Smart Utility—Then and Now

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ABSTRACT

Utilities are faced with aging infrastructure, budget constraints, extreme weather conditions, stricter regulations, technological advances, and other issues. Smart Utility—a new approach to utility management—pulls data across systems and departments into one location and transforms them into valuable information to make planning and decision making easier. Smart Utility provides utilities with the relevant information they need to develop priorities; plan for the right projects; and ultimately adapt to environmental, technical, and financial changes.

In the early 2000s, a Smart Utility concept in the context of managing assets and leveraging data was the buzz in the industry. Smart Utility has since evolved into a dynamic utility management approach that connects a utility's information systems and departments with its business goals to effectively plan for the future. In this paper, we explore what a Smart Utility approach looks like and our lessons learned over the last decade, benefits of adoption, and business cases for this approach.

KEYWORDS

Smart Utility, Internet of Things, SCADA, Business Intelligence, Utility Management, Emerging Technology, Big Data, Asset Management

INTRODUCTION

The rise of the Internet of Things (IoT) and subsequently "smart" systems is revolutionizing utility management. As demand increases, costs decline, and technology improves, Smart Utility is gaining momentum because of its ability to reduce operating costs, increase efficiency, and justify business decisions. Increasingly, municipalities are leveraging Smart Utility to address critical issues like limited water resources, growing populations, and aging infrastructure. Smart Utility allows utilities to exchange data in real time and secure the needed architecture to access answers from any device, phone, tablet, or personal computer and at any location. The IoT represents devices that are connected wirelessly to monitor and control anything your imagination will allow.

The IoT is a collection of connected computing equipment, sensors, or control devices that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Examples of IoT devices are solar powered Ethernet level, pressure or temperature sensors, IP cameras, and Ethernet connected digital thermostats. The enablement of IOT is really the ability to get low cost real time process data, control, and information from anywhere to anyone when needed.

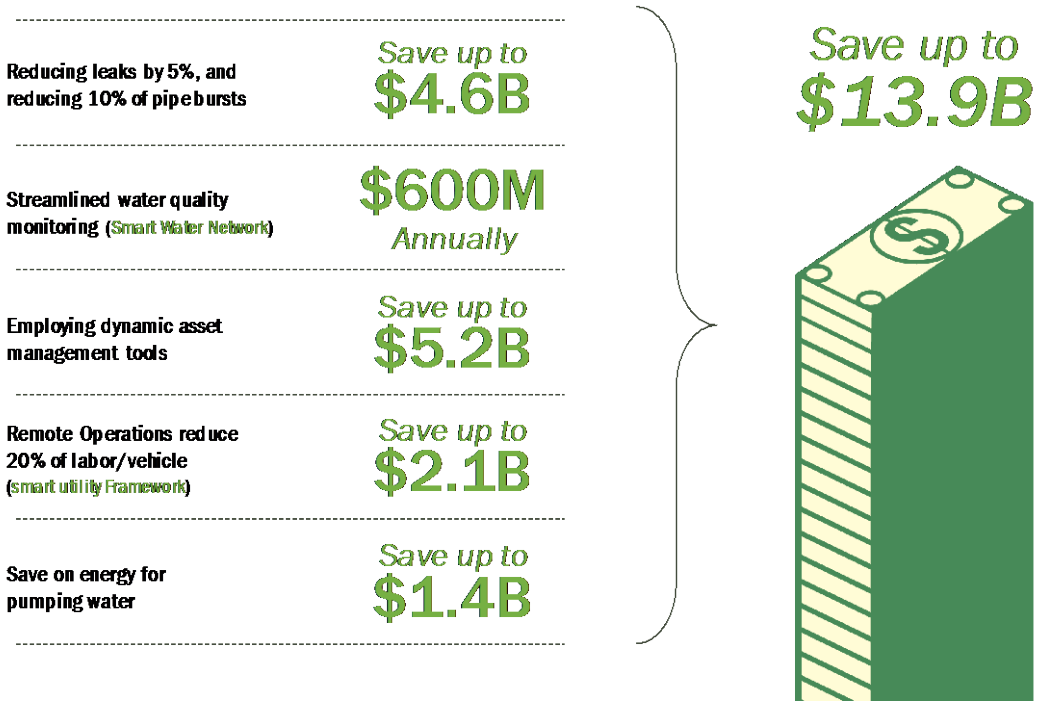

Figure 1. Smart technologies can be leveraged to save an impressive $13.9B globally[3]

Globally, utilities are spending nearly $184B each year related to the supply of clean water according to a study published by Sensus in 2012. The study was conducted through in-depth interviews, comprehensive surveys with 182 global water utilities, and analyzing utility operations and budgets. The analysis found that up to $12.5 billion in annual savings could be achieved by improving leakage and managing pipeline pressures; prioritizing capital expenditures; and streamlining operations, maintenance, and water quality monitoring[3]. Couple that savings with the savings of optimizing pumping and treatment of water and the savings could be even more than what is illustrated in Figure 1.

What Is a Smart Utility?

A Smart Utility is more of an approach to how you use and analyze data than a thing or a software you purchase and implement. Smart Utility is an approach that connects people and technology in a way that provides clarity in a world of extensive data. Smart Utility takes information processing to the next level with the use of analytics that merge business data with real-time operational data from across the organization, enabling users to make well-informed and immediate decisions.

With the rise of the IoT, modern control system data that are being made available, and business systems and intelligent reporting tools, using a Smart Utility approach will become more and more important. By 2020, the IoT will change the way we perceive data and how to collect them. Placing very inexpensive devices that are connected wirelessly to the control system or business systems of a utility to measure or monitor information through the utility's infrastructure will

change how decisions are made from using only assumptions to using actual data. New providers are entering the market every week with new IoT appliances and widgets. Something that simply produces more data, however, is not "smart." "Smart" data must readily improve operations. Businesses and organizations around the world are developing methods of organizing data into "smart" data.

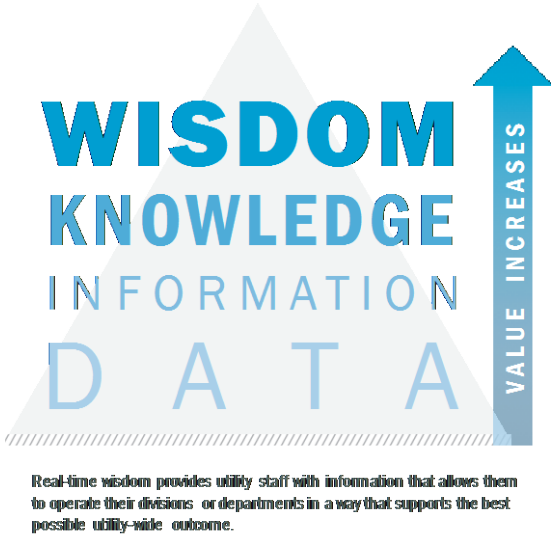

Figure 2 is an illustration of how the foundation of data can be transformed into information, knowledge, and, ultimately, wisdom. It's possible to create context and meaningful information by combining operational experience with data provides information. Knowledge is then developed by connecting information from multiple systems to provide an understanding of the entire utility will provide to improve operations and capital planning efforts. Lastly, by applying analytics to that knowledge, we transform current conditions, departmental operating parameters, and utility objectives into wisdom to create a holistic understanding of the entire utility.

Figure 2. Transforming data into wisdom

What Are the Stages to Achieving a Smart Utility?

Smart Utility cannot be easily achieved in a single step. It takes careful planning with foundational data from the control system as well as business systems to be in place to allow for an easier implementation of a Smart Utility approach. Figure 3 is a graphical representation of this staged approach.

Stage 1 Awareness. Awareness comes from connecting control and business systems together to provide information of current operational performance. It is common in this stage to develop a Smart Utility master plan that uses existing technology assets and identifies new assets that need to be installed or modified. Use cases need to be identified to add clarity to operations of the existing facilities by connecting these assets together in a meaningful way that communicates wisdom across departmental software. Examples of use cases include source water quality, distribution water quality, and wastewater wet weather flow prediction and management.

Enabling the view of data across the entire utility will allow for long-term capital investment planning in a smarter manner. Creating shared dashboards of these data views will ultimately improve decision making. You might be thinking right now that dashboards are not new and have been around for at least 2 decades. And you would be right—dashboards are not a new concept. What is new is how the data are combined with other information and presented to create new views without a major report creation investment. Using modern reporting tools will simplify the task and bring context to your data.

Stage 2 Analytics. Knowledge comes from leveraging awareness of interrelationships between utility divisions and systems by comparing the current status with pre-defined operational strategies. Capturing the information from the awareness stage to develop analytics will add historical context to data through pattern analysis. Implementing real-time process modeling and control strategies focused on reducing the cost of services, and improving quality, are the biggest wins from situational awareness. Utilities are empowered by identifying possible scenarios and outcomes based on current conditions to enable better decision making at the operational and business levels. Many control systems today did not implement analytics in the past because they were too abstract and time-consuming to develop and program. Today, software tools are becoming available like Microsoft's Power BI and IBM's Watson, among others, that can easily develop information-rich reports and run pattern analyses to bring knowledge to information.

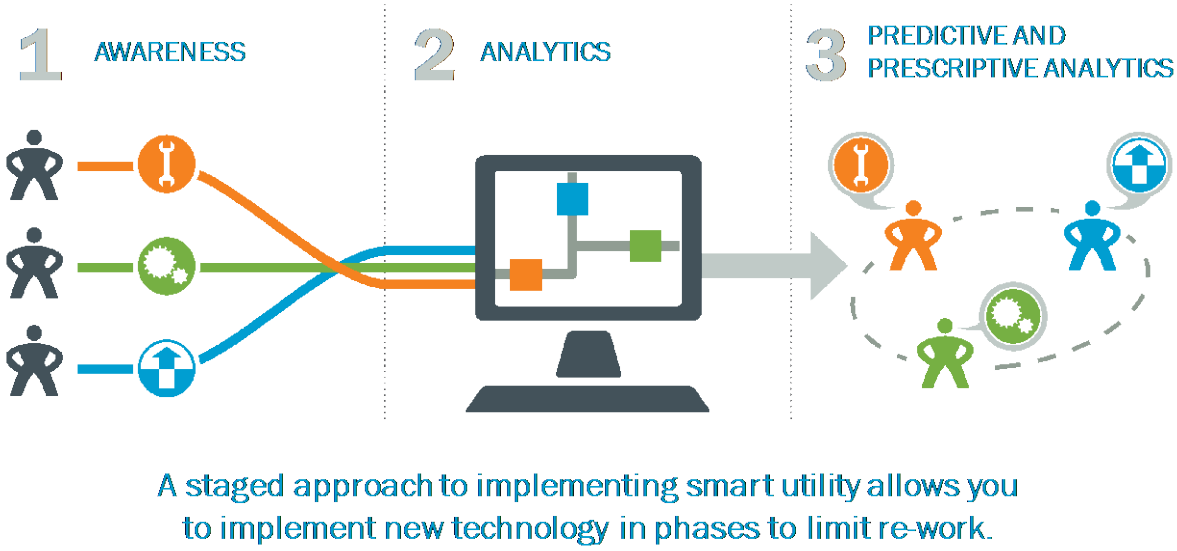

Figure 3. Phased approach delivers wisdom without reinvestment

Stage 3 Predictive and Prescriptive Analytics. Wisdom comes from applying predictive and prescriptive analytics to help utilities understand what is likely to happen and what the best possible outcome is based on a set of parameters. Based on the results of the model, actions are recommended to help the utility achieve the best possible outcome at the lowest operational risk through improved capital planning efforts and by predicting potential system failures. The result of this stage brings wisdom with an informed understanding of the future to enable balancing of competing priorities across the utility to become a more sustainable, reliable, and cost-effective organization. In other words, utilities are doing more for less, which is a goal that many organizations have today with tightening resources available—both financial and people.

CHALLENGES

Two of the biggest challenges the water and wastewater industry faces are the workforce gap and data overload. Baby boomers are approaching retirement and a new generation of data-hungry millennials are expecting easy user interfaces and information at their fingertips. In the past, we've been able to rely on the experience and expertise of employees to take raw data, combine

them with their knowledge, and convey this wisdom to others. But with the increased amount of data, retirement forecasts, and increased regulations, this approach is no longer sustainable. We need to move away from the old ways of knowledge transfer and build context into our data systems. We need to combine data into reports and smart decision-making tools to enable our utilities to be more efficient and engage their new workforce.

Figure 4. Organizational challenges

Besides workforce and data overload, organizations face significant challenges to effective operation and economic sustainability due to aging assets that require significant reinvestment, and stricter environmental regulations. Budget constraints and long budget cycles make it hard to respond quickly to changing conditions. Utilities also face critical issues like limited water resources, aging distribution and collection infrastructure, and growing populations, all of which compound the problems. It is a delicate balance for sure. Taking a Smart Utility approach could be the answer.

BENEFITS OF SMART UTILITY

The Smart Utility approach has a number of benefits including operational cost savings, improved customer service, water conservation, and faster response times. Rather than having to go to numerous places to locate information, staff can quickly and easily access the information they need from a single interface to make informed decisions. Smart Utility combines business applications like computerized maintenance management systems (CMMSs), supervisory control and data acquisition (SCADA) systems, and document management systems to provide operations and maintenance (O&M) staff with information when they need it, as illustrated in Figure 5. For example, if the SCADA system is exchanging data with the CMMS in real time, it can easily detect abnormalities in operation that may alert O&M staff to the problem. They would receive an alert on their phones with a summary of the abnormality and have instant access through the document management system to the standard operating procedures, installation documents, and manuals. Should this problem escalate to a failure, the system would automatically guide O&M staff to the procedures for bringing on the manual backup system.

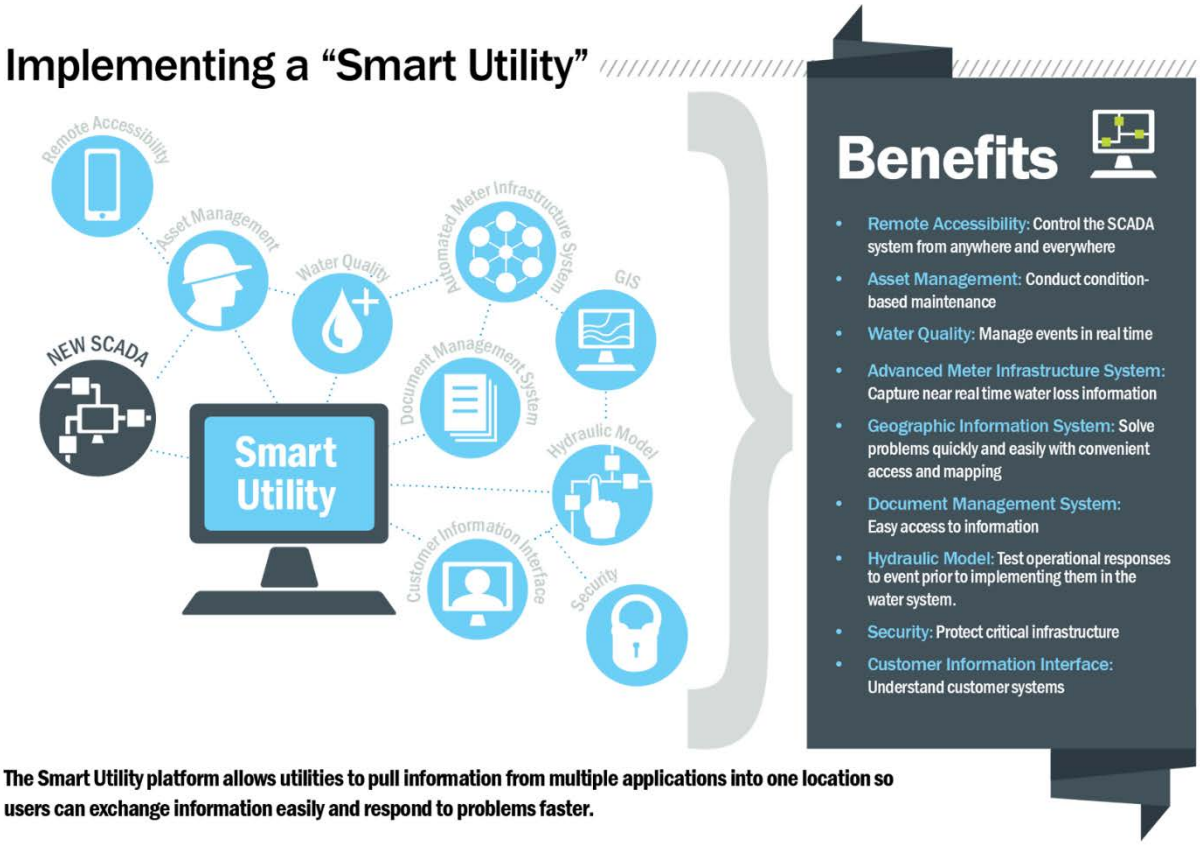

Figure 5. Benefits from implementing a Smart Utility

By using real-time business intelligence techniques, utilities can better organize and understand the data they collect and capitalize on new and enhanced information through Smart Utility equipment and sensors. It is common for utilities to ignore most of the data they collect because they do not have the ability to analyze or apply the data in an impactful way. Advancements in information technology (IT) are now making it possible to equip staff with the knowledge they need to proactively make decisions, reduce the risk of equipment failure, and optimize performance. Initial pilot studies have shown that utilities could save as much as 12 percent in operational costs by implementing Smart Utility concepts.

Implementing A Smart Utility To Achieve Effective Utility Management

The steps to implement a Smart Utility approach may be different for each organization. However, common phases, illustrated in Figure 6, apply to building a Smart Utility for your organization that align with the stages identified in Figure 3. The first phase is to do a self-assessment of the business and systems as they exist today. During the assessment phase gaps are identified for future improvements. The next phase is to develop a strategic business plan for how the organization will best benefit from all or some of the Smart Utility elements. Part of the business planning will include identification of the improvement projects such as an upgraded SCADA system or network security upgrade, cost for each of the improvements, and schedule for the improvements.

Implementation of the business plan and measurement of the results are critical for the success of the Smart Utility approach. User adoption and understanding of the new information and knowledge presented from the various analytics and visual reports will require training and, more importantly, a change of how the user acts on this new wisdom. Once the project is implemented, the organization needs to reflect on the outcome and confirm that the objectives identified in the planning phase were met. If not, a refinement in the implementation approach coupled with a new assessment of where the organization is will be necessary. This reassessment is performed in concert with the vision of where the organization wants to go.

Figure 6. Getting to work: Implementing effective utility management

The American Water Works Association (AWWA) in 2008 published a document titled "Effective Utility Management: A Primer for Water and Wastewater Utilities," which was updated in 2017. The primer discussed the keys to unlocking the potential of your utility to protect public health and the environment in the 21st century. The document was designed to help water and wastewater utility managers make informed decisions and practical, systematic changes to achieve excellence in utility performance. Figure 7 provides a concise overview of the five key management criteria to achieve success with the 10 attributes of effectively managing water sector utilities. The relevance of this strategy is in line with how a Smart Utility will operate in the future. The Smart Utility embodies the data, information, knowledge, and wisdom elements of how to effectively manage the utility in the 21st century. Giving a closer look at the specific attributes of effective utility management, you will find that they align closely with the tangible benefits of a Smart Utility. You might also say this *is the utility of the future* where effective management and knowledge of the system through analytics will deliver improved quality, outstanding customer satisfaction, and resilience to point out a few of the attributes illustrated in Figure 7.

Figure 7. Effective utility management[1]

Cybersecurity Considerations

Cybersecurity refers to the security elements necessary to protect your network and its assets from an external or internal threat. A threat can be an active or passive attempt to take control, cause damage, harm people, or destroy assets through the manipulation of computer systems or destruction or theft of sensitive data. A publication was prepared by the U.S. Department of Homeland Security to assess the future of smart cities.[4] While this publication is broad in its scope to cover virtual and physical threats, it is important to understand why cybersecurity is an important aspect of Smart Utility.

Coupled with this accumulation and integration of data are risks in the form of outside threats to operational and business systems. Bad actors in the form of independent or state-sponsored cyber attackers pose a threat to the safe and effective operation of utilities, and these utilities must be prepared to effectively defend their networks against such threats. An obvious challenge, storing and manipulating operational controls data on a network, presents unique cybersecurity challenges. While the industry has been moving to adopt guidelines promulgated by the Department of Homeland Security via industry-specific guidance published by organizations like AWWA, significant security gaps remain among many utilities.[4] If Smart Utility is implemented without adequately addressing these security concerns, the water and wastewater industries would be ripe targets for ongoing and emerging cyber-threats.

An example of how the use of early developed IoT technology without proper security configurations was a vector for a cyber-attack that occurred on October 21, 2016. A series of distributed denial of service (DDoS) attacks hosted by IoT appliances such as Internet Protocol (IP) cameras, smart thermostats, and field sensors caused widespread disruption of legitimate Internet activity in the United States.[2] While a DDoS is not harmful to a utility's systems, IoT appliances could be a vector that is "weaponized" by bad actors to do harm against the utility or

others connected to the Internet in targeted attacks. These attacks may be more directed to stop process, damage equipment, or steal sensitive data/information than what occurred with the example from last October.

This points to a need for utilities to improve their cybersecurity capabilities, by either bringing talent in house or engaging qualified IT security firms to design, implement, and monitor security features on a utility's behalf. Nonetheless, the network infrastructure for both business and control system networks needs to be part of the Smart Utility implementation plan. It is also important to note that no network is secure. However, having a properly architected network security provide layers of defense can effectively delay and alert the utility of unauthorized access to its network systems.

LESSONS LEARNED

Through our 10 years of planning, implementing, and designing Smart Utility platforms, we've learned that it's important to integrate management goals and current risks to effectively customize the system and deliver the most value. This allows us to prioritize the challenges a utility wants to tackle with Smart Utility, whether it's customer complaints, water leaks, energy savings, or other priorities. We've facilitated workshops with representatives from all divisions of a utility to brainstorm their challenges and explore the business use cases. For example, condition-based CMMSs become much more valuable when utilities can leverage real-time data from their SCADA systems. This has enabled us to move from calendar- or schedule-based maintenance to a condition-based maintenance (CBM) strategy that monitors the actual condition of the asset to decide what maintenance needs to be done. This allows asset conditions needs to trigger maintenance with sufficient time prior to failure so work can be finished before the asset fails. This significantly reduces failures and time spent on maintenance, increasing reliability while saving time and money.

Additionally, we have learned that financial constraints and cybersecurity concerns often prevent early adoption. To help alleviate the financial investment, partnerships are forming to share infrastructure and data to avoid duplicating equipment and unnecessary costs. Projects are also being phased with the end vision in mind. This way, utilities can make near-term software and technology decisions that ultimately give them the flexibility to implement Smart Utility without much re-work or reinvestment in the future. State agencies like the New Jersey Board of Public Utilities are also addressing cybersecurity concerns by adopting unprecedented requirements for water and wastewater utilities. These include developing a cybersecurity program, conducting risk assessments, and providing training programs to bolster security. These are some of the many creative approaches to reduce cost and risk in order to realize the benefits of Smart Utility and discover the best ways to allocate funding.

CONCLUSIONS

Advances in IT have allowed utilities to capitalize on the abundance of available data and turn them into valuable information to achieve operational and environmental goals. Smart Utility is integrating information systems, departments, and business goals to provide more clarity across an organization. This evolution of utility management is driving a powerful cycle of better data,

better systems, and better decision making. Figure 8 provides a holistic view of a Smart Utility in the context of a smart city where information is gathered, analyzed, displayed, and reported to support the effective management of the utility of the future.

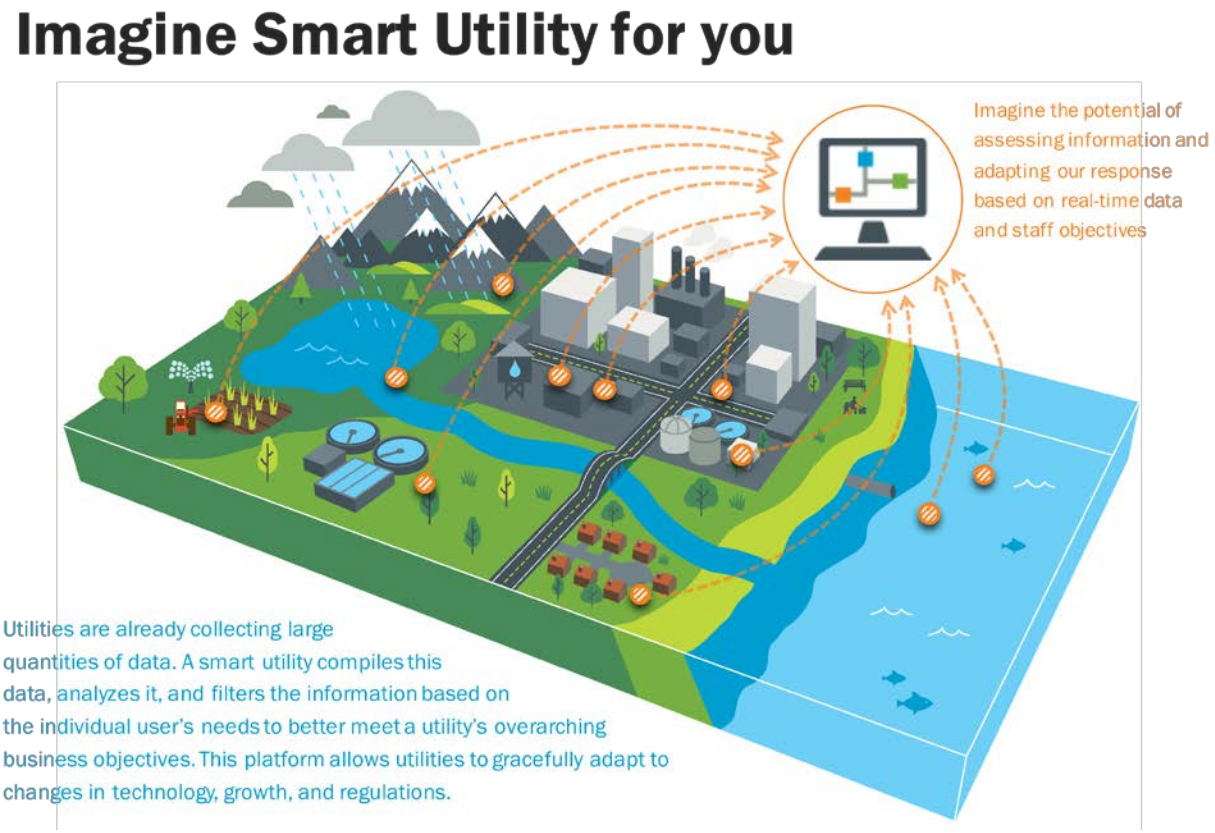

Figure 8. Imagine a Smart Utility for you!

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