Smart Water and Wastewater Plants: How a Digitized Workforce Drives Higher OpEx Reductions

by Hermann Wartinger

Executive summary

Key processes within Water & Wastewater operations can now be digitized. This is good news, especially for an industry under pressure to both lower OpEx and manage an aging workforce. Trends such as the Industrial Internet of Things (IIoT), cloud computing and "edge" control are emerging as technology engines that present cost-effective options for modernizing operations. When it comes to OpEx reduction, however, technology is what enables plant workers to make the biggest savings impact. It's estimated that digitization of core Water & Wastewater plant operational processes can generate 20-40% in cost savings. This paper provides guidance on how the workforce can be empowered in this new digitized world to drive new levels of operational efficiency.

Introduction

A unique turning point has been reached in the history of industrial automation. Up until recently, reduction of OpEx through automation has been a top priority. One of the results of this OpEx reduction push has been the elimination of menial human jobs. But now, the story is changing. The question has become "How can we harness the power of the Industrial Internet of Things (IIoT) and the people working in plants, in order to create additional value, and achieve even higher OpEx efficiency through digitization?"

Water and wastewater plants depend heavily on a pool of experienced workers to ensure that operations are run efficiently, safely and securely; generating high quality output in a manner that adheres to regulations. However, controlling operating expense (OpEx) within water and wastewater environments presents a unique set of challenges.

It is estimated today that, in some countries, 45% of existing water and wastewater distribution and water treatment infrastructures are near the end of their useful life. As the physical assets age, the cost of maintenance rises exponentially, and instances of downtime increase in frequency. Maintenance is often performed in a reactive mode; only once equipment breaks down. During such instances, stress levels are high, productivity is lost and costs accelerate.

Aging facilities is not the only problem. A full 38% of utility employees will be eligible to retire within the next decade. The expertise they have nurtured over the years will be lost unless mechanisms are put into place that capture their knowledge and share it with the incoming generation of millennials.

Figure 1

Digital transformation will play a major role in reshaping water and wastewater workforce capabilities

Bringing in a new, younger workforce also presents a barrier. For many young people graduating from colleges and universities, the water and wastewater industry does not immediately come to mind as a possible career choice where one can exploit the latest in modern technology. Interactive mobile workforce tools are scarce and application interfaces are not deemed as user friendly.

The combination of an aging workforce and aging infrastructure, along with current cost control measures, mean that these issues need to be addressed quickly. Workers should be supported with tools that enable them to make better operational decisions. Fortunately, new technology trends, such as IIoT and artificial intelligence (AI) present themselves as opportunities for the industry to reinvent itself. Proper implementation of digitized solutions can both address operational costs while addressing some key workforce evolution issues.

These technologies will both enhance knowledge retention and provide more flexibility when managing a changing workforce – another crucial part of the modernization puzzle which requires careful consideration. Digital technologies will be key for attracting and training new workers now and into the future. Such tools also enhance the ability of the plant to capture the knowledge of the more experienced workers so that it can be shared with the new generation of incoming workers.

Workforce considerations
How can these fundamental workforce considerations be put into practice and how will the deployment of new digitization technologies expand to quickly improve workforce capabilities? Such questions are particularly relevant considering that, as city infrastructures and water/wastewater facilities age, very few municipalities have the funds to engineer wholesale infrastructure improvements. Fortunately, many of these new technologies are designed to operate within open architectures, which allows for easy "snap on" upgrades to existing infrastructures. This avoids the need to "rip and replace" in order to achieve modernization and the corresponding operational benefits.

In order for plants to execute their digital transformation plans, three phases of workforce empowerment need to be considered: a connected workforce, proper decision support, and global collaboration. Each phase represents a higher level of digitization maturity. Therefore, depending on where a plant finds itself in the digitalization journey, each stage will act as a guide for the solutions best suited to achieving the desired OpEx goals.

Connected workforce

Gather data from the field and make it available for everyone

The first stage of empowering the workforce is the "Connected Workforce" concept. Under such a scenario, data is generated to represent one single version of the truth and that data is linked and shared with all workers or stakeholders. This phase involves the generation of digital recordings and mappings of core operational processes to ensure everyone is accessing information based on the same data, whether it be a water and wastewater plant or network. The process addresses not only the control room, but the design and engineering stage, field staff, and maintenance teams. When a workforce is truly connected, even the CEO will be accessing exactly the same data as everyone else. The only difference is in the way that data is presented to each stakeholder (this is where Decision Support comes in later).

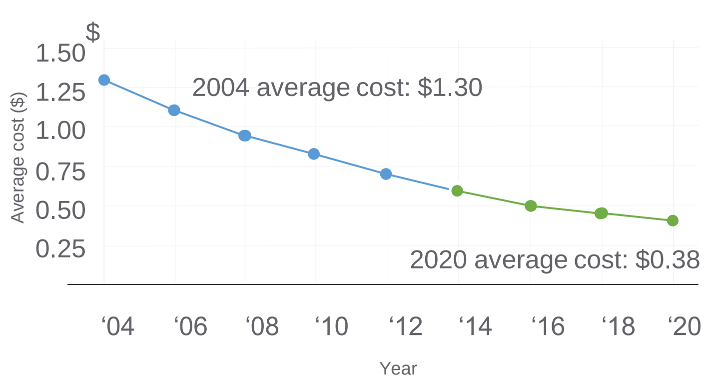

Figure 2

The average cost of IoT sensors is falling (Courtesy of Goldman Sachs, BU Intelligence Estimates

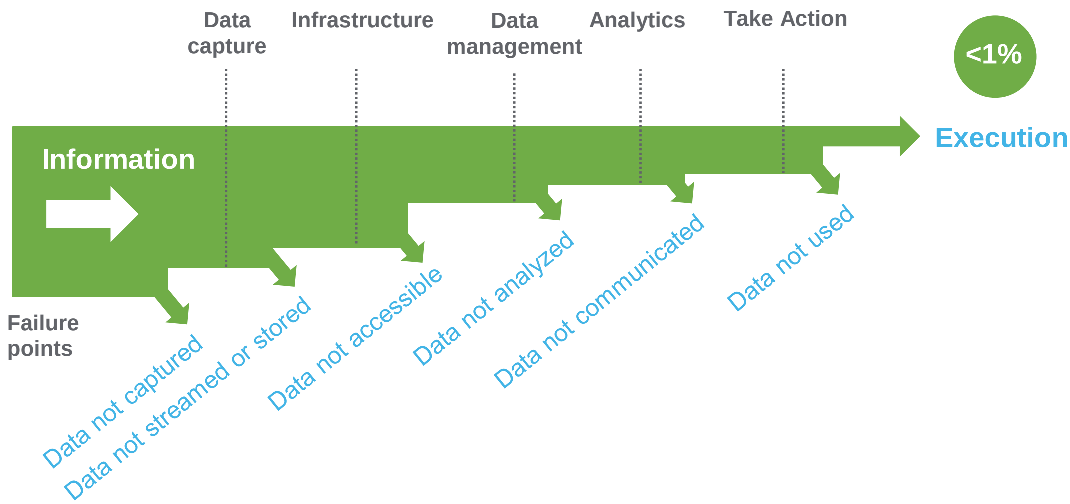

Figure 3

Companies across the industry still use only a fraction of the data available to them (Courtesy of McKinsey & Co.)

IIoT is key to enabling this new level of connectivity. It has never been easier or more affordable to close existing data gaps with the help of IoT sensors. While the average sensor cost in 2004 was $1.30, today this cost is less than $0.40. At the same time, studies show that today less than 1% of the data available in the field is used for decision making. Therefore, without the crucial step of generating a single version of the truth and then connecting it to all of the stakeholders, the data collected by equipment sensors cannot be put to good use.

Integrated Automation System

A solution that can help achieve this first step of connecting the workforce is an Integrated Automation System. This is a traditional automation system combined with powerful databases that seamlessly connect the field level with the control and IT levels. Open, Ethernet-based architectures are desirable, as supplier-independent systems can be easily implemented and - thanks to the use of open communication standards - no manufacturer dependencies arise.

Global Collaboration: Linking distributed infrastructures

Another important aspect of many water and waste water networks is the management of distributed infrastructures in the field. As mentioned above, "Global Collaboration" is one of the three stages of workforce empowerment. Usually this is represented as the third stage of maturity in cases where plants have already achieved the levels of a connected workforce and decision support.

Global collaboration implies that plants in different regions or countries can then be connected together in order to share best practice information and standards within the company. Water and wastewater networks are unique in that connecting the workforce often requires several physical locations/facilities to be connected together. Therefore, an extra layer of connectivity, even at the first stage of a connected workforce, makes water and waste water facilities unique when compared to other industries.

SCADA and Telemetry

With thousands of outstations, the right system is needed in order to manage up to 1 million distributed data points and map the entire network. Workforce mobility is another important aspect of connecting the workforce. In water and wastewater environments, connecting maintenance service technicians in the field to the control room main interface, and then to the operators, sometimes hundreds of kilometers away, is invaluable for saving time and money.

Through the use of fully integrated SCADA and Telemetry systems, remote sites with limited internet signal can be connected reliably. An example of this is England's Anglian Water company, which covers a geographical radius of 10,000 miles, and consists of 12,000 remote stations that need to be connected and 630,000 telemetry data points. The company has also collected 25 years of data since the time an old system was installed in the 1970s. In order to successfully complete their modernization project, they needed to migrate this data as well as integrate it with existing systems, while still maintaining operations. As a result of this exercise, they have achieved a leakage rate at 4,97 m/3km/day, one of the lowest levels in the entire UK.

Workforce mobility technologies that utilize mobile Human Machine Interface (HMI) technologies such as smartphones, tablets, portable wireless devices and wearables are also expanding capabilities and are improving the operator experience. Australia's Yarra Valley Water company saved 80% in external support costs, and reduced faults by 66% thanks in large part to their SCADA system and mobile data access.

Cybersecurity vigilance

Given the rising influence of digitization, the water and wastewater industry finds itself in a position of having to reassess the levels of cybersecurity risk that it can tolerate. The influx of connected devices, if not properly managed from a cybersecurity perspective, could introduce a new level of threats.

The good news is that the vast majority of installed critical control and safety systems have always come with inherent protection because, in essence, these are the systems that run the facility. There has always been a high degree of attention paid to how these particular critical systems get accessed, who gets access to them, and how that process in managed.

Although most of the new connected devices being installed are not part the critical infrastructure of the facility or plant, the mere fact that the volume of connection points is increasing means that the cybersecurity threat is rising. Therefore, many water and wastewater plant executives are facing a dilemma: either risk losing competitive advantage by failing to "go digital", or invest more in better managing the growing level of cybersecurity risk.

Proceeding to the next phase

Once the first step of workforce empowerment has been achieved - the creation of the single version of the truth, including the secure connection of all stakeholders - has been realized, it is now a matter of providing the persons involved in the process with the right information for decision-making. It is therefore a matter of contextualizing the data to make the right information available to the respective user at the right time.

Decision support

Make the single version of the truth available to all stakeholders in a meaningful format

Once company employees are able to connect to the same data, that data then needs to be translated into information that is relevant for each person's job. It needs to be contextualized according to the needs of that stakeholder. For example, the CEO will need information that is different from the maintenance staff, as he or she uses a different set of apps and analytics than does a control room operator.

By implementing new technologies and standards that better supports workers, the workers themselves achieve a new level of empowerment, simplifying the daily routines of all stake holders concerned and enabling them to achieve higher efficiency. This will have a big impact on reducing OpEx in water and wastewater facilities

This is highly relevant for operators in front of their supervision monitors. Water plants and networks are getting larger and more complex and there is an increased level of information. At the same time, utilities need to manage an increased level of operator turnover and staffing reduction. Old-fashioned screen designs and an uncontrolled use of colors result in an overload of information and operators get lost in the detail, which leads to human errors. With human error contributing to more than 50%[1] of abnormal situations, incidences of process downtime and service interventions are still high.

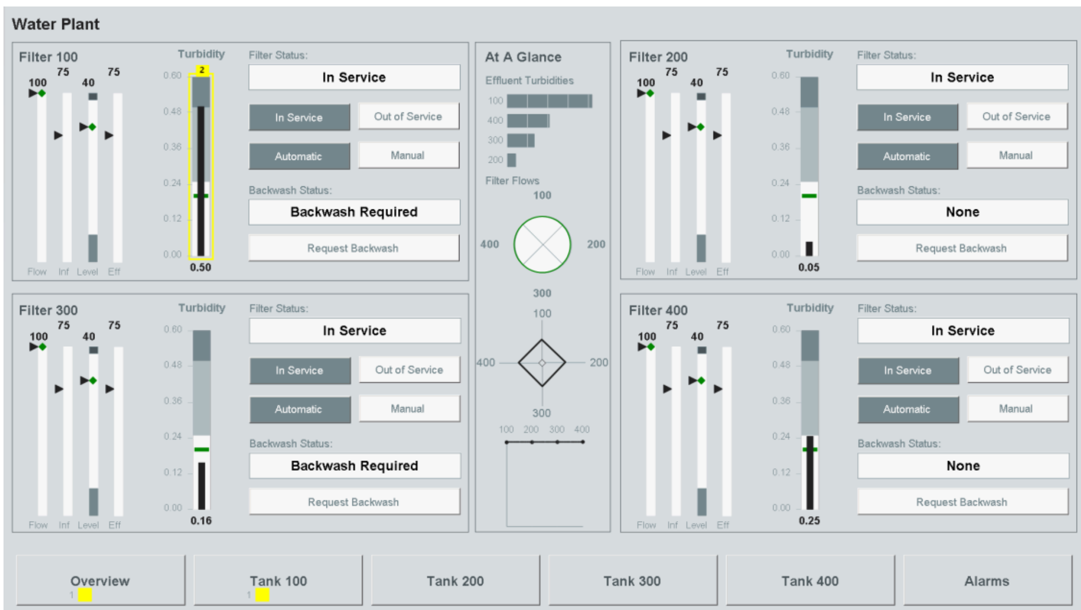

Figure 4

“Level 1” situational awareness screen of a water treatment plant

To help assist with this, new standardized Situational Awareness solutions have been developed with screens that feature standard symbols, colors and shapes, all of which are integrated via software libraries. Operators with supervisory responsibilities can quickly and easily identify issues on their monitors and then interpret how core systems are behaving, so when issues occur, they are addressed immediately, and downtime is either avoided or even eliminated (According to the ARC Advisory Group, the average impact of unplanned downtime in the process industries alone is $20 billion, or almost 5 percent of the annual production, making minimizing unplanned downtime attributable to automation one of the best ways for industrial organizations to improve their return on assets)[2] . Even an unskilled operator is able to use them, which not only helps reduce OpEx the short term, but also addresses the long terms implications of a changing workforce by reducing training time and opera-

[1] Abnormal Situation Management Consortium, “Managing Human Reliability”, 2015

[2] ARC Advisory Group, “Reducing Unplanned Downtime and Helping Future-proof Automation System Assets”, August 2016

tor errors made by new staff. Situational awareness tools can also quickly be integrated into process screens so that plant operational efficiency can be improved as soon as possible.

State of the art DCS systems can virtually navigate users (operators, maintenance and service staff) with one mouse-click to the root-cause of abnormal situations, provide access to manuals or handbooks or instruction sheets, provide an overview about all process-relevant sensors and actuators and can immediately open the application source-code of the concerned controller device. Such run-time navigation services lead to a reduction of intervention times of up to 50%.

Simulation technology

For water distribution networks, which can have hundreds or thousands of kilometers of pipelines, it is impossible use sensors to gather the data needed to generate insights. Up until recently this has meant that while 70% of the original investment is spent on the pipeline network (pipes, motors, valves),[3] there has been hardly any automation available to enable the operators to monitor and optimize it. This means that operators have had little visibility to what is happening in their pipelines in terms of water pressure, water velocity, water quality, and other parameters.

New advanced simulation technology now makes it possible to generate a digital twin of water distribution networks in real-time. Today's remote SCADA applications can then integrate this information on the operator's screen. Operators can now have real-time information regarding every meter of the pipeline, which allows efficient pressure control of the network. This can result in up to 20% energy savings in pumping and reducing the stress on pipelines.[4] What is significant about this advancement in simulation technology is that, not only does the digital twin allow understanding of the current behavior of the network, but it also enables accurate prediction of the network's future behavior. Maintenance activities can be planned in advance by predicting the ideal intervention time.

Another advancement which is relevant for water distribution networks management is monitoring of the entire network, including remote stations from the control room. Using Geographical Information System (GIS) data in combination with advanced graphical capabilities of remote SCADA systems and integration of cloud-apps, it is possible to generate an overview of the entire network displayed on standard maps (e.g. Google maps). It also shares information such as the position of workers and allows the overlay of other maps such as weather forecast maps. If a problem occurs in a remote station, it can be pinpointed geographically, and data is shared regarding how the network will be affected. From the control room it is now possible to visualize the actual position of service and maintenance technicians or other outside elements that may be impacting the situation, such as weather. This type of technology is the perfect example of how workers can be supported with intuitive, familiar, and standardized tools. This generates a positive impact on OpEx both immediately and in the future, as onboarding of new staff will occur much faster.

Augmented reality

Advancements in the areas of augmented reality are also helping to address the workforce development challenge. Augmented reality is a game changer for field operators like maintenance or service technicians. As processes, systems, and devices gain more intelligence, they also become more complex, which makes every intervention a complex task. This has led to a situation where at present, based on

[3] Global Water Intelligence – "Global Water Market", 2017

[4] Figure is an average result of implementations of the "Aquis" hydraulic-simulation software

Schneider Electric survey interview feedback, 50% of time spent on maintenance involves finding information, with the remaining 50% devoted to actual intervention on the equipment.

An operator using new augmented reality tools, sees information graphically superimposed on the real-world environment in an augmented reality fashion. Data consisting of catalogs, piping diagrams, manuals, troubleshooting steps and procedures—is made available to the operator, but only those portions of the data that are needed. This instant and easy access to relevant information helps to reduce operator and/or maintenance technician error, avoid unnecessary downtime and increases the safety of the workforce through the ability to open electrical cabinet doors virtually.

What is surprising to plant managers is how easy and fast it is to implement these technologies. Tenaris, the leading supplier of tubes for the world's energy industry, installed an augmented reality system and managed to have it up and running within 15 minutes. Water and wastewater plants can expect similar results in terms of speed and ease of integration.

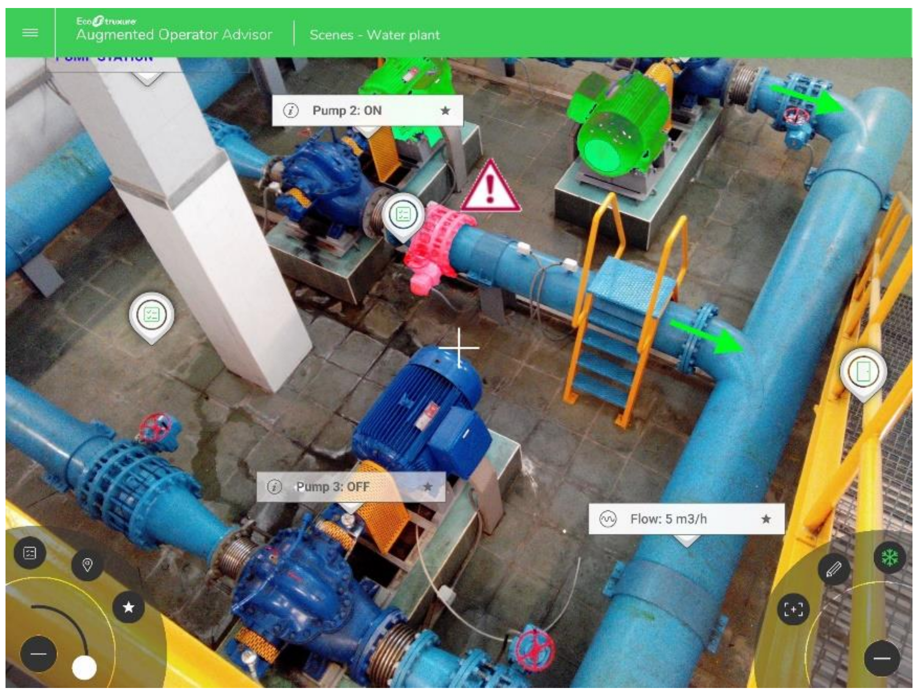

Figure 5

A water pump station seen through an augmented reality screen of a tablet

Virtual reality

Immersive virtual reality tools offer water and wastewater industry operators a safe environment where they can mimic all possible situations while reducing water losses and optimizing clean water production. Virtual reality training simulators can help to accelerate training times by up to 50% and can help new operators to secure higher uptime operations through the reduction of human error risk.

Energy management

Much of what has been discussed to this point revolves around workforce empowerment involving operators executing hands-on processes. But it is important to note how today's technologies enable all stakeholders whose decisions impact OpEx.

For example, plant or energy managers who are responsible for control of operational expenditures of facilities rely on specific KPIs and dashboards which are available in real-time. They access this information on standard office computers or laptops which allows them to execute faster and more accurate decisions. In order to address these types of reporting needs, technologies have to be flexible.

Overall energy consumption of the plant, for instance, down to a rough consumption breakdown of individual functional units or processes, is no longer sufficient to drive efficient energy management and high return on each asset. Today's devices like speed-drives, motor-protection-relays or circuit breakers can now deliver an energy consumption overview down to a single asset out-of-the-box. They also provide all relevant asset information which is accessible via ethernet connections to the device.

Open, ethernet-based architectures enable direct access to the data from software-apps at the IT-level, analyze the data, and produce meaningful information in real-time.

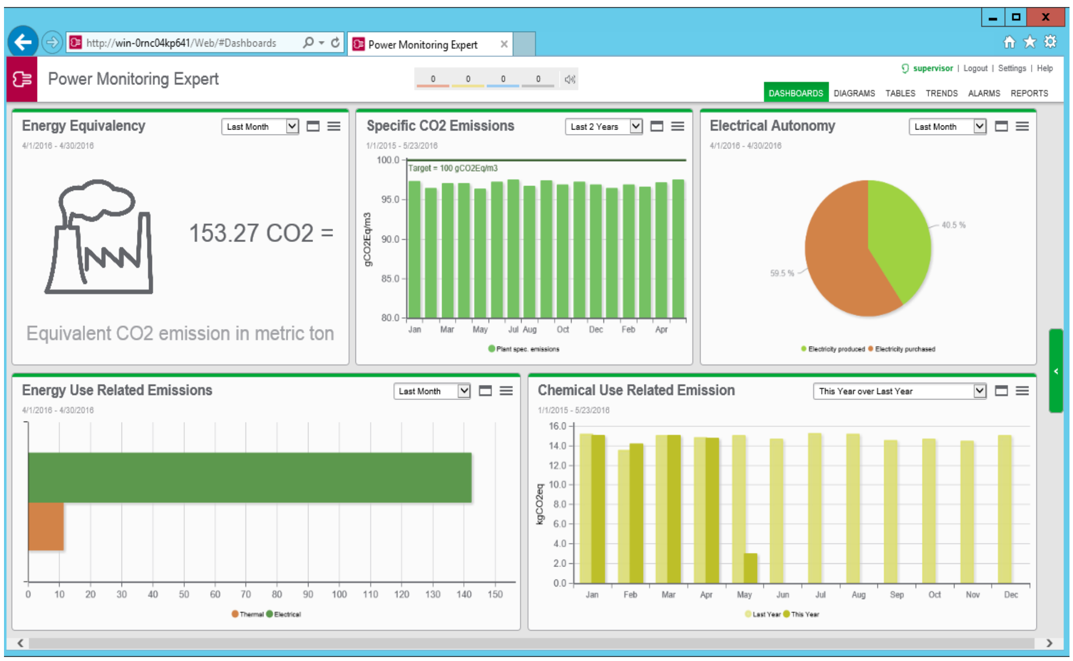

Figure 6

An example of a sustainability dashboard from a water plant performance app

Energy performance apps can run on premise or in the cloud and make energy efficiency a routine part that can be influenced by all concerned stakeholders. Using these apps, we have seen a reduction in energy costs of water plants or pump stations by up to 30%. These energy savings can be sustained and will lower the carbon footprint, especially when energy management is standardized across facilities.

An open architecture foundation

Modern digitized systems can achieve operational efficiency improvements (and hence lower operational costs) through technology investments across the following operational layers:

- **Equipment layer** - IIoT-enabled equipment and devices with integrated sensor capabilities provide connectivity and generate data. In some cases, existing components can be retrofitted with communication modules, sensors and high-end control units to achieve similar functionality. For example, retrofitting smart circuit breakers, motor starters and variable speed drives will save energy, reduce environmental impact, reduce the risk of production downtime and simplify installations. This resource circularity protects operators' health and safety, and the environment. The equipment layer, combined with the edge layer, are key to connecting the workforce.

- **Edge layer** - Edge computing at the equipment level can provide more intuitive interfaces for monitoring and controlling operations, using the latest communication and automation technologies to detect and manage leaks and other water distribution issues across public networks. This can include web-based access to operating parameters and interfaces with other systems. Edge systems can also interface with the cloud and either upload or download data only when needed, thereby reducing transmission costs.

- **Analytics and services layer** - This layer is increasingly cloud-based, and merges and correlates data to assess current equipment status and potential problems. It's at the analytics layer that data gathered by devices at the equipment layer is then contextualized and made into information available to workers. The analytics layer is where decision support is enabled, and access to better and more comprehensive information enables workers to make key decisions that impact operational efficiency and ultimately reduce OpEx. The analytics and services layer is what enables the decision support.

The modernization requirements of each water and wastewater facility will be different. An assessment by professionals who are knowledgeable regarding both water and wastewater operations and digitalization technologies can help determine priories and potential "quick wins" for piloting new modernization projects.

Complete plug and play solutions that integrate the three layers of the open architecture mean that plants can integrate these technologies seamlessly without disrupting operations or needing to reinvest in existing infrastructure.

Conclusion

A key concern for the water and wastewater industry is how to address the dual challenge of both aging infrastructure and a workforce that is on the verge of retirement. Stakeholders realize that, within a critical and financially restricted operational environment, much greater OpEx control and productivity gains can be had by equipping their workforce with modern digitized tools that drive efficiency.

Modernizing the existing infrastructure asset base through use of cloud-based services and enhanced connectivity of devices will require a gradual redesign of how data gets captured, analyzed and put to good use. Industrial Internet of Things (IIoT) technologies now offer new, more affordable opportunities for optimized asset performance improvement by combining the growing wealth of data with advanced analytics.

In this new world, real-time reliability risk can be measured, and, as a result, real-time reliability control becomes possible. The empowered workforce of today maintains constant access to real-time operational data, along with smart process control and real-time reliability risk information. Plant performance managers and operators will be able to adjust set points and visualize, in real-time, the impact their adjustments are having both on the process and on operational cost savings. Operators can apply this feedback to make decisions that maximize production without significantly increasing downtime risk. As a result, reliability and optimization of assets will improve.

The essential “tribal” knowledge of experienced workers who are nearing retirement can also now be captured and shared with a new, younger, more digitally aware workforce. The ability to remain cost-effectively productive will depend on how that wealth of information can be safeguarded, sustained, and transferred to the incoming workforce. Benefits will include not only a less disruptive transition to a younger workforce but also more effective talent retention well into the future.

In many cases, some of these new technologies will change the nature of how water and wastewater workers perform their jobs. The need for humans to perform repetitive, menial tasks will be eliminated and most workers will find themselves evolving more as value-add decision makers, more empowered to reduce energy consumption and operating expense. As part of the industry’s change management strategy, these new tools all contribute to establishing a work culture that is well positioned to operate new, highly digitized plants.

The three stages of empowering the water and wastewater workforce (connected workforce, decision support, and global collaboration), are a useful framework for helping plants to navigate through the various stages of digital transformation. Oftentimes an outside consulting firm can also help to set a direction for how to best get started when pursuing digitization-driven process modernization. Working with a consultant like Schneider Electric, for example, with a global presence in the water and wastewater industry, helps water and wastewater stakeholders to identify and address operations bottlenecks. By sharing knowledge that has been acquired over time and across the globe, new technologies and tools can be leveraged to reduce operational expense.

About the author

Hermann Wartinger joined Schneider Electric in 1993 and has more than 25 years automation experience in various roles including support, project execution and management. He has held numerous management roles in sales support, project management and service development and delivery at Schneider Electric, Austria and was part of the country’s management team. He has rich experience with the water & wastewater industry and was part of an international Schneider Electric team that developed and maintained the SESAME software solution for the water segment. In 2011 Hermann joined the corporate automation team and performed multiple roles to lead the automation offer marketing from a segment perspective.

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