Building the Water Utility of the Future

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American Water Works Association

CONTENTS

Front Cover: By taking advantage of today's advanced technology, water utilities will be able to embrace a digital transformation by building smarter infrastructure with intelligent devices, connecting insights to action with real-time data, and doing more with advanced applications and services tailored to their needs. Image from Metamorworks, Shutterstock.com.

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FOREWORD

Water utilities provide life-sustaining services at an amazing value. While providing water for public consumption, many water utilities also help protect their communities by maintaining adequate storage, pressure, and flow capabilities to fight fires. All of this is done while managing millions of dollars of assets, daily operations, providing customer service, and ensuring future sustainability. It's a daunting task that is further constrained with issues that can't be controlled, such as climate change, population growth/shift, industrialization, rising energy costs, and increasing irrigation demands. Utilities also face the normal day-to-day challenges, such as meeting customers' needs for transparency, rate fluctuations, aging infrastructure, regulatory compliance, and balancing an aging workforce with the need to attract young talent.

This guide, part of the AWWA Essential Knowledge Series, is intended to help water utilities look to the future and explore the means to apply and integrate technological developments and skill sets to unlock each utility's hidden potential. Advanced metering infrastructure (AMI) has initiated new insights on how to optimize operations; deliver next-level data granularity; and identify, more specifically than ever, when, where, and why water is being used. But smart meters are just the beginning. It's our sincere hope that by taking advantage of today's advanced technology, water utilities will be able to embrace a digital transformation by building smarter infrastructure with intelligent devices, connecting insights to action with real-time data, and doing more with advanced applications and services tailored to their needs.

Sincerely,

Dan Pinney
Vice President of Global Water Product Management
Sensus

INTRODUCTION

The water utility of the future needs to be resilient, efficient, analytical, economical, and risk-averse all while focusing on the health, safety, and happiness of the community it serves. With so many current challenges in each municipality, such as population growth, climate change, and budget constraints, it's hard to know where to begin.

The key focus areas contained in this guide will help you address immediate concerns and prepare you for future challenges. You'll also learn about innovative technology and data-usage scenarios that will help you implement new business practices and allow you to adjust age-old policies. The result will be a modernized approach that will take your utility from sufficient to resilient.

MOVING BEYOND METERING

Water utilities provide safe drinking water around the clock to millions of customers every day—every home and business is connected, and almost every customer has a meter. Meter reading provides important data used for water loss prevention, billing, revenue, and much more.

A water meter is quite literally a utility's cash register, used to measure and document each customer's consumption. Without proper metering, water utilities lose money because they aren't receiving fair compensation for what they provide to their customers. Water metering also provides a way to equitably assess users and encourages responsible, efficient water use. With areas of the United States suffering from long-term drought, proper metering has become more important than ever.

Different methods of metering have been around for a long time, including different types of mechanical meters such as propeller, turbine, multi and single jet, positive displacement, and combinations of these for specific applications. For decades, methods of measuring water through a meter didn't change much, although the technology for reading meters evolved. However, the need for increased accuracy has gradually pushed the development and implementation of nonmechanical meters into new applications. Today, the number of water utilities adopting electronic water meters for commercial, industrial, and residential uses continues to grow. These solid-state meters have no moving parts to wear out, degrade, or break like mechanical meters. As a result, electronic meters, such as ultrasonic and electromagnetic meters, can maintain the same level of accuracy long term, especially at low flows.

AMR, AMI, AND BEYOND

During the past 40 years, meter reading has evolved from manual entry in a route book to automatic meter reading (AMR) systems to advanced metering infrastructure (AMI) technology. AMR was a significant step up from manual meter reading, which involved a person visiting each meter site and reading and recording each meter. Water and snow in the meter pits, as well as access to homes and buildings, made this a challenging task.

With AMR, each meter has a small transmitter that sends the reading electronically on command. For example, the readings can be sent by phone, cable television, or electric power lines. A reading also can be sent by radio signal when a meter reader walks down the street or drives in a truck with a hand-held computer to collect the meter data.

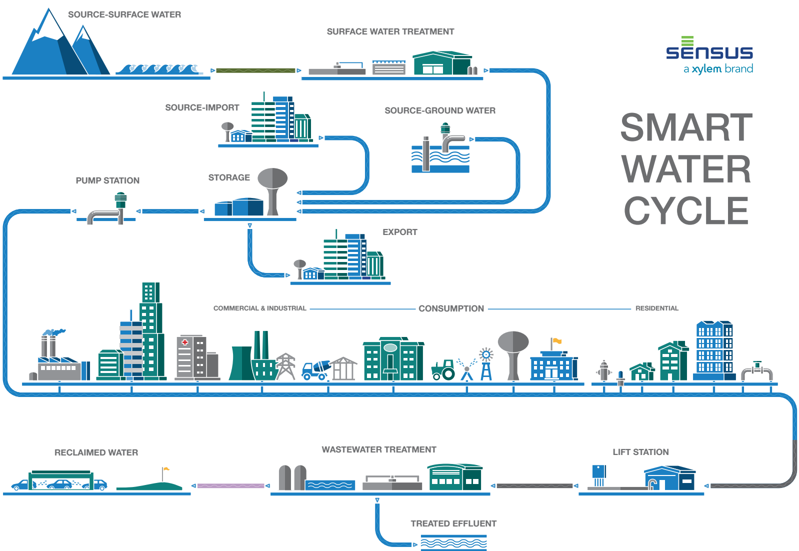

Figure 1. Utility intelligence provides insights for all activities in the water cycle.

Meter readers handle a flood of data every day, and entering that data manually can increase the chance for human error. Accurate and dependable water metering is more important than ever for utilities to help drive key business and customer service objectives.

AMR continues to help utilities across North America automatically collect consumption and status data from their water meters and transfer that data to a central database for billing and analysis. However, regardless of how the meter is read, AMR only allows one-way communication. The meter talks to a meter-reading device, but the device can't send a command back to the meter.

On the other hand, AMI includes smart meters and sensors that provide utilities with a wealth of data to give them greater insight into consumption for billing and customer service. But a water utility of the future needs to go beyond AMI by using an integrated system of smart meters, communication networks, and data management systems to enable two-way communication between the utility and its customers. This is a smart utility network, and the result empowers customers to take control of their water use and helps utilities handle numerous operational issues by providing more advanced metrology and sensors, smarter end points, more bandwidth, stronger security, and a reliable network. When smart meters and sensors are connected, they can provide insight into all aspects of a utility's operations, not just consumption and billing (Figure 1).

Combined with other data sources, such as supervisory control and data acquisition (SCADA), geographic information system (GIS) technology, asset data, work order history, etc., water providers can now capture and analyze more information than ever before. The question then becomes, how can utilities best manage all these operational workstreams to complete their normal daily routines while using the advanced data to optimize their water systems?

From source to tap, water providers are capturing and analyzing more data than ever before to meet their customers' needs.

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TAKING ADVANTAGE OF A SMART UTILITY NETWORK

One of the key benefits of an intelligent network is the ability to expand and accommodate new applications as a utility's priorities change. Depending on the system components, numerous capabilities are possible. The following sections provide some examples:

NONREVENUE WATER TRACKING

Water loss is a common challenge for drinking water utilities, the extent of which varies from system to system. The current wave of critical water infrastructure reaching the end of its useful life has made these challenges that much more difficult. While many utilities have made water loss control a priority, many older systems across North America leave a significant portion of their nonrevenue water unaddressed each year.

To reduce nonrevenue water and advance efficiency efforts, utilities can use enhanced metering, measurement, communications, and analytics software technologies provided by smart utility networks, as detailed in the case study below, "Smart Utility Network Helps Georgia City Reduce Annual Water Loss." In the end, these technologies can help close the gap between the volume of water supplied and the amount billed to customers each month. A smart utility network also provides insights into system operations that help operators and decision makers identify areas that could be further improved.

The City of Dallas, Ga., is a northwestern suburb of Atlanta.

SMART UTILITY NETWORK HELPS GEORGIA CITY REDUCE ANNUAL WATER LOSS

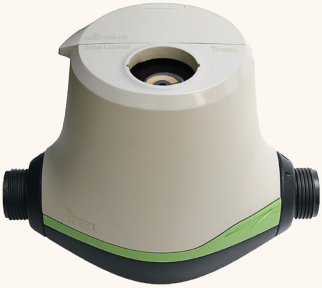
When staff at the City of Dallas, Ga., launched an initiative to get a handle on water loss, they couldn't know how far the journey would take them. Solid results from an initial smart metering upgrade just scratched the surface of what was possible.

"It was clear early on that our water loss control initiative would pay off well into the future, so we jumped at the opportunity to understand what more we could do," said City of Dallas Billing Clerk Amber Whisner.

REDUCING NONREVENUE WATER

Nonrevenue water is an industrywide issue, and state government regulations also started putting more pressure on the city to

Photographs from Rob Hainer, Shutterstock.com (main image), and Sensus, a Xylem brand (page 7).



As part of a robust water loss and control program, the City of Dallas, Ga., replaced its existing water meters with electromagnetic meters supported by an AMI system to help minimize nonrevenue water.

conserve resources.

"Georgia is at the forefront of movements happening across the country to improve sustainability," said Whisner. "Every utility in our state is now required to have a water loss control program and submit yearly audits to show results."

The city decided to expand its metering upgrade program to address water loss by deploying a smart utility network from Sensus, a Xylem brand, as the next step in the journey.

With an aggressive, five-year timeline, the city expanded the rollout of Sensus iPERL residential water meters and added OMNI commercial meters to its arsenal. Backed by the secure, two-way FlexNet communication network for near real-time remote monitoring, the city was able to quickly address leaks on the customer's side and the city's side. Because each district metered area is fully metered, the city can quickly compare the water volume supplied to the volume consumed.

"We could resolve issues within hours that might have taken us 30 days to even identify with our old system," said Whisner. "The network helped us make a major dent in water loss and improved billing accuracy for customers."

The value of the system became more apparent as the city continued the rollout.

"It didn't take long for the entire system to pay itself off in terms of the money we saved from reducing water loss," said Whisner.

REACHING FARTHER

Hungry to see what else was possible, the city's water team began looking for other ways to advance the water loss program. The city launched a pilot program with Sensus ally water meters combined with Sensus Analytics for enhanced pressure monitoring across residential accounts in three targeted zones or district metered areas. The solution allowed staff to help locate issues beyond leaks, such as a broken main or open hydrant. The city also analyzed data to catch background leakage.

"Data analytics helps us identify areas with leaks that we can't visibly see underground due to small cracks or pipe deterioration," said Whisner. "Adjusting the water pressure in those areas can help address any issues and it also protects our infrastructure over the long run."

A UNIVERSAL CHALLENGE

The city's latest challenges are those that many municipalities are dealing with amid the COVID-19 crisis—keep essential services flowing and maintain workforce safety. The city's smart utility network allows remote operations and ways to connect with customers while following social distancing guidelines.

The city remains committed to advancing its water loss control program.

"We're aiming to reduce annual water loss from 47 million gallons lost per year to less than 10 million gallons within the decade," said Whisner. "That's an ambitious goal for a utility, but we have the infrastructure in place to make it happen."

By combining sensors through the smart utility network with advanced analytics technology, utilities can integrate their data to capture metrics around usage patterns, hydraulics, water quality, sustainability, and asset management. Because these data streams can change over time, smart utility networks allow utilities to evolve as new priorities and challenges are identified. Optimization isn't restricted to operations; system intelligence also allows for better planning and support to achieve long-term financial and sustainability goals (Figure 2).

Utility Intelligence Progression

CONTROL
SCADA, Pump Controllers, PLCs, Loop Controllers

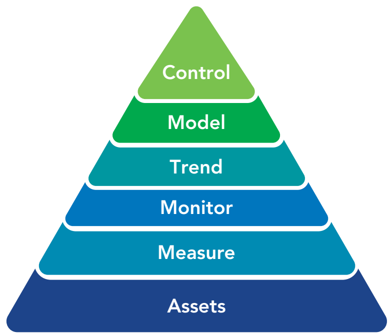
MODEL
Hydraulic Models, BioWin, Canary, Storm Water Scenarios

TREND
Reports, Historical Analysis, Data Aggregation

MONITOR
Reports, UI, Messaging, Alarms

MEASURE
Location, Elevation, Flow, Level, Pressure, Age, Microorganisms, Turbidity, Disinfectants/DBPs, Inorganics, Organics, Radionuclides, Conductivity, pH/ORP, Algae, Temperature, Taste & Odor, Soil Conditions, Friction, Acoustics

ASSETS
Tanks, Reservoirs, Pumps, Pipe, Valves, Hydrants, WTP, WWTP, Flushers, Samplers, Meters, PRV, Vehicles, Security, Tools, Wells, Backflow Preventer, PRV (Pressure Reducing Valve), Chem Feed, IT Hardware, Sensors, Communications



DBP—disinfection byproduct
IT—information technology
ORP—oxidation-reduction potential
PLC—programmable logic controller
PRV—pressure-relief valve
SCADA—supervisory control and data acquisition
UI—user interface
WTP—water treatment plant
WWTP—wastewater treatment plant

Figure 2. With multiple stages, utilities can choose the right level of investment for them and capture return on investment as they progress through the stage.

LEAK DETECTION AND LOCATION IDENTIFICATION

With the right platform and data points in place, detection of slow-developing leaks, water main breaks, or pipe bursts can be localized. Alerts are sent in real-time and can be integrated with a SCADA system for an operator's convenience and faster response. The utility also can prioritize notifications based on severity. Such prioritization can prevent unnecessary after-hour callouts while providing immediate response to large leaks.

PRESSURE MONITORING AND MANAGEMENT

Pressure transients, also called water hammer, can damage water networks and lead to leakage or pipe bursts. Rapid changes in water flow or velocity cause these pressure transients and can shorten a system's material life. When the flow is abruptly stopped or changed, pressure waves form that travel back and forth through the pipe.

Smart utility networks help utilities optimize operations as well as achieve long-term financial and sustainability goals.

Photo from Natee Meepian, Shutterstock.com.

Any situation that quickly changes the flow rate may create pressure transients. This includes common distribution activities such as a valve opening or closing, a pump starting or stopping, or a change in flow direction. Large commercial and industrial water consumers with fluctuating flows can often create and experience pressure transients.

By combining pressure sensing with smart analytics, utilities can identify sections of the network most at risk, as detailed in the case study below, "Park City Uses Smart Device to Extend Monitoring Reach." Such insight can be used to target hotspots for condition assessment instead of spending money in areas where it isn't needed. Most utilities lack monitoring at pressure-reducing and pressure-sustaining valves, high and low points, etc. Having such visibility helps a utility dial in set points and operations with confidence that customers are getting water at desired pressures. When issues are detected, the utility can address them by installing hydraulic dampers or other surge-relief technology.

Park City's tourist population greatly exceeds the number of permanent residents.

PARK CITY USES SMART DEVICE TO EXTEND MONITORING REACH

Beyond being a popular ski destination, thousands of movie fans flock every January to Park City, Utah, to check out the best films that independent cinema has to offer at the Sundance Film Festival. For the city's water utility, providing effective water service for both residents and tourists is a major focus.

WIDESPREAD BENEFITS

Staying at the forefront of technology helps Park City's water services team manage the unique dynamics of bringing water to its ever-fluctuating population. Park City was an early adopter of a smart utility infrastructure, combining smart water meters with real-time remote monitoring capabilities provided by its secure, two-way communications network.

"Our smart utility network has been a great investment for the community," said Park City Water Resources Manager Jason Christensen. "In addition to helping improve efficiency and service for our water customers, it has allowed us to expand the system with new applications."

To extend the benefits of its Sensus advanced metering infrastructure, Park City decided to look deeper into its water distribution data, and Christensen and his team sought an affordable solution that could extend the system to combat water loss and help the city proactively respond to issues with water pressure and flow.

"We've experienced scenarios in which a pipe bursts or a business develops problems

Photographs from Kevin Ruck, Shutterstock.com (main image), and Sensus, a Xylem brand (page 11 image).

Park City uses the battery-powered Sensus Smart Gateway Sensor Interface to connect to a variety of applications in locations where no power or land-based communications are available.

with water pressure," said Christensen. "We want to be able to monitor this type of activity so we can address issues before they reach crisis mode."

REMOTE MONITORING

Park City needed a system solution that could connect to its pressure-relief valve (PRV) sites, located on water distribution mains where no power or land-based communications were available. The city decided to conduct a pilot program with a battery-powered Sensus Smart Gateway Sensor Interface to help staff make critical and prompt decisions for customers by remotely monitoring water pressure and flow. The network-connected device is capable of powering and reading up to two analog sensors and two switch-type inputs.

As an extension of its smart utility network system, Park City installed the smart gateway interface at two PRV sites. Soon after deployment, Christensen's customer service team noticed an issue when the distribution pressure downstream of one of the PRVs spiked.

"The alarm went off and you could see the failure happening in real time," said Christensen. "The issue was resolved without incident, but it was a lesson for us on just how impactful the system could be."

The system increases the city's level of service by helping employees respond quickly to issues.

"At these sites, in order to detect a pressure event, we used to rely on either a customer calling in or a field technician visiting the site," said Christensen. "Now we can detect an issue in close to real time and reduce unnecessary wear and tear on the water system."

Based on its successful pilot, Park City extended PRV monitoring to a total of 26 sites. The city looks forward to using new insights from the data gained, such as expansion to identify nonrevenue water.

"While the added connectivity enhances operational performance, it will also help us get smarter as a utility," said Christensen. "As we monitor more sites, we'll be able to store the data and use it as a resource for ongoing asset management and water loss reduction."

Christensen and his team see their ability to deploy the smart gateway application as a perfect example of their network's key differentiator.

"With the system, we can implement incremental projects quickly that require less capital and help maximize our return on investment," said Christensen. "These incremental projects allow us to continue progressing as a smart utility and extend those benefits to the community."

Such analytics provide a nonintrusive way to monitor pipe condition and stress level through ongoing data analysis. This creates a more proactive and cost-effective approach to water network asset management because critical mains can be monitored for deterioration and high-risk areas can be identified.

NETWORK IMPACT ASSESSMENTS

With smart analytics, a utility can better use network hydraulic models. Hydraulic simulations can show the impact of valve closures, flushing, or pipe isolation. This allows for improved project planning and execution as well as helps to avoid unintended consequences such as pipe bursts and water quality issues. The platform can also monitor valve operations automatically, which is especially critical for establishing a pressure boundary and ensuring district metered areas (DMAs) are secure.

GREATER CUSTOMER VALUE AND INSIGHTS

Smart meters measure consumption data, which can be provided to customers through an online portal to help them understand their water usage and bills. Consumption data are analyzed in conjunction with factors such as weather to show anomalies in water usage that could indicate a leak. Such capabilities allow the utility to alert customers to potential issues and resolve them at a lower cost to the customer as well as conserve water.

IMPROVING ENVIRONMENTAL SUSTAINABILITY

Smart water management reduces waste and protects the environment. By monitoring and quickly repairing leaks and bursts, utilities conserve precious water resources. Better customer engagement further encourages conservation through consumer understanding and action. Improved network monitoring and targeted asset repair and replacement also preserve existing network resources.

Such applications serve as good examples that building utility intelligence is about addressing problems with solutions. The right combination of smart technology paired with enhanced analytics can result in success and sustainability.

ACHIEVING UTILITY INTELLIGENCE

By combining sensors through a smart utility network with advanced analytics technology, utilities can integrate their data to capture metrics around usage patterns, hydraulics, water quality, sustainability, and asset management. Thus, utility intelligence is the result of a holistic approach to the entire water cycle and all of a utility's operational and asset parameters.

The essence of utility intelligence is the reliable, long-term capture of the right data at the right time. Far too often data capture is too little, too much, inaccurate, latent, or not correlated. This results in an inability to act or, even worse, a poor return on investment, with little confidence that the right decision was made leading to inadequate results. By correlating multiple data sources and measurement parameters, utilities can create useful information that can improve the validity of the issue(s) and allow the utility to move forward with confidence.

Equally important are data integration and accessibility capabilities, which allow utility managers to gain more insight into their daily and future needs. For example, technicians have an easier time making decisions if they have one master dashboard with a view of the enterprisewide status on water production, reclaimed water, energy usage, and alarms. Utilities can also incorporate digital heat maps that track water distribution dynamics such as water age, pressure, tank and sewer levels, and inflow and infiltration. These heat maps provide technicians with more transparency for the overall health of their water distribution and wastewater collection systems. Acting as a Doppler radar of sorts, heat maps give a sense of where "storms are brewing" within a system so issues can be addressed proactively.

The influx of data also means utilities can create more advanced modeling and management strategies. For example, emergency response should improve with the capabilities to remotely monitor and manage meters. As technicians gain better clarity on their systems, reactive repairs can change into proactive maintenance, reducing costs dramatically.

A UNIFIED APPROACH

To bring all of this together requires a time-honored engineering approach: measure, monitor, analyze, improve, and lastly maintain control (Figure 3). This approach can be iterated over time to improve any aspect of utility operations.

	MEASURE	MONITOR	ANALYZE	IMPROVE	CONTROL
FUNCTION	Flow, Pressure, Level, Quality, Status	Alarms, Reports	Aggregate, Trends, Model	Work Orders, Policy, Practices	Maintain, Automate
EXAMPLE	30 psig	Low-Pressure Alarm, 123 Elm St., 2:50 p.m., Active	Water Tank Level Low, Burst 2 p.m, Typical Pressure 55-65 psig, Hydraulically Tied to Tank	Repair Burst, Replace Pipe	Repair Burst, Reduce Pressure, SCADA Rules to Pumps
IMPORTANT ASPECTS	Accuracy, Latency	Settings, Noise, Awareness	Data Integrity, Usability, Actions	Logic, Location, Asset Management, Urgency, Cost	Cost, Planning, Related Impacts

Figure 3. The utility intelligence approach is to measure, monitor, analyze, improve, and control.

Control of a process is nearly impossible without measurement. Key improvements can be revealed just by gathering data. Simple data such as the water pressure at a location can point to a pressure-relief valve (PRV) failure or a closed valve. To avoid additional consequences, be mindful of the accuracy of the measurement and latency of the data.

Monitoring helps solve the issue of latency and makes the data usable, particularly with the use of alarms based on operating thresholds. For instance, an operator may not need to watch the pressure on a main line if there are high- and low-pressure alarms that inform the operator an abnormal condition exists.

As previously mentioned, analytics improve data usability and tie in trends related to other events, such as weather. For example, if a sewer overflow happens in the same location anytime it

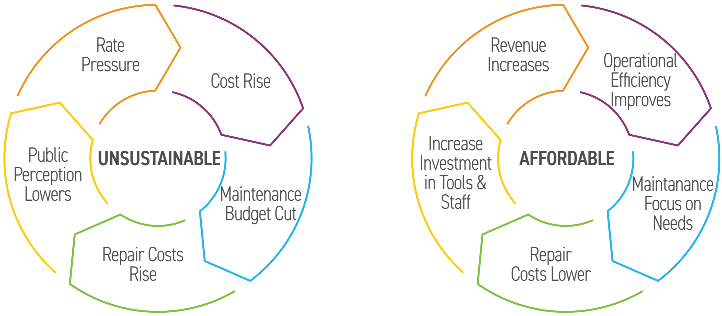


Figure 4. By making prudent changes a utility can break out of a vicious cycle and enter a virtuous cycle.

rains more than three inches in 24 hours, this indicates inflow into the system.

Analytics also help with modeling, long-term planning, and potential operational adjustments based on seasons. Consider the case of Jacksonville, Texas, during February 2020's winter freeze. The storm wreaked havoc on water systems across the state, but Jacksonville took a less severe blow thanks to a recent citywide installation of new smart water meters. Jacksonville avoided catastrophic leaks and no service to their residents by remotely turning off service to meters in areas where pipes were bursting. The AMI system helped the city minimize property damage, prevent water loss, and avoid a complete shutdown like other towns experienced.

Gainesville, Ga., is another city that's always looking for ways to improve. Having a smart utility network in place, the city was able to adapt its system to respond to new situations. When the pandemic hit in early 2020, the system helped the city keep residents and employees safe with remote management capabilities. City staff took social distancing to heart but never compromised on water service for their residents. Ensuring adequate and safe water supply for the future is top of mind for Gainesville, and, with a smart utility network, the city's water team is educating customers about efficient water use for greater sustainability.

Improvements leading to operational efficiency can come from simple measurement, monitoring, trending, or analytics. The key is to make the improvements as early as possible with the ability to capture the most return on investment. Work orders and business practices often need to be integrated to coincide with these improvements. For example, using DMA data to target leak detection efforts would also suggest the repair be evaluated, as potentially a small leak could be deferred to the next year when the distribution line is scheduled to be expanded. Urgency, costs, and asset planning can often hamper the best return on investment.

Once an improvement is made, a new paradigm exists, and the utility needs to ensure the beneficial change is maintained. For example, after studying the pressure in a zone, a utility may be able to identify an area to reduce pressure to save on water loss, but this reduction needs to be controlled and monitored with new alarm settings and operation practices. Sometimes these changes can be automated and controlled effectively, but all cases should be considered to avoid new problems resulting from the improvements.

This approach can help a utility break out of a continuous cycle of maintenance deferments, additional consequences, poor public perception, rate pressures, and budget cuts. By making prudent changes, a utility can begin to be more predictive in nature (Figure 4), whereby changes in maintenance and operations avoid risk, customer service and maintenance budgets improve, staffing development increases, and public perception is enhanced, thereby easing rate pressure and budget constraints.

ADAPTING TO CHANGE

Building the water utility of the future will require a better understanding of the obstacles utilities will face in the years ahead—a never-ending combination of social, environmental, regulatory, and financial challenges coupled with aging infrastructure, information technology (IT) architecture, staffing, policies, and business practices that aren't compatible with current concerns and available technology.

For example, the world's population will continue to grow, shift, and urbanize. As the population changes, the world's water demands will stress local supplies and force the need to sustainably manage the world's water resources.

Climate change is already affecting water access for people around the world, causing more severe droughts and floods. Increasing global temperatures cause water to evaporate in larger amounts, which will lead to higher levels of atmospheric water vapor and more frequent, heavy, and intense rains in the coming years, thereby magnifying stormwater impacts. Rising sea levels will exacerbate saltwater intrusion in coastal areas and will be compounded by population growth.

The need for more agricultural food production, coupled with land development, will strain water resources. According to the U.S. Geological Survey (USGS), three times the amount of public water supply is withdrawn for agriculture irrigation and is likely to rise, thus continuing to challenge aquifer levels. Additionally, nutrient runoff associated with agriculture challenges source water with algae blooms and oxygen-depleted water bodies that further constrain food chain sustainability.

With advances in pharmaceutical medicine and pandemic threats, health also plays a key role in water quality. As populations age and medicine advances, more people ingest pharmaceuticals and pass them into the watershed. These micro constituents present a removal challenge as well as human health hazards, as many people even now receive micro doses of medicines that could be detrimental to their long-term health. As the risk of pandemics rise, the threat of waterborne or transmitted diseases could also significantly affect treatment needs and costs.

The continued rise of industrialization also challenges the water cycle. More complex materials and processes produce the potential for new contaminants with latent effects. Consider the potential impact of per- and polyfluoroalkyl substances (PFAS) on treatment and biosolids processes.

Similarly, with population growth and industrialization, the need for energy continues to rise. According to USGS, thermoelectric power withdraws the most water in the United States, with almost four times the public supply. Additionally, the cost of energy plays a key role in the cost of water treatment and transport.

The amount of infrastructure and the associated value of the infrastructure within water utilities is enormous. Because the infrastructure is mostly out of sight, updates and replacements are often deferred or minimalized, pushing the boundaries of the infrastructure's useful lifespan. This is intensifying failures, causing additional collateral physical damage, expenses, and water quality risks. Items such as lead service lines and increasing water main bursts are just two examples of the stress and costs.

Social and environmental challenges aren't the end of the problems. Regulatory changes can also redirect investments. Items such as PFAS, lead, and copper service lines can redirect budgets to achieve compliance, as the solutions are often capital intensive.

Additionally, the increasing desire for citizen access to data and smart city needs are creating data and workflow challenges. Utilities are being forced to increase their customer service models that depend on more data, integration, security, and access.

Financial pressures further constrain utilities. Rate pressures, rising costs, and budget cuts present a vicious cycle of maintenance and upgrade deferments, increasing the frequency and consequences of failures, lowering public perception, and creating a difficult situation to create financial sustainability.

Internal challenges such as policies, business practices, staffing, and IT present additional barriers. Often policies and business practices aren't adjusted with the adoption of technology, thus choking the return on investment. As the complexity of the solutions rise, the skillsets of the staff need to include more data science, analytics, and IT skills. The IT architecture is too often siloed and prevents data from interfacing beyond the native system, creating duplicity and confusion with the analytics. With these silos comes a labyrinth of firewalls, application programming interfaces, file transfer protocols, user access, and cloud services that require additional maintenance.

Unfortunately, additional problems with data can arise. Often the volume of the data is too large or too small to address an issue. Problems with the veracity of data and overuse or false positives of alarms can render their value negligible. Such challenges can be daunting, but with the right approach, the vicious cycle can be broken and turned into a virtuous and sustainable cycle.

LOOKING TO THE FUTURE

To help meet future challenges, water utilities need to understand the process for transitioning to a smart utility framework, and many utility managers wonder where to start. In the hierarchy of utility intelligence, resources at the monitoring level—meters, communications structure to provide hourly data, and hardware/interfaces to view and aggregate data—serve as the best starting point for upgrades that yield an immediate impact in efficiency and cost savings.

As detailed in the aforementioned case studies and examples, utilities can benefit from taking a step-by-step approach to improve their networks. Utilities that have upgraded and secured their assets can explore monitoring and measurement solutions to gain more insight into and control over their systems.

The ability to marry operational data with utility management functions is key for utilities to get the best value from their smart utility ecosystem. Business planning and objectives, policy, asset management, and human resources can all be affected by the stories that integrated data create as well as provide guidance on what tactics are feasible.

The advancement of smart utility networks and infrastructure means objectives in areas such as water loss prevention and customer service don't have to be analyzed individually. Utilities can merge these strategies with new data capabilities and better models to make their systems more efficient, sustainable, and secure. By integrating the right mix of smart water technologies and applications, utilities can build a more flexible foundation to better serve their customers and communities now and into the future.

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