Aclara

White Paper

Analytics for Water Utilities: The Key to Maximizing AMI Value

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Executive Summary

Among the many challenges water utilities face are aging infrastructure, an aging workforce, water loss control, asset management, and paying for necessary infrastructure investments. Improving relationships with customers is also a challenge for one in five respondents to a 2019 American Water Works Association (AWWA) survey.

All the matters noted above can be tackled more efficiently and effectively using analytics, the computational analysis of raw data to discern useful patterns, and actionable information. Using analytics, water utilities can enhance leak detection efforts, prioritize maintenance and pipe replacements, optimize operations, and serve customers more effectively. This paper examines the challenges water utilities face today and how analytics that leverage data from advanced metering infrastructure (AMI) can be used to address the industry's most pressing problems.

Analytics 101 – A brief definition

Analytics is a computational approach to interpreting data gathered to uncover meaningful patterns that can support decision making, automation, and business processes.

There are four commonly recognized types of analytics:

- **Descriptive analytics,** which summarize existing data to show what has already occurred or trends currently underway
- **Diagnostic analytics,** which is a computational analysis that focuses on why something has happened
- **Predictive analytics,** which leverage statistical models to forecast what might happen and probabilities with which events might occur
- **Prescriptive analytics,** which focus on actionable insights and finding the best course of action to take based on available data

What data and devices feed into an analytics engine? For water utilities, those information resources include meters from AMI systems, data loggers from acoustic analysis solutions, and additional sensors.

Here are some of the critical types of sensor data that will likely be valuable for water utilities to deploy throughout their systems and use with analytics in the future:

Pressure: The higher pressure is, the more water flows out of pinhole-sized openings. High pressure also stresses pipes, which increases the risk of pipe splits. When utilities know the pressure throughout the distribution system, they can lower it and keep the pressure within allowable limits. One utility on the Eastern Seaboard hopes someday to have so many pressure sensors deployed; they can create a pressure "topology map" of the system similar to those that show mountain elevations and use this pressure map for system balancing. Eventually, pressure sensors and analytics may help utilities deploy automation for valve and pump controls to raise and lower pressure remotely.

Turbidity: Cleveland Water has a great definition of turbidity on its website: "Turbidity is a measure of the degree to which water loses its transparency due to the presence of suspended particulates such as clay, silt, and other organic or inorganic material. The more total suspended solids in the water, the cloudier or murkier it seems, and the higher the turbidity will measure." The microscopic particles that create turbidity can promote microorganism growth that may contain pathogens and inhibit disinfection. Sensors can measure turbidity, allowing utilities to improve water quality.

Water quality: According to the EPA, online water quality instruments for real-time measurement of water quality at one or more locations in a distribution system allow water utilities to more efficiently manage distribution system operations by detecting changes in water quality as they occur, facilitating a timely and effective response. These systems can be stand-alone or part of a water-quality surveillance and response system that is designed to detect changes in water quality from source to tap.

Acoustics: For more than a decade, water utilities have been finding leaks before they become pipe bursts through acoustic analysis. Through this technology, data loggers listen for the sound of water escaping from a hole or crack in underground pipes and propagates along the pipe wall. The acoustics differ differs by pipe composition, and sophisticated algorithms can help utilities identify the location of the leak.

In addition to the sensor data noted above, other data sets can feed into analytics, too. Soil type, for instance, can have an impact on pipe integrity, and analytics that take this characteristic into account can estimate the likely lifetime of a pipe and predict when a pipe might break. Pipes that are surrounded by rocks will generally have a longer lifespan than a pipe that sits in wet, hard clay where water does not drain away from the pipe itself.

Weather impacts aging, too. Pipes in a wet, rainy area may fail more quickly than those in a dry area with little rainfall because the erosion of dirt undermines the support of the pipe. Pipes that are subject to areas with freeze-thaw issues in the soil also may age more quickly than those in a more temperate climate.

Finally, age and composition impact pipe integrity. All these data points can be layered into an analytics solution to help utilities make more effective operational decisions with regard to asset management and development of pipe maintenance and replacement programs.

How analytics expands AMI benefits

One of the biggest jobs water utilities perform – and reason number one for investing in AMI – is billing customers accurately. AMI does that easily, and the fact that data often is collected each hour and sent to the utility daily or more frequently means that AMI can do much more as well.

Addressing non-revenue water losses

Among the issues that analytics can help utilities address are non-revenue water (NRW) losses.

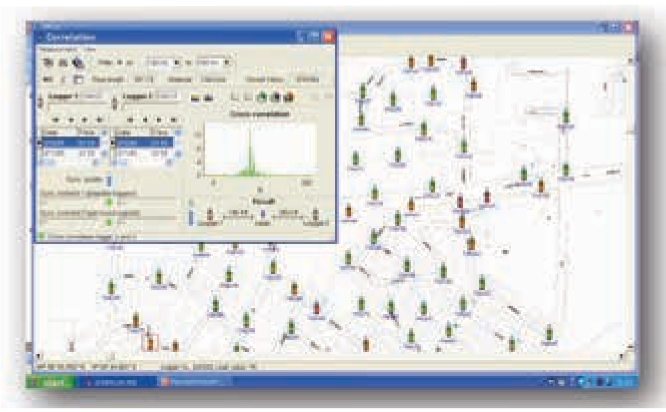
NRW is made up of three components, with the first two being “apparent” and “real” losses. Real water losses result from leaks in utility-owned water lines. Apparent losses stem from inaccurate metering, billing errors, and theft of service or other consumption without the utility’s authorization. The third category of NRW loss comes from authorized but unbilled consumption, such as that which occurs when firefighters tap a hydrant.

Each year, the American Water Works Association surveys water-utility professionals and produces a sizeable report. The most recent report, titled, “The 2019 State of the Water Industry.” If you looked to see what issue most worries survey participants, you’d find 63% named “renewal and replacement of aging water infrastructure” topped the list followed by “financing for capital improvement,” a concern cited by 55% of survey respondents. Those two worries have topped the list annually for the past five years, and here is why: Aging infrastructure is a major contributor to real NRW losses

Researchers from Utah State University surveyed hundreds of water utilities in North America in 2012 and 2018. The 308 participants in the 2018 survey managed a total of 197,866 miles of pipe and reported main break data on 170,569 miles of that pipe. As the researchers note, these survey participants’ data represents 12% of U.S. and Canadian water mains and served 14% of the two nations’ populations.

Here is what the researchers found:

- 28% of pipe material was cast iron, and another 28% was ductile iron.
- 82% of the cast iron pipe is older than 50 years, and break rates of that pipe increased 43% between 2012 and 2013.
- 13% of the pipe reported is made of asbestos cement, and 27% of pipes made from this material also is 50+ years of age.
- For asbestos cement pipes, break rates increased to 46% between 2012 and 2016.
- Overall pipe breaks rose 27% in the six years between the two studies. The number of installed pipes that were beyond their useful life rose to 16%, up from 8% in 2012.



Acoustic data from loggers placed on valves or hydrants along the water main is correlated, allowing identification of potential leak locations.

Currently, the U.S. Environmental Protection Agency estimates NRW to average 16% nationwide. It is not uncommon to find a utility with NRS in the 20% range. According to EPA, 75% of those NRW losses are recoverable. Analytics can help.

Finding leaks with acoustic analysis

Acoustic data loggers detect the vibration of water when leaks create turbulence in the pipe. An article in WaterWorld magazine explains it this way: “Water escaping under high pressure from a pipe leak or crack makes a distinct rushing or hissing sound that can carry considerable distance along the length of the pipe itself (in contrast, the loose soil surrounding the pipe in its backfilled trench makes a poor conductor of sound). In this sense, the pipe acts as a medium for transmitting sound. In doing so, it can act like the strings on a guitar, vibrating with different pitches for different pipe lengths, diameters, and materials.” Analytics correlate the sound, pipe material, and location of the data loggers to provide visual identification of high probability leak locations and push alerts to utility staff.

Optimizing system operations

Accurate and timely pressure data can also help utilities optimize the operation of the entire system because the data allows them to lower pressure overall without violating minimum pressure thresholds. This will decrease the energy required to pump water, minimize leaks, and reduce wear and tear on distribution infrastructure. Pressure sensors can indicate the presence of leaks, as well. If flow rates drop significantly between the front end of the pipe and its terminus, the change could indicate a leak exists between these two points.

Maintaining water quality

A study conducted by scholars at the University of Sheffield in Yorkshire, England, found that groundwater can be sucked back into leaky pipes under certain pressurization conditions. When this happens, contaminants enter the pipes and travel through the network. Turbidity sensors might help identify such issues. Pressure sensors and analytics can help mitigate the danger. Speaking to a science-oriented news site – PhysOrg – lead researcher Joby Boxall recommended water utilities focus on preventing the pressure changes that enable contaminants to enter the system.

Prioritizing maintenance

Pipe age, soil types that pipes reside in, pressure in the pipe, and weather patterns all impact pipe integrity. Analytics allow utilities to model all these factors together to prioritize proactive maintenance and pipe-replacement efforts. That, in turn, helps prevent pipe bursts and costly emergency repairs.

Serving customers proactively

Along with benefits to utility operations, analytics deliver alerts that utilities can use to help customers find unknown leaks, reduce water bills, and conserve water effectively. Among the alerts that utilities can get from AMI are:

Continuous consumption

Water keeps running non-stop, even when a business is probably closed, or the people in a household are likely asleep. That indicates a possible leak, and letting the customer know about that leak proactively can score a hefty dose of goodwill for the utility. The right analytics can even allow the utility to guess at the source of the leak, determining whether it is from a toilet with a bad flapper valve or an irrigation system with a leak that could turn the back yard into a swamp.

Abnormal consumption

Sometimes consumption veers so dramatically away from day-to-day usage at a customer's premises that it points to some issue. That issue could be a hose that was accidentally left running all night, there may be a leak inside the house, or a neighbor might be filling a swimming pool from the neighbor's tap. Abnormal consumption analytics can help customers experiencing these problems discover why that water bill was so high.

Negative consumption

Negative consumption might indicate a meter was installed incorrectly, or it could indicate theft. Backflow is what prompts a negative consumption alert. Under certain conditions of pressurization in the network, the water can flow backwards, making it look as though the utility owes the customer money. The meter is registering consumption, but not in the right way

Zero consumption

When there is absolutely no consumption, it could indicate a residential customer is out of town or away. However, it could indicate meter malfunction or theft, especially if zero-consumption is registered on a commercial account.

Low consumption

With age, meters tend to under-register consumption. If it happens at a residential customers premises, it may not be cost-effective to send a truck out and replace the one meter. Commercial and industrial accounts are another matter. There, an under-registration could mean costly losses for the utility, so having this alert could be valuable, particularly if the analytics also signal the account size or type to help utility managers prioritize repairs or replacement of the meter.

High consumption

This is another analytic flag that may indicated a leak within the customer's premises. Unlike a leaky toilet, it could be a leak that only comes on sporadically, such as an irrigation leak that pumps too much water into the yard when the associated valve is open for the irrigation cycle but doesn't leak at other times. Again, detecting this type of leak and letting the customer know about it proactively can save water and raise customer satisfaction.

The future of water utility analytics

Right now, most water utility analytics are mostly descriptive. They confirm to the utility that a water leak or some other event has happened, or provide an indication that some other condition exists, such as a non-working meter. However, the analytics used by utilities eventually will become more precise and predictive. For example, a negative consumption alert today simply tells the water utility something is wrong. In the future, analytics may be able to specify what the issue probably is, such as theft versus an incorrectly installed meter.

Predicting pipe bursts is another example of a predictive analytic under development. Pipe bursts often result when something unusual happens in the system – like a giant surge running through a weakened pipe. Research is underway on predicting bursts using analytics to understand which pipes are most susceptible to specific events such as valve operations that could create a surge in the first place.

Analytics also will become more prescriptive. For instance, a residential meter that triggers a low consumption alert might not be worth replacing because the analytics might tell you it would take 18 years to deliver payback on a truck roll and a new meter. But if it is a large industrial account that is underreporting, that new meter may only take a few months to earn a return on investment. Analytics will be able to determine the probability that a meter is under-reporting and the payback of fixing or replacing it.

Finally, when combined with virtual twin technology, analytics can be very powerfully.

Digital twins are computer models. For a water utility, that model will digitally replicate all the processes, pipes, physical assets, pumps, and other devices within a water system. They are like a circuit simulator that electrical engineers might use to design a circuit without putting a physical model together. Such a model simulates all the components mathematically, allowing a circuit designer to design something and test it virtually.

The City of San Diego, for example, is using a digital twin of the advanced water purification facility to improve commissioning and long-term operations as an operator training platform as part of its Pure Water San Diego program, which will supply one-third of the city's water by 2035.

A digital twin enables computer-aided decision making. For instance, one water utility facing a broken trunk line used the organization's digital twin to figure out which valves to turn to do repairs with minimal customer impact. The digital model could also help pinpoint things like how far down a burst line boil alerts should be sent, or which parts of the system should be replaced first to get the greatest benefit for money spent.

While AMI and the analytics it enables are not digital twins, they do feed these models. AMI and sensors that send data back over the AMI network give the digital twin an accurate snapshot of how much water flowed and the state of pressure in the pipes.

What to look for in an analytics solution

Customizable dashboards and alerts

Dashboards bring all a user's critical information into one handy screen, making that information easy to see and understand. Because each utility has its own priorities, you should look for a dashboard that can be customized and send alerts. With a good dashboard, you can monitor system performance in near real-time. Another handy customization would be looking for dashboard functionality that allows different groups to see different dashboards when they login.

An extensible platform

In computing, the term extensible means the system was designed to accommodate the addition of new capabilities and functionality. That is what water utility managers should look for in an analytics package because analytics for water providers are still in its early days. For example, Aclara currently offers integration of pressure sensors to its AMI system, but looking to add other types of sensors as well. Also, the Aclara AMI software platform, AclaraONE® (One Network for Everyone), is designed so that non-Aclara data from sensors can be brought into the platform's analytics. This enables customers to factor in even more data when they evaluate operations and infrastructure investments.

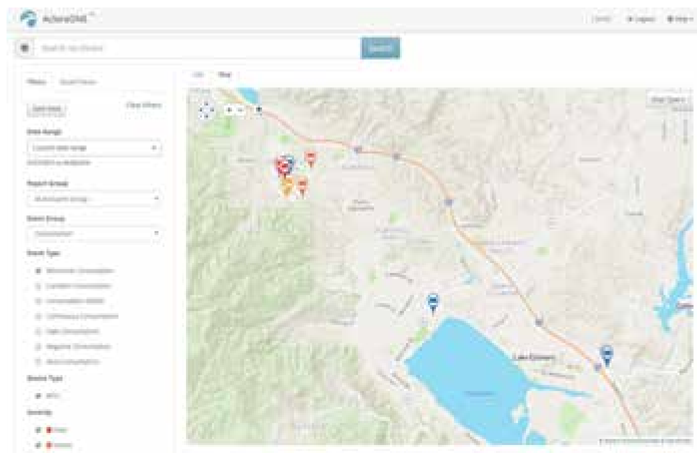
Cloud hosting

The core business logic of AclaraONE is deployed using cloud services that eliminate the need to manage server infrastructure and build, deploy, and manage applications. This enables dynamic scaling to match the surges and swells of end-users to the website. A cloud-hosted solution like AclaraONE, which is hosted within the Microsoft Azure® cloud, offers several advantages. Among them are:

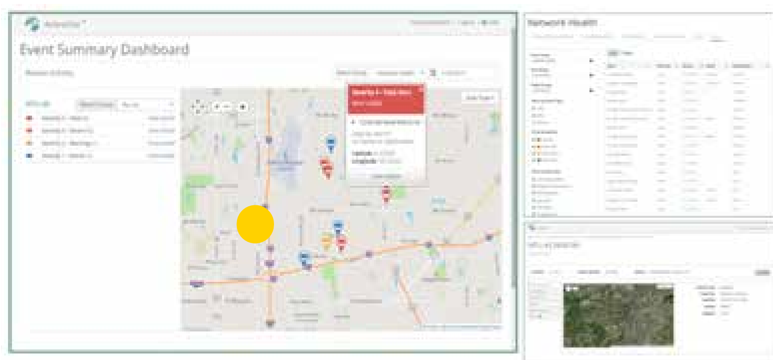
- **Reduced infrastructure costs**
  Utilities do not need to purchase additional hardware, servers, or storage because everything resides in the could.

- **Pain-free upgrades**
  Because hosted solutions enable users to gain access to new features and functionality without the headaches and potential downtime of major upgrade activity, there is no need to worry about upgrades. Any time an update occurs, it is immediately available with no upgrade effort required. At Aclara, enhancements are released as often as every three weeks, and major upgrades are performed quarterly.

- **Enhanced disaster recovery**
  Cloud hosting offers a cost-effective way to have multiple data repositories in geographically dispersed locations. That means if one becomes unavailable, the utility's data are still safe and accessible in the other. Automatic backups can ensure both sets of data remain up to date. All of this happens without taxing the IT staff.



Analysis of meter data can determine locations where abnormal consumption is occurring.



Analytics can provide utilities with insights into how well meter-reading networks are operating, allowing them to identify failed components.

- **Scalability**
  Because there is no need to purchase newhardware to manage the data, the solution is quick and easy to scale up or down as your uses and user numbers grow. Everyone who needs the data can have the necessary access and functionality.

- **Flexibility**
  Some utilities prefer a mixed solution, where specific software, such as the head-end system, is located on-premises, and data resides in the cloud. If that fits your organization, the vendor chosen should be flexible enough to support this option.

- **Cost-effectiveness**
  Some people worry that hosted solutions will be more costly, but this is not the case. Since the software runs in the cloud, the utility no longer needs to keep its own data center up and running. This means that there is no need for physical servers, information technology staff to support them. In the end, fully hosted solutions have comparable costs to on-premises solutions, but they come with the above-mentioned advantages of scalability, easy upgrades, and rapid, reliable disaster recovery.

Conclusion

Analytics are not widely used in water utilities today, but that is changing, and now is a good time for it.

According to AWWA, water utilities will be hard hit by Covid-19, which will likely cost water providers nearly $14 billion and have a 17% impact on the drinking water sector. "These impacts are a result of drinking water utilities eliminating shut-offs for non-payment, anticipated increased delinquencies as a result of high unemployment rates, reductions in non-residential water demands and associated revenues offset by increases in residential consumption, and lower customer growth," noted AWWA researchers.

Now, more than ever, water utilities need to solidify customer relationships. Sending customers helpful and proactive leak alerts will help.

Water utilities need to stem NRW and get paid for as many gallons of treated water as possible. Acoustic analysis, pressure monitoring, and analytics can help there, too. With them, water providers can find potential leaks before pipe bursts close streets and chalk up costly overtime hours for maintenance crews.

And, now, water utilities must run their systems as efficiently as possible, prioritizing maintenance based on data rather than on arbitrary timelines. Here, again, analytics delivers insight and savings.

Automated meter reading was all about saving money on the meter-to-cash process. AMI is about operating utilities with data-driven analytics that optimize system operations and deliver enhanced customer service.

About Aclara

Aclara, a division of Hubbell Utility Solutions, is a world-class supplier of smart infrastructure solutions (SIS) and services to more than 1000 water, gas, and electric utilities globally. Aclara SIS offerings include smart meters and other field devices, advanced metering infrastructure and software and services that enable utilities to predict and respond to conditions, leverage their distribution networks effectively, and engage with their customers. Aclara won a Frost & Sullivan Global Smart Energy Networks Enabling Technology Leadership Award in 2017 and was named a finalist in three categories of the Platts Global Energy Awards in 2016. Visit us at Aclara.com, follow us on Twitter @AclaraSolutions or subscribe to our blog.

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