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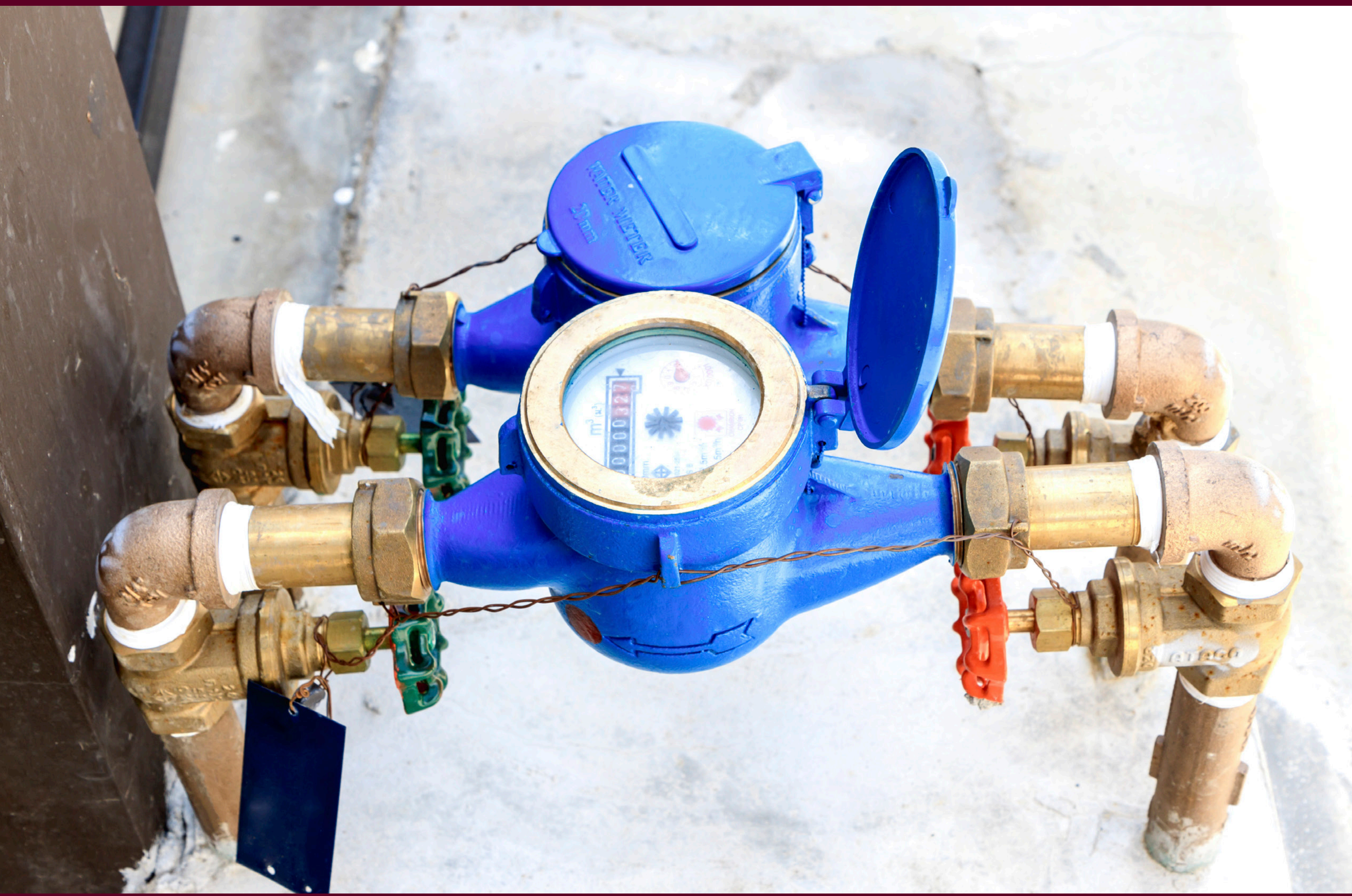
Considerations for adopting AMI and AMR

A comprehensive guide for water utilities



Considerations for adopting AMI and AMR

A comprehensive guide for water utilities

October 2015
College Station, Texas

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I. How to Use This Primer

When considering using Advanced Metering Infrastructure (AMI)/Automated Meter Reading (AMR) systems, every utility has different needs and will have varied experiences in making decisions about changes to its system and how to carry out those changes. As a result, this primer serves as an overview of major considerations for utilities that are considering, or are currently undergoing, a project to change from standard meters to AMI/AMR systems. What follows is a review of important technological aspects, the benefits of an AMI/AMR system, and major considerations important to a successful conversion project. In addition, the book includes some real-world examples of utilities' and water professionals' experiences with AMI/AMR conversion projects along with some of the best pieces of advice for tackling conversion projects. All of the examples used in this primer are real-world experiences by utilities of all sizes from across the United States. However, not all of the utilities interviewed gave permission to be named, and in some cases provided information for which there is no citable reference. These experiences and information were included anyway because of the insight they lend.

II. Motivation and Goals

A. The Importance of Motivation and Goals

> *Advice #1: Use the goal as the project mantra; it will help keep the project on track, and making decisions will be easier. Emphasizing the goal will also help when it comes to persuading a board or council of the needed system requirements.*

Utilities often have a single motivating factor for converting to AMI/AMR. For example, if a utility is motivated by improving its business model, it will want to make sure that the new system is equipped to prevent water theft and detect leaks, and that operational impacts to battery life are considered. Additionally, the quality of the meter is an important consideration because only a system that can perform frequent and accurate reads will allow a utility to both eliminate lost water and move away from estimate-based billing. However, these systems can be very holistic; a utility that operates under one motivation is likely to realize benefits in other categories. For example, utilities that seek to improve customer service with more accurate billing may experience an increase in conservation as customers become more aware of how they are billed, how much they consume, and when they have leaks.

Though motivation is important to keep in mind, it is only one consideration in the decision-making process. It is helpful to think of the motivation as the context within which decisions are made. However, the identified short- and long-term goals set for AMI/AMR systems help ensure that the best system decisions are made. A simplified example of this concept is that if the motivations are to better maintain infrastructure, a long-term goal can be to reduce lost water.

It is critical to organize the motivations, goals, long-term plans, and priorities before pursuing a conversion project. Determining priorities at the beginning of the conversion process will help prevent the utility from becoming overwhelmed or sidetracked throughout the process and will help guide the utility in its decision-making.

Identifying what is prompting the discussion of conversion is the most important step in converting from a manual system to either an AMI system or an AMR system. It is also important in helping determine which system is a practical option for the utility. Utilities of all sizes in many parts of the country are opting for AMI/AMR systems for four primary reasons: 1) to help meet requirements resulting from a law or mandate, 2) to improve conservation, 3) to improve customer service, and/or 4) to improve the business model. Of the four, the business model and customer service are the most common reasons for converting to an AMI/AMR system. Knowing the underlying cause for change will help in decision-making throughout the conversion process and will help keep the project focused and on track.

Laws, Mandates, and Management Schemes Unrelated to Conservation

In some cases there may be a law, mandate, or management scheme that requires some quota or environmental protection, which can be best achieved with an AMI/AMR system. In these cases utilities are not legally obligated to implement AMI/AMR systems; rather these systems are the most cost-effective and reliable way to meet requirements. For example, in 2009 the California Legislature passed the Water Conservation Act, which called for a 20% reduction from historic demand baselines. To comply with this, the city of Corona implemented an AMI system to reduce lost water and achieve water conservation targets. This is probably the least common motivation.

Conservation

These systems allow improved conservation in two main ways. First, notification to both the utility and customer of major and minor leaks and atypical use patterns can help reduce the volume of lost and wasted water. Second, collected data can be offered to customers through web portals, mobile applications, and billing statements providing them with greater access to detailed information of their water use than previously possible. Allowing customers to be more aware of their use, their use as compared to their neighbors' use, and water conservation measures they can apply themselves may cumulatively result in a decrease in demand. Both AMI and AMR systems support leak notification and web portals; however, AMI offers more benefits for conservation than AMR because the data collected is accessible in real time.

> *Real-World Example: New York City Department of Environmental Protection has been operating its AMR system since 2009. A large part of its implementation was the customer leak notification system and the "My DEP Account" web portal. Efforts to communicate conservation efforts, usage trends, and leak notification through the web portal and mailed letters have saved customers more than $26 million dollars since 2011.*

Customer Service

Customer service is an important role in utility services. As the primary interface between customers and the utility, the customer service department fields a variety of questions about billing discrepancies, utility policies, infrastructure problems, leaks, and numerous other issues. If customer service is the motivation for change, then it is prudent to define what good customer service means for both the utility and the customer before setting goals and making system decisions.

> *Real-World Example: Utility A was a small system of about 5,500 homes and 6,100 connections (including some residential irrigation meters). Utility A's water accountability was at ~96% before the system was converted to AMI. The customer base in Utility A's service area was well educated, in the medium- to high-income brackets, and understood and was comfortable with technology. As a result, the customer base was attentive to billing practices and actively asks for conservation programs. Because of the characteristics of the customer base, Utility A believed that good customer service required giving the customers what they wanted: conservation assistance and accurate billing. Both were achieved by a new AMI system.*

Business Models

> *Advice #2: Be conscious of all the different financial scenarios involved in taking on such a large project.*

These systems can have a tremendous impact on a utility's business model. These systems can improve employee safety by reducing claims and injuries, allow for more efficient allocation of employees, minimize maintenance expenses associated with major breaks, and produce more accurate billing statements. Utilities with high water loss, high rates of leaks and breaks, older systems, or heavy reliance on estimated reads for billing are among those that benefit the most from AMI.

A Note on Conservation and the Business Model: Encouraging conservation while generating revenue is difficult to balance. Historically, conservation is not considered a source of water; however, this view is slowly reversing, and conservation is increasingly viewed as the most economical source of water for many utilities. The impact on revenue becomes a more critical consideration when changing the system to AMI/AMR, as systems greatly improved by AMI/AMR may face a decline in revenues if customer-side infrastructure problems are resolved (reducing the amount of water registered at the meter) and if customers respond by consuming less. Conversely, system revenues may increase if lost water is recovered through utility-side leak detection, remote on/off capabilities, and tampering notifications. This underscores the importance of understanding the customer base.

B. Identifying How AMI Can Help Meet Goals

It is important to ensure that converting to an AMI/AMR system is a worthwhile investment. In other words, it is critical to identify how an AMI/AMR system will help a utility meet its goals to justify all the change and expense that comes with such a conversion. To do this, it is prudent to review documents pertinent to the goals and to meet specifically with the individuals who prepared the documents. Below is an abbreviated list of documents that may be useful.

- Water Loss Audit (or non-revenue report)
- Water Use Survey/Meter Reports for the last year
- Annual Conservation Report
- Five-Year Conservation Plan
- Five-Year Water Plan
- Long-term Water Supply Plan
- Local reports filed with groundwater districts or other authorities in the last year
- Production billing data/reports for the last year
- Drought Contingency Plan
- Rate structure
- Relevant laws and ordinances

Additionally, it is important to share this information with all the relevant departments because each individual department provides unique perspectives and useful feedback.

Summary Examples

If the goal is...	Then....
More accurate and timely billing ,	a mobile AMR system is the most reliable, cost-effective solution.
Data that allows management of utility performance and the ability to provide enhanced customer service,	an AMI system is the better solution.
Cost effectiveness for the system,	select a system that can operate as a hybrid AMI/AMR system.
Data and information that can only be obtained with a new meter system,	develop a system that can be upgraded from mobile AMR to fixed-base AMI.

Some AMI/AMR professionals suggest that for systems comprised of 15,000 endpoints (meters) or fewer, AMR is more practical; systems with more than 15,000 endpoints are better off with full AMI because managing an AMR system on a larger scale is impractical. Considering the number of connections is a useful starting point, but ultimately the utility's goals should dictate the type of system selected as well as any additional system features.

III. System Selection

A. AMI versus AMR

Many different system combinations can be made between system type, information interfaces, forms of data conveyance, and additional features. To this extent, systems can be somewhat customizable. Vendors or third-party consultants will help in this process, but it will be important for the utility to determine what its minimum needs are to determine what type of system is most fitting.

What is AMR?

AMR doesn't require an extensive installation plan or significant maintenance, because the units that comprise AMR are not part of a larger physical network. It is a fixed system that can offer improved customer service through more frequent readings and the ability to detect leaks and tampering. There is also opportunity for additional data collection such as GPS survey, time-of-day rate systems, and system modeling. However, because AMR is fixed, it requires employee drive-by visits, often conducted on a monthly basis. Because of the drive-by visits, AMR can be much safer for meter readers since readers are not required to enter properties, which in turn reduces the likelihood of injury. AMR systems can take reads as frequently as every 15 minutes; however, the collected data will not be available until weeks after it is registered. As a result, any problems in the system may go unnoticed for a significant period unless the utility retains a full staff of meter readers to collect data more frequently. Maintaining or increasing the number of staff is likely to impact operational expenses.

A Note on AMR: For a few reasons, many utilities have used AMR as a stepping-stone between standard metering and AMI systems. Some utilities made changes as technology became available, others made system decisions for financial reasons, and others wanted to try out the technology before committing to an AMI system. All of these approaches have merit, and the best approach will vary with the utility. However if the goal is to eventually have a full AMI system, then it is smart to explore the cost-effectiveness of growing from AMR to AMI. A slow transition may lead to setbacks or delays on the road to a complete AMI system and be more expensive.

What is AMI?

AMI is more complex than AMR and requires a large physical network. AMI performs the same data collection function that an AMR system does, but instead of holding the collected data until a meter reader can collect it, AMI relays the data to the owner of the meter in real time. Because AMI can relay data in real time and has a physical network, it has additional features.

Comparing Mobile AMR to Fixed-Base AMI Systems

> *Advice #3: Know your current water system inside and out before making any decisions, and understand what the utility's needs really are.*

AMI and AMR systems have many operational differences, but they can be enhanced with different tools and features that are addressed later. The most basic AMR and AMI systems have the following capabilities.

An AMR system can provide:
- Reads as frequently as every 15 minutes or more, depending on staff availability
- Accurate bills in a timely fashion
- Improved work efficiency and safety

- Generated reports of unusual or outstanding events
- Tamper and reverse-flow alarms
- Drastic reduction of estimated readings
- Depending on the frequency of reads, data collected and analysis of the collected data, there is opportunity for both customer-side and utility-side leak detection.

An AMI system can provide the features of an AMR system as well as:

- Daily, hourly, or 15-minute read increments without reading staff
- Billing by gallons instead of thousands of gallons, which is more common
- Improved customer service
- Customer web portals
- Quick and accurate replies to inquiries
- Faster resolution of billing disputes
- Select billing date
- Real-time diagnostic operation and maintenance reports
- Targeted data collection and report generation
- Operational updates for the collector, repeaters, and endpoints

B. Transmitting Options for AMI Systems

Data is transmitted in AMI systems in a few ways: one-way, two-way, and quasi two-way AMI systems. It is useful to think of these systems types as system directions; in other words, what directions can information be shared in a system. The most appropriate option will largely depend on how much data is collected and what special features the utility wants.

One-Way

A one-way system has four points in its communication line. Data first goes from the meter's register to an interface unit, then goes from the interface unit to a fixed-base data collector. From the collector, data is sent to the server and the server is the last point where information is pulled for billing and analysis. The server is also where the data is continually stored. The result is that data flows in only one direction. There are two types of one-way systems:

Bubble-Up

In a bubble-up system, the transmitter relays readings continuously every few seconds. The data travels from the meter transmitter to the meter-reading receiver.

Awake-Sleep

In an awake-sleep system, a radio transceiver relays the data by sending a signal to a particular transmitter serial number. When the signal is sent, the transmitter is "woken" from a resting state and the data is transmitted. One-way systems are the most basic AMI systems and provide the most basic AMI benefits such as more accurate billing and reduced meter-reading expenses.

Semi-Two-Way

Data can flow bi-directionally between the data collectors and the server, but the interface unit is fitted only with a receiver and communicates in one direction. This is done so that the server can poll the data collectors, but the server cannot communicate with the interface unit.

A utility that is motivated by factors other than billing or safety/reallocation of its meter-reading staff may want to pursue more advanced AMI systems. A quasi two-way enables the server to poll data from collectors at more frequent intervals. The increased volume of data can be used for billing, conservation, or customer-service goals.

True-Two-Way

A two-way system differs from a one-way system only in that the interface unit has both a transmitter and a receiver. A full two-way system offers additional abilities beyond those of the quasi two-way and makes it easier to achieve system and utility goals. Some examples of features supported by a two-way system are remote shut-off valves and meter-tampering alarms. Although two-way systems are the most expensive, they have the most potential for maximizing system benefits. Additionally, while the utility may only require a one-way system at present, it may be important to consider using a two-way system because it can affect the implementation of future upgrades and system changes.

C. Methods of Data Transmission

Radio Technologies

Because of its reliability and cost-effectiveness, radio frequency (RF) is the most common communication technology for AMI/AMR systems. Antennas or transmitters are attached to the meter or register, and data is transmitted from the meters and the data collectors by RF. Although this is the most common transmitting technology, there are a few challenges to be aware of.

Both the RF of the system and physical terrain and obstructions will affect the type of equipment needed. AMI/AMR frequencies are generally 30 MHz or greater. These are referred to as "line-of-sight" systems because the radio signal moves in a straight line. Line-of-sight signals can be blocked by a variety of structural elements such as trees, buildings with lathe and plaster construction materials, telephone poles, and chain link fences. In addition, some system elements can be barriers, including cast iron meter tiles and lids, steel vault lids, reinforced concrete meter box lids, and flooded meter boxes, tiles, and vaults. This can sometimes necessitate additional equipment, such as stronger transmitters that can push a signal through obstructions or repeaters to get the signal around the obstruction. Additionally, when signals have to cover long distance, points between the meter and the collector require additional equipment, such as repeaters to ensure the signal gets to the data collector.

Environmental factors, such as shifting soils, can also change the direction of the transmitter or otherwise prevent the signal from reaching the data collector. Environmental factors are generally unique to the utility and are often dealt with as they arise. There are some basic approaches to avoid the impact of potential influence from environmental factors. First, talk to nearby utilities that have AMI or AMR systems to see if they have encountered anything to be aware of. Second, installing a system that has some redundancy can help ensure there is more than one way for signals to reach data collector units. Third, implementing a system with bi-directional signals is useful so utilities can perform diagnostic tests from the office and more quickly locate where there may be a problem.

Non-radio technologies

Power Lines

Data can be sent over existing power lines, which is why electric utilities frequently pair AMI systems to them instead of installing additional transmission equipment. This may be an option for a water utility converting to AMI if the utility is able to work with an electric utility planning to convert its system (also known as piggybacking). If piggybacking is not an option, it is unlikely to be an efficient method of data conveyance because of issues related to maintenance and access to the lines.

Cable

Using existing cable television lines to communicate data is only an option for utilities or municipalities that own their own lines; otherwise, it may be financially prohibitive to lay a large system of new cable lines. Even when cable lines are owned outright by utilities or municipalities, upgrading the line to support an AMI system may not be cost-effective. Some municipal electric utilities that own local cable companies have upgraded the cables in a way that would support an AMI system (they include bi-directional digital signal transmission and ultimately much wider bandwidth using fiber optics). An important consideration here is that utilities using host-service to house the data may run into problems since the lines are local and the servers are likely to be in another city.

Cellular

Cellular endpoints are a new option for water utilities. They are ideal because they can drastically reduce the cost of the physical network, since antennas, repeaters, and other parts aren't needed. Additionally, cellular networks are very safe, secure, and resilient, which is useful in emergencies, such as floods, that might damage a large physical network. However, the cellular data needed can be very large and expensive on its own depending on the volume of data collected.

Satellite

The satellite option has become much more affordable for utilities. In fact, some systems come with satellite data transmission. Like cellular endpoints, fewer infrastructure pieces are needed for satellite service. This option is increasingly popular for rural areas where there is low meter density and the meters are far apart but may also be very practical in big cities that would necessitate a large amount of endpoints and other infrastructure. Satellite systems are often two-way and have the same benefits as a two-way radio system. Sometimes, additional software is required to make a satellite system viable. However, many vendors that provide hosting services already have this software, which helps utilities avoid the expense.

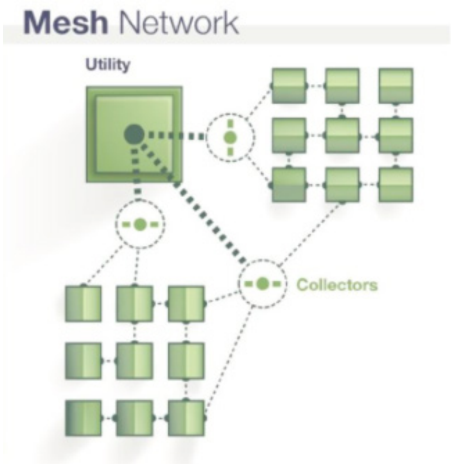
Telephone

This is a less popular option because of the difficulty in establishing it and because fewer people have landlines. However, there are several benefits, such as not requiring batteries and being largely compatible with AMI systems. There are two types of telephone-based remote metering devices: inbound and outbound. An inbound system operates by having the interface unit use a telephone line to call a data collector at prescheduled times to provide consumption data. In an outbound system, the utility's master station calls the interface unit and collects the data. An outbound system is more useful for being able to make on-demand reads; for example if there is an indication that an event is a major leak or could become a major leak, the utility can call the interface unit for increased reads to assess whether the event is worsening or stopped. On-demand reads can be made without any involvement of the customer and without interference to their phone service.

D. AMI System Network Topology

Mesh Network Architecture

In a mesh network, each point is called a node. All nodes operate together to distribute data through the network and back to the data collector. The data collector is generally the main server located at the utility or a third party storage center. Two methods by which mesh networks can relay data are: routing and flooding. With routing, the message "hops" from node to node until it reaches the data collector. For routing to work, the network must have clear pathways between nodes and be programmed to "hop" around bad connections to reach the data collectors. These systems are very reliable and are typically paired to wireless networks. Flooding the network means pushing data from one node to all nodes in the system.



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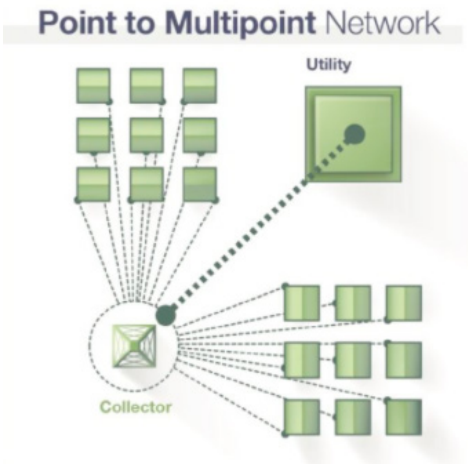
Star (point-to-multipoint) Architecture

A star network has one central data collector that can communicate with all nodes individually and nodes can transmit data to the collector. All data has to pass through the data collector before it can be distributed to a utility.



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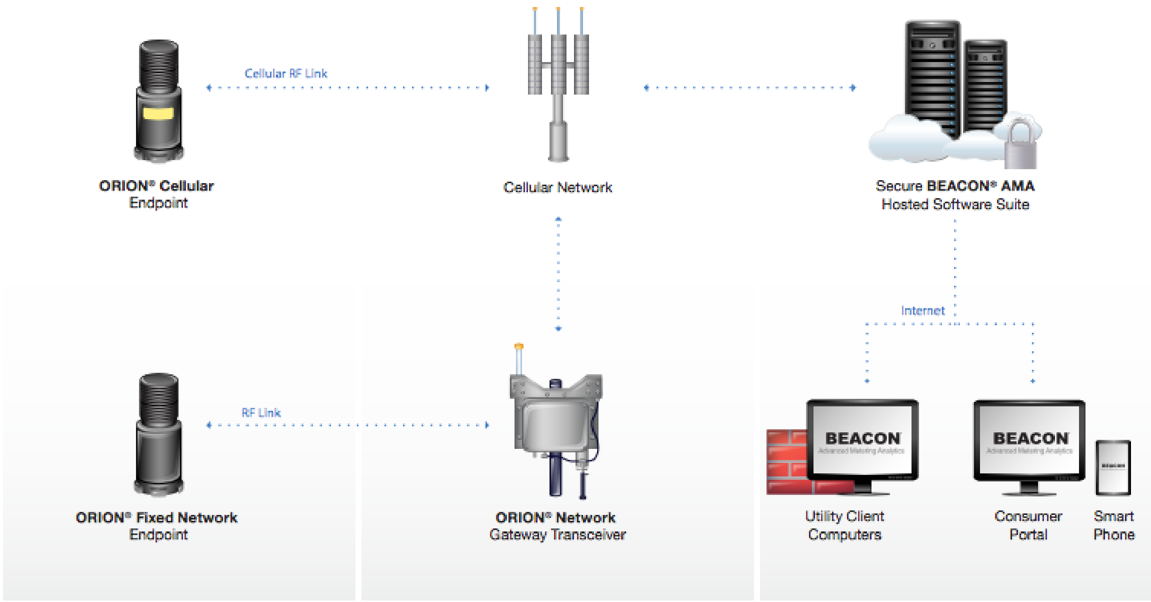
Cellular Endpoint Network Architecture

Cellular networks operate by way of the nodes on the meters transmitting information through already existing cellular networks. Data is sent from all the nodes to a satellite and then bounced back by cellular signal to the data collector/server. Depending on the size of the system and the frequency that the data will be transmitted, this can be a great option. Some utilities purchase data packages, but many vendors have their own satellite space, a portion of which can be reserved for a utility that wishes to go through their vendor.



Graphic reprinted with permission from Badger Meter. This graphic and more information about Badger Meter's BEACON AMA managed solution are available at www.badgermeter.com/BEACONAMA.

IV. Finance and Budgets for AMI/AMR Systems

It is important to understand all of the options and channels through which funding can be achieved because conversion projects can be cost prohibitive.

A. Standard Approaches to Financing an AMI Project

Rate Increases

Rate increases are the most common approach to covering the cost of system conversion. They can take on different forms that can make them easier on customers and easier to pitch to a governing body. Some rate increases are tiered, some involve increases over several years, and others are even initiated prior to the conversion so that there is more available for the conversion.

User Fees

User fees are fees or taxes imposed on users of a service or resource to help in covering the cost of providing or maintaining the service or resource. These fees are common among public services and utilities; for example, there are often fees associated with garbage collection services.

Revenue Bonds

Revenue bonds (also known as municipal bonds) are available to municipalities that need funds for income-producing projects. These bonds are secured by identifying in advance the revenue sources that will enable repayment, such as revenue generated by improved billing in AMI systems. These bonds can be issued to any agency that operates like a business, generating revenue and incurring operational expenses. Revenue bonds require repayment of the principal and the interest accrued, much like a loan, and in this sense should be obtained with care.

Reserve Capital

Every utility sets aside some funding for long-term capital investment projects or anticipated future expenses. In some cases, reserve capital can be used to fund a portion of the project or, with enough planning, the entire project.

> *Real-World Example: In 2013, Utility A had a budget surplus of $2 million, which was the result of increased water sales due to prolonged drought. It was able to build a case for AMI that was approved by its board and used $1.8 million of its surplus to fund the conversion project. No loans or bonds were taken out, and the city has stayed entirely in budget.*

Grants

A number of grant opportunities at the state and federal level can contribute to covering the cost of the conversion. However, many of them are treated as bonds or loans and require some contribution to the granting source, or a deliverable.

Performance Contracting

Performance contracting is a contractual partnership between a utility and a vendor company that identifies and guarantees certain energy, operational, and resource savings opportunities. The guaranteed savings are accounted for from increased billable revenues, energy savings, reduced Operation and Maintenance (O&M) costs, and avoided capital expenditures, which derive from implementing an AMI system. These savings are considered a certain future source of income, which can be used to pay for the completed project. Any savings that are obtained in excess of the amount owed the vendor are kept by the utility. Shortfalls are generally assumed by the vendor but can be delegated to the utility.

<u>A Note on Rate Studies</u>: Rate studies are critical to the fiscal health of a utility because they are the most common way for utilities to ensure that current and future rates are in line with current and future needs, including capital improvements, upgrades, standard maintenance, and sometimes emergency repairs. Despite the importance, many cities do not have rate structures sufficient to cover necessary capital costs and do not conduct regular rate studies. At the same time, more pressure and responsibility are placed on utilities to maintain infrastructure and water quality. As a result, some utilities are starting to rely on bonds and loans to pay for maintenance and system improvements. However, to pay back the bonds or loans, utilities increase their rates to cover the interest and the principal, which ensues a game of catch-up, in which utilities are constantly raising rates after the fact. This is only one scenario in which a utility would benefit from regular rate studies to ensure that the utility can keep up with expected costs and large projects.

> *Real-World Example: Utility C did conduct regular rate studies but did not make necessary changes to the rate structure. When the utility's water system reached 105-years old, it required $60 million to replace the 70-year-old water mains. Thus, postponing infrastructure replacement could cost more money because of system disruptions.*

B. Financial Benefits of AMI Systems

Increased Billable Water and Sewer Revenue from Improved Meter Accuracy

Meter Typing

Meter typing is an important step in selecting the system because having the incorrect meter for the pipe size or source can result in inaccurate registration. This is particularly true with oversized meters at low flow. Making sure that correct size and type of meters are installed throughout the system is critical to remedying locations of lost water. The appropriate meter type ensures that meters will record all the water that passes through it. Correctly typing meters requires a careful evaluation of testing and recording metered use and comparing that use to historical usage. A correct meter will often have a higher overhead cost but may pay for itself in the end. How quickly a meter will pay for itself will depend largely on the brand, size, material, the amount that read accuracy will increase, and other elements relating to meter choice.

Audit of Utility Billing System Errors

Once meters are updated and the correctly sized and typed meters are installed, utilities can conduct audits of their billing system to find errors including inaccurate readings, leaks, and tampered meters.

Reduced Operational Expenditures

Major reductions in operational expenses are realized, in particular with respect to reducing the number of meter readers and technicians and reallocating those positions to other departments. Because there are fewer readers and technicians in the field, fleet vehicle expenses are reduced. Most importantly, employees are much safer because they rarely have to enter properties or conduct fieldwork. This results in a large decrease in Worker's Compensation claims and other costs associated with injuries incurred on the job.

Prompt Notice of Unauthorized Usage and Tampering Events

Lost water is greatly reduced for utilities that have system features that notify of unauthorized use and meter tampering in real time. Although in some cases it is difficult to identify the responsible party, the utility can deal with the situation much more quickly and limit the extremity of the severity of major water loss or significant theft.

Near-Elimination of Technician Dispatching Expenses

In cases where customers either fail to pay or are opening or closing their accounts, the utility can operate a remote shut-off or reconnect function (so long as a two-way transmission system is in place). This single function helps drastically reduce the time and expense of sending out a technician and other staff to interrupt, turn off, or restore service. Those expenses may be almost entirely removed from operational expenses. Additionally, AMI systems operating with two-way transmissions can receive notification and location of any problems so technicians do not have to make multiple trips to fix the problem. Together, this means that staff can be reallocated to take on other duties within the utility, even more so than staff could be with an AMI system that does not have this feature.

<u>A Note on Revenue</u>: Projecting changes to revenue is critical to estimating the return-on-investment period. However, revenue can be impacted by several things. First, as mentioned earlier, if AMI is instituted as part of, or in conjunction with, a conservation program, the decrease in water use resulting from those efforts may diminish expected revenue. Additionally, as addressed later, opt-in and opt-out programs can have unpredictable consequences for anticipated revenue streams. Additionally, more accurate meter reads and the availability of data for those utilities that provide usage feedback to customers or otherwise make consumptive use information public, can work together to cause a shift in consumptive use. The feasibility studies listed in the References section of

this primer provide good examples of projecting revenue changes. Other business or feasibility studies are likely to be good examples as well, particularly if the system size and demographics are similar to that of a utility that is considering AMI.

C. Budget and Costs

Budget

Advice #4: Consider the overall cost of ownership when selecting the vendor and system.

Recent conversion estimates suggest that AMI system costs are gradually declining. While this helps to make AMI a more plausible option, it is important to keep in mind that utilities will experience varying costs depending on the unique aspects of their systems.

When budgeting for an AMI system, roughly 45% of the total budget is generally allocated to cover the endpoint hardware (meters), 20% to cover network hardware (infrastructure), 15% covers the installation (assuming installation is conducted by the vendor), 11% will cover project management, and finally 9% will be required for IT upgrades. Of course, no two utilities are identical and so no two budgets will be either when it comes to converting a manual meter system to AMI or AMR. The important lesson is that the physical meters tend to be the most expensive part of the conversion project.

Although there are many options to choose from when considering equipment, vendor, and vendor services, it can ultimately be more expensive to purchase inferior equipment and cut back on services. It is most useful to approach decision-making with a big-picture mindset that questions overall cost of ownership before making each decision. Utilities will often find that over the long term, better technology with better warranties and vendor support services is worthwhile and more than pays for itself.

Convene with Stakeholders

To get a sense of the scale of the project and associated costs, it is important to talk to utility managers and officials, potential vendors, utility accountants and financiers, and in some cases customers or representatives from customer service and outreach departments. Talking to all parties will help raise any issues or concerns early on and make it easier to resolve any concerns when all relevant stakeholders are already aware of the project.

Creating a Budget and Priorities

Creating a budget and establishing system priorities is one of the most challenging parts of a conversion project. Be aware that plans may change throughout the process and a lot of time may be spent on revamping projections and assessing needs. Even though plans may change, three values should be determined before a budget can be settled:

1. Anticipated project cost

Work with the vendor to determine what average costs are and to extrapolate costs from the utility's number of connections and the service population, and costs associated with the life expectancy of the equipment selected. The anticipated project cost is relatively easy to assess, but be sure to evaluate how any uncertainties will affect overall cost.

2. Anticipated project cost recovery

This is a critical aspect of justifying the expense and effort of converting to AMI. For this reason, it is important to consider various financial scenarios including a full range of potential return on investment (ROI) time frames. Again, investing in an AMI or AMR system is a 20-30 year commitment. Identifying the longest potential period of ROI and the likelihood of its occurrence is important for planning and is likely important to the approving board or council. The utility should consider things such as shifts in usage (increased conservation resulting in decreased revenue, lost water rates), rate impacts, and use of opt-in or opt-out programs to name a few.

3. Project benefit value

This is the cost-benefit analysis. Though this will vary by utility, it is useful to tie benefits to financial considerations as well as whatever the utility's defined goals are. Sometimes benefits come in non-monetary forms such as improved customer perception.

V. Installation and Implementation

A. Selecting the System

Advice #5: Talk to many vendors and other utilities, ask questions, and have patience.

Make a Wish List

Selecting the right system for the utility is critical to meeting goals and long-term operational success. Because there are so many options and variables in a system, the best action is to do some light research examining how systems can help meet the utility's goals and then make a list, in order of priority, of your utility's wants and needs. Then, go back and do more thorough research on those features. This helps identify the most critical system aspects. Some of the most popular and useful system features include:

- **GPS**: useful in tracking meters, spotting outages, locating leaks and breaks, and providing another important element to data assessments. It also allows for distribution automation. This can be tied into a personnel-dispatching system to facilitate quick responses.
- **Leak Detection and Notification**: locates problems early on and sends notifications by phone or email to residents and/or the utility.
- **Pressure Controls**: allows utilities to reduce pressure during non-peak hours and reduce the number of breaks and leaks by slowing the rate of wear-and-tear.
- **Remote Service Connect and Disconnect**: enables utilities, when two-way systems are used, to turn water on and off from the office.
- **Prepayment and Select-Date Billing**: helps eliminate collection problems and enhance cash flow by making payments easier for customers.
- **Sub-metering**: allows utilities and commercial properties to obtain more detailed information about use among multi-tenant properties.
- **Customer Interface**: helps utilities engage their customer base by providing user-friendly web interfaces where customers have access to their usage as reflected in volume and expenses dollars. Other information, such as a comparison to neighbors or to the average user in the city, can also be made available to help customers learn about their usage. In areas where there are separate meters for irrigation, users can also identify where and when their use is greatest, identify abnormal peaks, and be alerted to major leaks. Providing this information can increase awareness, encourage conservation, and help customers verify and reconcile bills.
- **Monitoring and Control**: allows utilities to remotely evaluate signal strength and communication between system infrastructure points, troubleshoot problems, and set or change synchronized time-based meter readings (i.e. readings can be set for the same time, at the same interval, such as daily at 6:00 a.m.).
- **Remote Software/Firmware Upgrades**: increases operational efficiency and lowers maintenance costs by reducing the need to dispatch utility technicians.
- **Alarm Signals**: can be included to provide notifications of leaks, tampering, and/or mechanical problems. Other alarms for specifically identified conditions of interest to the utility can also be set (i.e. alarm signals may be set for predetermined flow parameters).

- **District Metering**: allows for the establishment of hydraulically independent districts, each with their own flow meters and boundary valves, all within the larger operation area. Districts are usually comprised of 1,500 to 2,000 service connections. Compartmentalizing sections of a larger infrastructure scheme makes identifying failures, leaks, losses, and broad billing discrepancies easier to identify since it enables utilities to monitor flows in and out of the districts and compare that to usage in the district. It also simplifies shutting down parts of the system to deal with failures or make replacements, repairs, or upgrades since shutting down a sub-district has fewer implications for the entire system.

<u>A Note on Warranties</u>: Warranties are fairly standard among vendors, but it is a good idea to read them carefully and understand what is covered under a warranty and what the policies on them are. For the most part, warranties are set up to ensure the meter, or other equipment, lives to a certain amount of reads/data bursts. The warranties usually only cover manufacturer defect and are insulated against incorrect operation and damaging water quality. Those stipulations are laid out in the terms of the warranty. Manufacturers will carefully check and inspect any returned equipment for damage from the utilities.

Interoperability

At present, there are no true interoperable systems; that is, there are no systems designed to be fully integrated with other systems. Many systems can be made to work together, but it is not ideal unless the utility is fully aware of discrepancies between them and there is a purpose to mixing vendors. For example, take a meter that is identified by an assigned number of eight digits. If the meter is paired to another company's system that only reads to six digits, then problems may result such as receiving notification of detected leaks.

Interoperability becomes more of a problem over time as equipment and software are upgraded and ultimately may become incompatible. Fortunately, major changes to systems and product shifts only occur every few decades, but because investing in an AMI or AMR system is a 20-30 year commitment, it is important to keep this in mind when selecting the system components. Ask the question: how well will the system keep up with technology?

Third-Party Assessments

Consultants have a wide knowledge base of different equipment and often have had some first-hand experience with it. Attending consultant workshops and vendor showcases are great ways for a utility to discover options and benefits. Additionally, consultants can assist the utility in establishing its priorities and goals. If a utility is moving from one system to another or will have a mixed system, a consultant may be useful for determining interoperability potential. However, when a consultant is used, it is important that a utility still develop a relationship with its vendors to ensure it has technical and operational support in the future.

Conduct a Pilot Study

Advice #6: Don't skimp on the pilot project, and try out different systems.

Pilot projects provide a small window of trial and error for utilities to test out the system, software, and equipment before expanding the new infrastructure to the entire municipality. Pilots provide a low-stress environment to experiment with the system and detect problems early on. During a pilot:

- Utilities can test out different products and systems to identify the best fit for a utility.
- IT staff can discover and remedy data flow issues.
- Field staff can learn and familiarize themselves with the computer software and hand-held equipment in AMR systems.
- Field staff gain experience with the mechanics of the equipment and the installation and programming process as well as other day-to-day tasks.
- Utilities can critique, review, and make changes to the system or equipment.
- Utilities can create realistic expectations for full implementation.

- Utilities can develop ideas about how to customize software and network services.
- Customer service can learn about any changes to the billing system and how to respond to customer questions about their bills or the new system.
- Utilities can "test-drive" the network and software system.
- Utilities can consider more thoroughly how the data will be used, managed, and protected.

Selecting a Meter

It is important for a utility to know about the quality of its water when selecting the vendor and equipment, and even when opting for some of the additional capabilities listed below. Utility A considered traditional mechanical meters, electromagnetic meters, and ultrasonic meters prior to converting the system. This particular utility's water is very hard and scales build in meters due to calcium, magnesium, and other mineral deposits. Because of this, the utility felt that signals from an ultrasonic meter might be too weak and opted for the electromagnetic meter that would more easily read flows. In addition, it is important to consider the following when selecting a meter:

- Failure rate
- Precise, long-lasting resolution
- Data storage
- Ability to identify and report anomalies
- Life expectancy
- Technological lifecycle/system upgrades
- Amount of energy use
- Security of the meter and the system
- Meter abilities such as GPS features

In the example above, the utility also needed to install a large number of new meters based on the age of its existing meters. The utility determined that it was more economical to install all new AMI meters than to replace the oldest manual meters and retrofit them for an AMI system. Meter replacement can result in an expense that affects meter selection and is important to keep in mind when reviewing meter options.

System Parts

Some vendors have parts made by independent manufacturers. Those manufacturers often make extra items in addition to those for the vendor, such as pipes and ball valves. Because of this, utilities are sometimes encouraged to purchase additional parts. In some cases, this is beneficial to the utility and other times unnecessary. In circumstances such as this, it is best to stay focused on the project and purchase only what is needed for a successful project. If additional parts are purchased, make certain they will be consistent with current infrastructure.

<u>A Note on Battery Life</u>: Age, temperature, read frequency, and distance from points in the system infrastructure, such as the distance from a cell tower, all impact the lifespan of a battery.

Retrofit or Removal

Deciding whether to retrofit or remove and replace standard meters is largely dependent on the meter's age and the size of the system. If the system's meters are newer at the time of conversion, it may be more sensible to retrofit them. However, if a significant portion of the system has older meters, it is better to replace them. This is because they will inevitably fail and have to be replaced, effectively forcing the utility to pay for two meters instead of one new one. A rule of thumb for conversion projects is that meters five years or older should be replaced, but this will vary depending on the type of meter and wear-and-tear it experiences.

B. Vendors

Advice #7: When selecting systems and vendors, make sure to get references from similarly sized utilities whose systems are already operable.

Even though with an AMI system, a utility can troubleshoot and can handle materials and warranty needs without assistance, it is important to have a good vendor to rely on in case of a serious problem that exceeds day-to-day challenges.

Selecting a Vendor

Unless there is a strong reason to work with multiple vendors, it is much easier to work with one vendor for all of the utility's needs. Splitting the system parts among separate vendors may make it more difficult to resolve problems, or at least in getting vendor assistance in resolving problems and discrepancies in the system should they arise. This is for two reasons: (1) if things go wrong, utilities may experience finger-pointing without receiving any real support in rectifying the problems, and (2) it may be difficult for the vendors to identify what is causing the problem if they are unfamiliar with some of the products. For example, discrepancies between meters from one brand and billing software from another may be difficult to resolve if the brands are unfamiliar with each other's products.

Additionally, be aware of the type of vendor the utility is dealing with so that the expectations of services are realistic. A service-based vendor is one that will perform all relevant services for the utility such as installation, notification systems, data mining, and reporting. Alternately, a technology-based vendor will help the utility learn to perform all relevant services for itself to the extent it is able and may provide additional services. With a technology-based vendor, the installation is managed and some training provided, but the analytics and data storage are the responsibility of the utility. Some vendors will function as both.

Finally, before making a final decision about the vendor, ask all of the contending vendors for references from utilities whose projects the vendor has completed. These utilities can attest to the quality of the product and services, the character of the vendor, and overall experience. They can also be informative about experiences in finance and budgeting.

Develop Relationships

Advice #8: Develop lasting relationships with your vendor and retailers.

It is important to develop relationships with vendors, and consultants if used. The biggest reason is to ensure a long-term presence for continued training, awareness of upgrades and changes, and assistance with trouble-shooting problems. One example of its importance is that in many cases, training is provided by a vendor several months before the system is operational. Later, when the system is operational and data begins accumulating, the utility employees may not remember how to access or use all of the features. Additionally, as staff changes, knowledge is lost without continued support and so the system becomes underutilized.

Talk to Other Utilities of Similar Size

Utility systems vary greatly across the country. When researching your infrastructure options, including the meter, the network, and the communication system, try to envision what will work best for your municipality. In particular, consider utility size, service population, geographic area, service lines, the municipal procurement process, labor contracts, and civil service rules. These aspects may be unique from one municipality to another and may influence feasibility.

Because of the various aspects of a conversion project, one of the best things to do is to talk to similarly positioned utilities about their experiences. Utilities with similar budgets, sizes, and goals can provide a lot of insight and make conversion projects much more successful. Additionally, they can provide vendor references.

C. Getting Approval

Creating a feasibility analysis and business case for AMI

When creating the business case for your utility, it is a good idea to lay out all of the options that were considered and when the expected benefits will occur. For example, depending on the budget, the system installed, and the installation process, benefits may not be realized until several years into the conversion process. This is a critical fact that you will want to be prepared to explain to the board and customers if needed.

Apart from establishing all of the options available, to demonstrate which system is the best, you will also need to identify the direct benefits to the utility. Benefits can be either broad or specific, but either way should correlate to the experiences and needs of the utility. For example, if a utility struggles with water theft but has selected an AMI system with tampering and theft notification features, then that should be expressly identified along with the dollar amount to be saved annually via AMI and this feature.

Submitting Plans to the Governing Board

To develop an effective feasibility analysis and business case, it is important to know what your governing body wants and what it wants to see in the future. To help think strategically about what needs to be included in the presentation to the board, here are some initial questions the utility should be asking, though there will certainly be additional questions that would be useful to ask depending on each independent board.

1. Does your governing body make decisions on numbers, data, and facts? Do they have financial or technical backgrounds (i.e. accountants, CPAs, or engineers)?

2. Who are the most influential board members in these types of decisions?

- As an example, many cities have subcommittees that recommend the forward progression of projects. You should put some thought into which committees would be important to approving the project and moving it forward. In most cases, it is important to confer with the Budget Subcommittee and Contracts Subcommittee.

3. What are the utility's priorities that are supported by your governing body (these will help to identify the most persuasive approaches)?

- Is your utility customer service oriented?
- Does your utility have a strong desire for employee retention and do they vote for items that are supportive of staff?
- Are economics the driving factor for most decisions?
- Is a strong capital improvement program important?
- Are there influential environmental lobbies that influence decisions?

These elements can be the most critical in preparing a good business case. For example, if a council prioritizes the financial aspect of the project and of water management then the feasibility analysis and business case needs to address total cost and return on investment and make sure those numbers will be justified by the benefits received by both ratepayers and the utility. Or, if a board prioritizes employee retention and satisfaction (because happy employees work better and more efficiently), then it would be wise to demonstrate how the system will affect employees from more than one angle. In this case, it would also be a good idea to work with the human resources department and managers of relevant departments to plan for displaced employees, reallocation of employees, and how the system can assist employees in their daily work.

4. Is the financial model strong? Return on investment and total costs can be difficult to assess, but making sure the model is comprehensive and accounts for potential problems makes a stronger business case. Similarly, having multiple financial models is incredibly helpful. Multiple models can be presented as the best- and worst-case scenarios for implementing AMI or even one model for two or three implementation scenarios (i.e. one model for AMR and one model for AMI).

5. Are your managers knowledgeable about the system? Make sure that the managers know the ins-and-outs of the system, including problem areas and system age. Meeting with system engineers and the Maintenance and Operations department is recommended.

Inter-local Agreements

Inter-local agreements are collaborative contracts between public entities. They are made in an effort to provide more efficient and cost-effective service, and are beneficial to all involved parties. For example, community A's animal control department may provide services to community B. Most communities are able to become party to an inter-local agreement, but utilities should always check the laws in their areas. These agreements are made for either shared services or purchasing practices. When implementing an AMI/AMR system, an inter-local agreement calling for both services and purchasing may be practical depending on the size of your utility.

1. Purchasing Agreements

Because purchasing in large volumes or using equipment for multiple purposes proves less expensive, towns and cities may choose to enter into cooperative inter-local purchasing agreements with other municipalities, counties, the state, or other public utilities to save money. Such agreements may be renewed annually or at a stated term such as five years, they expire at a set term, or they may contain clauses for parties to revoke if the agreement does not prove to be beneficial. The scale of the products subject to purchase agreements can range from capital equipment, to high school stadiums, to toilet paper. It is up to the parties to decide what will be included and what standards will be imposed.

2. Shared Services Agreements

Sharing service responsibilities saves money because it inherently requires cost sharing with other parties to the agreement. Examples include the animal control service previously mentioned and school bus services. Municipalities might arrange to share this service, which means that, individually, schools do not have to maintain separate garages, vehicles, and extra employees, and shares the maintenance expenses of fleet vehicles.

D. Installing an AMI System

Most installation plans follow the following steps:

1. Begin with the end in mind.

- Determine how meters will be phased in.
- Develop data management plan.
- Develop contingency plans for broken or defective meters.
- Develop best management practices for implementation including customer strategy and distribution tracking and installation system.
- Develop a plan for addressing inactive accounts.
- Develop a plan for removing old meters.

2. Order Materials.

3. Install AMI System Server(s).

4. Install AMI System Collectors and Repeaters.

5. Test system, conduct data validation, and verify that the meter multiplier is correct and that the meter-reading units are also correct.

6. Integrate systems including billing, monitoring, and data collection.

7. Conduct vendor training.

i. Installing the system

Installations can be performed by a utility, consultant, vendor, or contractor. Generally, most opt to have the vendor install the system, because they are experienced, or the utility will install it because it is more knowledgeable about the positioning of the system. Utilities may opt for an additional vendor or contractor to perform the installation because it may be less expensive; however, utilities making this choice should request references for the additional vendor from other utilities whose AMI system is operational.

ii. Installation Timing

Spreading out the installation process over a longer period and/or in phases helps prevent all meters needing to be replaced around the same time in the future. This helps utilities avoid paying for a major meter replacement program since meters will not begin to fail or break all at once. However, if installation is spread out too much, then there may be some conflict with system technology. For this reason, even though installation in stages is encouraged, ensuring that there won't be any technological problems with installation should be discussed with the vendor. Because most technologies are regressively compatible, also known as backwards compatible, this is not usually a problem, but is something to keep in mind if a project is spaced over a number of years. It is generally more of a problem for systems crossing over from AMR to AMI.

iii. Common Installation Problems

Advice #9: Make sure to double check factoring, and matching radio and meter numbers during installation.

There are two major problems that can arise from a faulty installation, and both are difficult to remedy and highly impactful on the successful functioning of the system. The first is that the numbers on the meters may inadvertently be assigned to the wrong radio number in a RF system. This can be problematic because it may result in incorrect billing or failure for the read to make its way to the server (i.e. no billing at all). Mismatched meter and radio numbers is a problem that may be detected after several billing cycles, primarily by observing that historic reads are used repeatedly for billing purposes in place of AMI reads. However, even if this problem is detected, it can be very difficult to find the exact mismatch and fix the problem.

Second, factoring resolution (how billing software factors meter reads) may be incorrectly established during the installation process and can significantly impact billing accuracy and utility revenue. Generally, billing software factors meter reads to either counts of 100 or counts of 1,000. If the meter reads in thousands but billing software factors to hundreds, a utility could bill for 30,000 gallons instead of 300,000 gallons. In a reverse situation, a utility runs the risk of substantial uproar of hugely inflated bills.

VI. Data Management

A. Technical Aspects of Data Management

Before the system can become operational, the data management system and any related databases, including billing, must be functional. The following steps are important to achieve functional data management systems:

1. Develop a meter exchange process.

2. Work with a utility billing service provider to develop file transfer structures.

3. Test the program with "dummy accounts."

4. Test swap program with small amount of "real data."

5. Start installing meters at a slow pace in order to verify data.

6. Accelerate installations once swap program is proven.

B. Managing and Storing Data

Advice #10: Know what party has proprietary rights to the data.

The data collected is stored by either the utility or a vendor at an off-site host facility. The volume of data and how long the utility intends to keep it determines where the data is stored. If the volume of data is substantial and the utility wants to keep several years' worth for analysis, then a host facility is probably needed.

Off-site host services are often provided by the same vendor that makes the system equipment. While different package services exist, some benefits of off-site hosts include: not having to procure or make space for oversized servers, notification of problems or hazards, identification and handling of malware issues, ability to keep data for longer than the utility would be able to, analytic tools for the utility. One important thing that utilities should check is who owns the data. Some vendors contract to retain proprietary ownership of the data accumulated with their systems, but other vendors do not so the data belongs entirely to the utility. This can impact how the data is used. For example, a utility may not be able to have the data released to a third-party consultant for analysis if the vendor owns the data.

C. Data Analysis

Data can be used to evaluate many aspects of consumptive use and operational trends. Looking at the utility's goals often helps in identifying what the best use of the data is and how much data is required to make appropriate assessments to meet goals. Additionally, many utilities keep data beyond that which is identified as necessary for intended analysis. This is useful because it allows more flexibility in analysis in the future.

Real-World Example: Utility B merged the consumption data collected with information about the physical meter to develop a model for meter replacement policies. The physical information considered included meter age, registration number, size, manufacturer, and technology.

Real-World Example: Utility A will use the data at a statistical level to track irrigation uses and identify areas within the customer base that have high irrigation so that it can then target that area for water audits and outreach on appropriate irrigation methods. The utility will also track leak trends to locate areas where there may be a wide need for pipe and main replacement. Last, the utility will use the data to identify its highest users and target those users for conservation efforts.

VII. Customer Engagement Strategy

Advice #11: Know your customer base (income, lot size, use, population projections, education level, personal opinions).

A. Customer Notification

A number of factors will affect the approach in customer engagement. Some things to consider will be the nature of the customer base — for example, attitude about conservation and the size of the service population — and the intended speed of system conversion, and whether installation necessitates customer participation. In communities that require indoor meter and register installation or permission to access property, customers will need to be informed as to the changes being made. To that end, there are still choices to be made as to how much information to provide to the customer. This can be a delicate and nuanced balance, particularly where pilot programs are being conducted, as many things can change from the pilot to full conversion.

The following are frequently used notification tools:

- (multiple) mass postcard notification mailings
- door-to-door canvassing and home consultations
- telephone and web-based appointments made by third party contractors
- bill inserts
- briefings with community organizations
- press coverage and news media
- informational websites including maps, photos, and relevant contact information
- customer focus group
- community meetings/town halls
- citywide mailer
- press conferences to announce changes or launch installation
- press releases to local media
- fliers distributed at community centers
- paid advertisements and media campaign
- media event for the first meter installation
- call center

B. Customer Contact

Making contact with the customer to successfully change or replace equipment can be difficult. In some parts of the U.S., meters are inside the home, in a garage or basement, or simply located on a part of the property that requires permission to enter. For this reason, it is ideal to have a customer contact plan in place. This ensures the customer is aware of changes, the meter read or maintenance staff has access to the meter, and the installation plan remains on schedule. A sample customer contact plan is below. This example follows the plan used by Utility E.

A. Two weeks before work begins in a scheduled area, the contractor and/or utility contacts the customer to make an appointment. Contact could be made by prepaid return postcards, a call center, cold-calling, and canvassing.

B. If an appointment is not made after two mailings, two phone attempts, and a cold-call, then the customer was visited again at home.

C. If an appointment is still not made and access has still not been granted, then a warning notice was left at the home stating that water services would be turned off if the customer did not schedule an appointment in the seven days following issuance of the notice.

Generally, commercial, industrial, and municipal customers pose no problem because they have more availability during standard business hours. Extended business hours may be useful during the installation process to meet customers before and after work hours.

Detroit had a multilayer community relations campaign that helped ease the transition. However, some utilities elect not to embark on a customer/community relations campaign, sometimes because there is a joint-utility effort that limits the ability to dispense information, or simply because the utility believes it will be easier to simply tell customers what the changes are after they are in place. Regardless of the path chosen, it is important to make these decisions well in advance of any physical or billing changes so that if and when questions come in from customers, information that is shareable has already been identified and can be conveyed.

C. Addressing Customer Concerns

Privacy

Many customers have the impression that AMI/AMR systems increase the potential for a Big Brother dynamic with their utilities. Customers do not want the government to know when they are showering or going to the bathroom. They need to be reassured that AMI/AMR meters do not actually do that. Although they provide an increased amount of data pertaining to total consumption and can reflect spikes in use, they do not measure individual appliances or fixtures. The utility will not know when customers are going to the bathroom and cannot distinguish from filling pools and power washing the house. Any spike trends the meters may capture are generally predictable such as in the morning before most people leave for work and at night when people shower and do chores such as washing the laundry. Moreover, because of this information, it is easier to identify when a problem may arise by noting unusual spikes. This is to the benefit of both the customer and the utility and can help prevent against outrageous bills.

Data privacy is also a concern to customers uncomfortable that their data may be sold to another company for research, advertising, or other uses. For this reason, it is important to be clear about who has access to the data and what it will be used for. If a vendor hosts the data, then it is responsible for managing customer privacy.

Meter Accuracy

Another major concern is that the meters may not be accurate and may result in higher bills. Generally, these meters are more accurate than standard analog meters. Overall the meter will not have to work as hard and as a consequence will not suffer as much wear and tear because instead of constantly running, the meter will only conduct readings at specified and predetermined times.

Health Effects

Meters that rely on radio frequency (RF) to relay information are increasingly under scrutiny as being safety hazards; specifically, there is growing concern over the impact of RF from meters and the associated electromagnetic radiation on human health. Meters that use RF for AMI/AMR systems use the same kind of radiofrequency waves that cellphones and Wi-Fi devices use to communicate information to the utility server, and the overall amount of exposure people experience from these meters is generally much lower than the amount they are exposed to from other sources. The World Health Organization has stated it will conduct a formal assessment of the risks from RF exposure, but this report is not yet available. The American Cancer Society has done some research and recently released a short report that states:

"RF radiation doesn't have enough energy to remove charged particles such as electrons (ionize), and so is called non-ionizing radiation. Non-ionizing radiation has enough energy to move atoms in a molecule around or cause them to vibrate, which can lead to heat but it can't damage DNA directly."

Additionally, some customers have expressed concern over thermal effects and electromagnetic hypersensitivity, but reports indicate that these sensitivities would be rare among customers.

Opt-out and Opt-in programs

In response to customer concerns, utilities are increasingly offering opt-out programs that allow customers to decline participating in the AMI system. Approaches to running an opt-out program include allowing customers to keep their analog meters, providing a smart-meter but not turning on the radio capability, providing a smart-meter without the radio capability included at all, and providing a non-wireless smart meter that transmits information by phone line. Any of these options may be viable depending on the needs of your utility and the customer base your utility serves.

Though some utilities would prefer to avoid an opt-out program altogether, some states, such as Vermont, are subject to mandates to provide such programs. Other states are not required to offer a program but are restricted in their operations of an opt-out program. For example, in Maine, customers who do opt-out are generally charged a fee to help the utility cover the expenses associated with having a disjointed operating system. However, those fees are currently subject to a court case and may not be enforceable. In addition, vendors and private providers may not allow opt-out programs at all. Because of these issues, it is critical to explore how revenue and operations will be affected because it could impact the business justifications for converting to AMI.

VIII. Operation and Maintenance

A. Training Employees

Whether or not employees are moved from meter reading to O&M, all O&M employees will need training in the new duties and responsibilities that come with an AMI system. It is important to begin this training early on in the process because the more staff understands the interworking of the system, the easier it will be to rectify any problems that do arise in a timely manner. Where possible, it is a good idea to work through different scenarios and even visit with staff from another AMI utility.

B. Maintaining Reliability

After the installation process is complete and the system is operational, it is important to continue testing for overall system reliability. The various areas in which it is prudent to test reliability are also all good areas for O&M staff to be trained in early on.

Accuracy

Be sure to have a meter replacement plan and pay attention to the age of the meters. Like any technology, reading accuracy diminishes with age.

Communications

Stay on top of transmission strength and look for any unusual occurrences, as they may be a defect in the equipment or a sign of environmental interference.

Warranty and lifecycle

Have a solid knowledge base about each part of the system and know what the life expectancy is. Remember, the life expectancy of different system parts can be impacted by how they are used. For example, remember that the more frequently a system collects reads, the more quickly its battery will die. In addition, have a working knowledge of the equipment warranties so that there are no surprises when components need to be replaced.

Maintain the communication and server equipment

If the utility is storing all of the data itself, it should be sure to develop a maintenance plan with its IT department. Keeping the machines physically clean and updated helps keep the servers in good order and prevents against glitches and lost data.

C. Continue the vendor-utility relationship

> *Advice #12: Invest in continued training.*

One of the biggest impacts to system effectiveness and efficiency is the loss of system knowledge. Employee turnover, gaps between training and implementation, and unchanged system use all contribute to less holistic use of the system. Investing in continued training helps ensure that all employees are equipped to make the most of the system and are updated about upgrades and system changes.

Keeping up with technology

Because this is a long-term commitment, be sure to discuss potential changes in the vendor's technology and how it might impact the operation and function of your system. Some manufacturers are good about using regressive systems (new developments and software updates continue to work successfully with older versions of the system), but many are not. This can be problematic for utilities when upgrades or improvements are developed since a non-regressive system will demand an entire system overhaul to keep up with developments. If a non-regressive update is developed and the utility cannot afford to update its entire system, it will steadily become less effective and efficient. Moreover, it often happens that a utility converts to a basic AMI system with the intention of adding additional features later. If too many developments occur between the installation and the date at which the utility can afford additional features, then the utility's system may become too outdated. This can be problematic for things like ROI and intended revenue.

Most systems are regressively compatible so that making adjustments in stages is usually not problematic, but it is important to consider early in the process. Additionally, talk to the vendor about the type of support offered. Some vendors do not provide continued education, technical support, or notification of system upgrades, while others will automatically or will do so for an additional fee included in the contract.

IX. Conclusion

AMI/AMR systems have much to offer utilities, many times even providing unanticipated benefits. These systems are very complex and highly customizable, and because of that, converting from manual meters to these systems can be complicated. It is important that utilities enter into a conversion project knowing that the process is non-linear and not one-size-fits-all. Utilities must perform their own product and system research, speak with other utilities, exercise flexibility, and anticipate worst-case scenarios. Additionally, rate studies and well-grounded financial plans are critical to successful project completion. Utilities should remember the following pieces of advice:

> ***Advice #1****: Use the goal as the project mantra; it will help keep the project on track and making decisions will be easier. Emphasizing the goal will also help when it comes to persuading a board or council of the needed system requirements.*

> ***Advice #2****: Be conscious of all the different financial scenarios involved in taking on such a large project.*

> ***Advice #3****: Know your current water system inside and out before making any decisions, and understand what the utility's needs really are.*

Advice #4*: Consider the overall cost of ownership when selecting the vendor and system*

Advice #5*: Talk to many vendors and other utilities, ask questions, and have patience.*

Advice #6*: Don't skimp on the pilot project and try out different systems.*

Advice #7*: When selecting systems and vendors, make sure to get references from similarly sized utilities whose systems are already operable.*

Advice #8*: Develop lasting relationships with your vendor and retailers.*

Advice #9*: Make sure to double check factoring, and matching radio and meter numbers during installation.*

Advice #10*: Know what part has proprietary rights to the data.*

Advice #11*: Know your customer base (income, lot size, use, population projections, education level, personal opinions).*

Advice #12*: Invest in continued training.*

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