sense of the data deluge that is already a reality in many water utilities. Once the platform is in place, a variety of advanced applications may be put on it to drive further business value.

The platform serves as the foundation for delivering the 'single view of the truth' that we described earlier in this article. It is also the bridge between applications such as SCADA, hydraulic models, metering systems, asset management and the line of business. It enables business users to quickly understand, analyse and ask questions about the operations in an intuitive and efficient way.

Conclusion

The above article identifies the components of the 'information engineering' paradigm for water management, and the level of integration required. We believe that the shift to this paradigm will allow water transmission and distribution systems to be operated at levels of energy, water and financial efficiency that are rarely achieved in the industry today – but that will be increasingly required worldwide as water supplies becomes stretched to meet demand, as countries contemplate the backlog in capital expenditure on their water systems, and as both water and energy prices increase.

Not all of the components of the information engineering paradigm are in widespread use today. Many will be more expensive to implement and integrate than many water agencies can currently afford, especially if (as is often the case, in developing and developed countries alike) they have inadequate levels of basic instrumentation on their water systems to begin with.

Water agencies will be confronted with the dilemma of where to prioritise their scarce investible surpluses – expanding infrastructure, expanding instrumentation and measurement, or integrating the systems they have. The road ahead will not be easy – climate change, increasing urbanisation and increasing demands from citizens will put growing pressure on both utilities and governments to deliver safe and reliable water while sustaining the environment.

The information engineering paradigm presented here is intended to represent a road-map for the water sector to apply over time, helped, one hopes, by the fact that the cost of the systems in question will decline as they become more widespread. ●

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Notes

The authors would particularly like to thank Peter Williams (CTO, IBM Big Green Innovations) and fellow IBM employees Eitan Israeli, Ian Abbott-Donnelly, Srinivas Kowligi, Pnina Vortman, Geoff Riggs, Susara Van Den Heever, Eoin Lane and Carey Hidaka for their contributions to this article.

This paper was presented at the 2014 Singapore International Water Week Convention, held in Singapore, 1-5 June 2014.

PROJECTS, PRODUCTS AND SERVICES

HWM launches controller for PRVs

The water and asset monitoring specialist HWM has launched a new electronic controller for pressure reducing valves (PRVs).

The Pegasus+ enables detailed multi-point PRV control without a flowmeter, either by flow or by time, together with sophisticated closed loop control. It also permits immediate control of pressure within a distribution network and automatically adapts to network changes and events by analysing data from up to three critical points (CPs).

By controlling PRV output pressure, the new controller maintains CP targets defined in terms of time, flow or a combination of the two. Networks can be optimised to reflect changing demand throughout the day or week. A latching solenoid output enables vales to be fully opened or closed in extreme or emergency situations, according to controller settings. Bidirectional GPRS telemetry can be used to trigger alarms or remotely control the valve. Pegasus+ features a

secondary channel, in addition to its main logging channel, for fast logging down to one-second intervals. This allows a more detailed investigation of events such as pressure spikes while helping to establish minimum night flow. The controller also offers the ability to control a network from any web-enabled device via the HWM Online web viewer whereby users can check and alter system and component configurations and settings. Controller set-up and programming can be conducted via a tablet or PC-based app. ●

www.hwm-water.com

AQUARIUS Forecast software launched

Aquatic Informatics Inc has announced the expansion of its AQUARIUS solution suite with the launch of AQUARIUS Forecast, a software solution for advanced environmental modelling.

It is intended as a support tool for water resource managers seeking to improve water accounting, optimize water supply allocation and to better predict and manage floods. The system is based on time series data, which it converts to the required time-step of environmental models.

Trend data is displayed in charts and grids and the system also has a Model Library of transparent elements, which enable the construction of complex models by using them to form new custom elements, which can then be saved. Errors are identified in a clickable list, which makes them easy to find and fix, says the company. ●

http://aquaticinformatics.com