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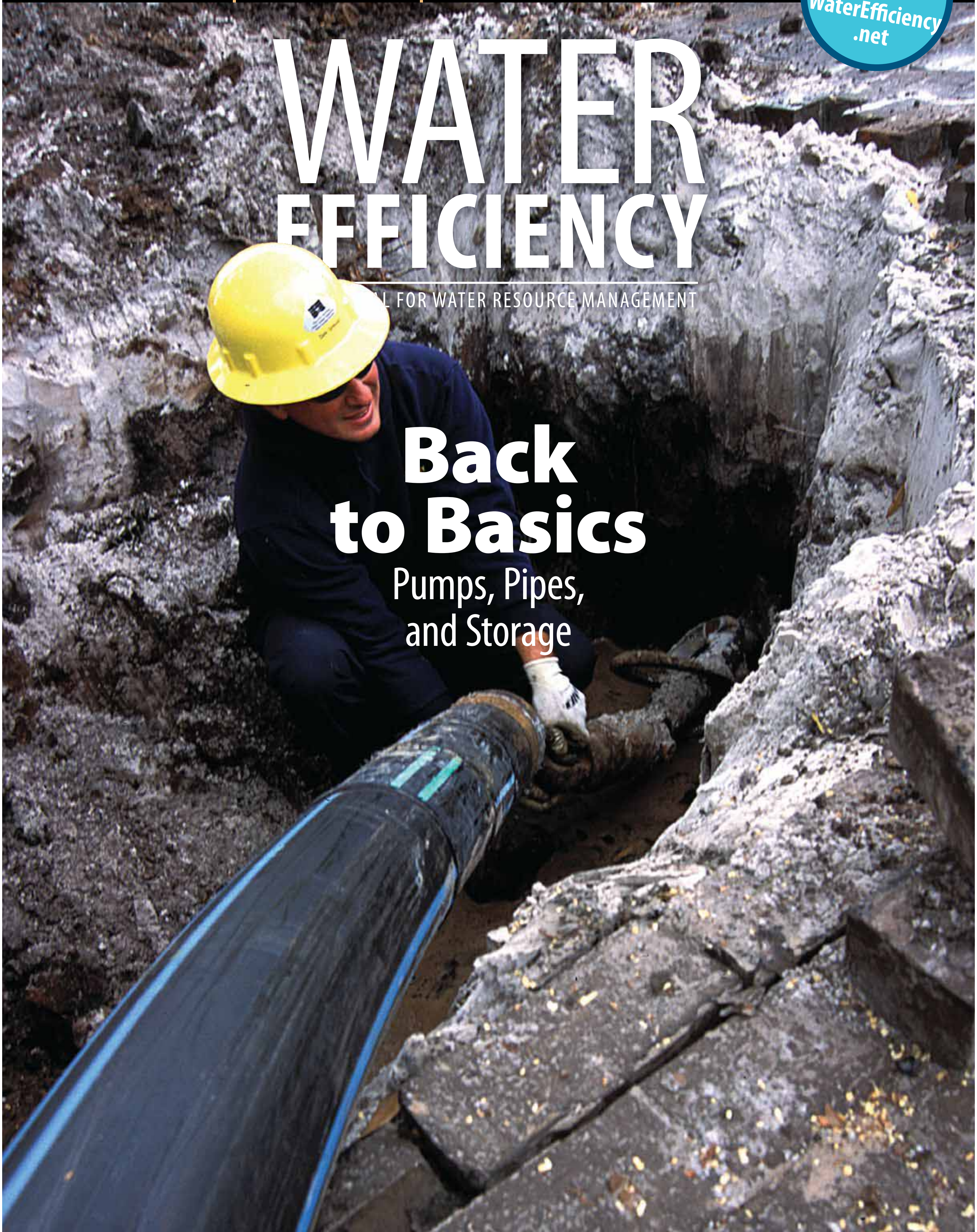

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features




Cover photos: The Plastics Pipe Institute

Taking the AMR/AMI IQ Test

Across the US, smart meter technologies boost infrastructure quality, data management, and much more.

BY ED RITCHIE

It's official, the age of advanced meter reading (AMR) and Advanced Metering Infrastructure (AMI) has arrived. At least, according to the numbers and from industry adoption to marketplace potential, these numbers can't fail to impress. Starting with a study about to be released by the Water Research Foundation, in Denver, CO, wherein researchers conclude that almost half of all North American water meters were equipped with AMR or AMI devices.

"That's about 44 million meter points since 1985", says Harvey Scott, lead author of the *Scott Report on AMR Deployments*, 4Q2010, Cognyst Advisors, Newark, NJ. "In 2010, there were 5.3 million new AMR/AMI points. So this is a very healthy industry."

Healthy indeed. Although Scott doesn't specify how many of those meters are in the United States, we can refer to another group that studies water, the EPA. And by their figures, in the US those meters are finding their way to about 53,000 community water systems and 21,400 not-for-profit, non-community systems. So we have a staggering number, but whether it's customers served (millions), leaks and losses by gallons per year (billions), or cost of infrastructure repairs (don't ask), any discussion of drinking water distribution in the US racks up its fair share of staggering numbers.

Moreover, those numbers add up to big business for the manufacturers of AMR and AMI products and related services. According to Lux Research, in Boston, MA, the universe of water-related businesses will grow to $961 billion in total revenue by 2020. The result is something of a stampede by manufacturers looking to help the utilities that supply drinking water in North America. And judging by that tally of water meters cited in the Water Research Foundation survey, utilities may be enjoying a bit of a stampede themselves. But if AMR has been around since the mid 1980s—and AMI systems have been the talk of water industry conferences since the early 2000s—why the sudden acceleration in acceptance by utilities and water districts?

TURNING THE CORNER ON TECHNOLOGY

That question gets an interesting response from Craig Hannah, performance engineer, Water Technology, Johnson Controls, Milwaukee, WI. "We did our first AMR project back in 1999, and AMI systems didn't even exist at that time," he states. "And I would say that from 1999 until 2008, the solutions were limited to mobile AMR for water. The industry turned a corner in 2008 with the technology and pricing for AMI systems. Now we have two-way communication and reliable battery life that will match the life of the water meter itself, which is designed for about 20 years of service. And then, the costs came down.

"So we have longer life battery technology and lower prices, but, even before the costs came down, Johnson [Controls] was using its experience as an ESCO [energy service contractor] to offer utilities performance contracts that made infrastructure projects budget-friendly," adds Hannah.

When an ESCO enters a performance contract, it guarantees savings over the contract period—10 to 15 years is typical—and the savings pay off the capital investment in the improvement. It's not unusual for the new energy efficient equipment and systems to have an immediate cost savings impact, and at the end of the contract the utility owns the new infrastructure, while continuing to benefit from the efficiencies that have reduced their bottom line. Performance contracts that combine water and energy projects into a single package can maximize returns on an entity's investment.

Hannah recalls that Johnson Control's first water and energy package happened in 1999 during a performance contracting project for the city of Hamilton, TX. Efficient lighting and environmental systems offered significant savings and benefits. But there was another nagging problem: Hamilton's water system included meters over 20 years old, most of which were losing the utility money due to decreased accuracy.

"They couldn't raise water rates, but still needed to replace those meters," says Hannah. "So Johnson [Controls]

The subject of leak detection on the customer's side of the meter gets a lot of attention as a major benefit of smart meters, but there are equally impressive benefits on the utility's side of the meter.

looked at improving available usage and increasing billable revenue, and operational efficiencies from AMR and other factors in a traditional energy project. We found that we could use a performance contract to fund this project."

PERFORMANCE GUARANTEES

Johnson Controls cites hundreds of performance contracts with water utilities across the nation since Hamilton took the first step. For example, in 2008, the city of Hollywood, FL, signed a $13.9-million performance contract combining an automated water meter reader system with a Wi-Fi wireless communications platform, and solar-powered, multi-space Wi-Fi parking meters. Operational and energy efficiencies were projected to save Hollywood more than $23 million during a 15-year period, with guaranteed performance and compensation to the city if shortfalls occur. Other cities with similar projects include: Cumberland, MD; Tyler, TX; Mount Vernon, IN; Harrodsburg, KY; Patriot, IN; and Lancaster, SC.

The adoption of AMR/AMI by Johnson Control's customers would seem to provide a lot of evidence of industry-wide acceptance, but a good percentage of the industry is still skeptical, according to David Hughes, Water Distribution Infrastructure Lead for American Water Innovation and Environmental Stewardship in Mount Laurel, NJ.

"The big question remains: Is it worth the investment," says Hughes.

Nonetheless, he does see many solid benefits that will contribute to the bottom line, such as the ability to analyze the usage of specific commercial customer segments. For example, by focusing on a customer such as McDonald's restaurants and tracking water usage, the data could likely reveal a range of high, middle, and low consumption.

"The middle is probably a good example of average usage, and maybe the low-reading locations might have a bypass or meter that's not running quite right," explains Hughes. "Then, with the restaurants that run high, there could be something like a broken toilet that's wasting water. So that's the kind of analysis that you can get into, and that's one example of hundreds that relate to customer usage and conservation."

The technology does have great potential, agrees Guerry Waters, vice president of Industry Strategy at Oracle Utilities, a division of Oracle Corp., in Redwood Shores, CA. "Water has become a major topic across the nation, and I think the drivers behind it [AMR/AMI] are conservation and leak detection," says Waters.

Oracle doesn't make meters or other hardware. Instead, it focuses on maximizing the data from smart meters. And of course, the subject of leak detection on the customer's side of the meter gets a lot of attention as a major benefit of smart meters, but, Waters notes, there are equally impressive benefits on the utility's side of the meter.

"Smart meters give you overall data about consumption, but they also give a fine granular description about where and when water is being used, so you can cross correlate that with your assets and understand the impact," he says.

An example would be using the data to model a distribution system to determine the energy consumption of a particular pump and the customers that it supplies. With detailed data on usage and flow, the capabilities of a pump can be analyzed for maximum performance and efficiency.

THE WATER ENERGY NEXUS

Such activities relate back to energy consumption, sometimes referred to as the water energy nexus, a critical factor for water utilities. "The water infrastructure is a major consumer of energy, so in this day and time of energy conservation and lowering costs, there is a lot of attention being paid to it, and it's something we hear about often these days," says Waters.

Don't forget about lowering costs through savings in labor, adds David Stoddart, vice president of Neptune Technology Group, Ontario, Canada. "One of the key initial reasons for the move to AMR and AMI is that labor is becoming scarce, while at the same time, there is a desire to move to more frequent monthly billing," notes Stoddart. "Here in Canada this has happened in areas where labor is not abundant, such as the oil patch area where most of the inexpensive labor has been absorbed with those jobs. That means meter reading labor has become a higher cost for utilities, and AMR is a way to reduce those costs."

As an example, the City of Toronto, Canada, has embarked on a wide-ranging project that will benefit from reduced labor and other AMR and AMI services. In January 2010, Toronto chose Neptune as the prime contractor for the supply and installation of lead-free water meters and a fixed area network and AMR system, covering the city's 465,000 water services accounts.

It's a major contract, scheduled for completion by 2015, and not without its share of complications. Stoddart anticipates installing about 72,000 meters at unmetered residences that are currently paying a flat rate, then, the balance of existing meters will be replaced or upgraded.

"In a system as large as Toronto there can be a variety of meters technologies out there, so we have to deal with whatever is installed," explains Stoddart. "As a service company, we are doing the supply and installation work and have encountered different obstacles such as plumbing problems in residences."

Beyond the residences are industrial, commercial, and institutional (ICI) meters—about 16,000 of them, in Toronto's case. "Those are the larger meters, and they generate most of the revenue so they're very important," adds Stoddart. "And that's almost a separate project."

THE DATA INTEGRATION CHALLENGE

A typical challenge going into a project of Toronto's stature is the integration of the data. "Now the problem is you have all that data and want to derive the benefits from it, so you need a way to organize it so it's more intelligent," says Stoddart. "I think that's why you're seeing more of an emphasis on meter data management due to the volume of data AMI systems can generate, and that requires tools to analyze the data so you can take action."

Large volumes of data require meter data management (MDM), another hot topic connected to AMI and another example of the staggering numbers utilities are struggling with. Consider that, in the past, data systems typically operated on the premise of one monthly read per meter. But today's meters can deliver reads as often as four times an hour. That would be 2,880 reads over 30 days. But let's be conservative and make it an hourly read, for a total of 720 reads in 30 days. That's still a data increase of three orders of magnitude and doesn't take into account additional information, such as leak and tamper, time and date, peak, and average flow, which could increase overall data volumes exponentially.

In Toronto's case, the city chose to start with reads every six hours for residential customers and hourly for their commercial industrial customers, while trusting its data to the STAR Network system from Aclara RF Systems, in Hazelwood, MO. Aclara has deployed the system in other cities such as New York City, NY; San Francisco, CA; Boston, MA; and Beverly Hills, CA.

"It is a big change," says Dean Slejko, product marketing manager at Aclara RF Systems. "And certainly, we are seeing readers becoming more powerful, in terms of the data they can gather."

When the data is gathered in a two-way communications network, it creates opportunities for analysis by methods such as Aclara's time synchronized reading feature. A time-synched network does a simultaneous read of all endpoints in a network, thus providing a snapshot of the system's usage.

By reconciling the usage snapshot with the amount of water entering the system, a utility can calculate water losses and their location. Says Slejko, "When you do that and see that you're producing 100,000 gallons yet only 75,000 are reaching the customers, it's the first step in looking at the efficiency of your system and figuring out where you need to take action to account for that 25,000 gallons."

System analysis tools are definitely of interest to water utilities, says Thomas Butler, Director of Product Marketing for Water, Itron, Spokane, WA. "Leak detection is the number one concern, and most utilities that are honest with themselves acknowledge leak problems throughout their distribution systems in excess of 10% and more," says Butler. "Actually, a utility that's losing 5% to 10% water would be considered an excellent utility, because it's not unusual to see estimates of 25%

water loss in the distribution system."

The good news is that starting a leak detection pilot program doesn't require a huge commitment or complicated hardware. Itron uses a small sensor that attaches to a water source line, and Itron has utilities that have started with pilot programs as small as 25 leak sensors.

"With AMR, readings can be done simply with a handheld mobile or drive-by system," explains Butler. "So you have a small route that can be covered and surveyed. The results can be uploaded to software that we provide and host. The utility can look at the maps of their system and it's a simple user interface that provides various color codes to define leak problems."

INFORMATION GETS GRANULAR

Itron's technology appealed to utility managers at Cleveland, OH, but data management was equally important. "They wanted a strong management system with the ability to store data and access it over time," says Butler. "One of the things utilities don't think about is the incredible amount of data and information when you're getting hourly readings from meters. You need to do more than just generate bills with this data. You want the ability to archive them for future analysis.

"It's one thing to be able to store the data from 30 to 60 days," he continues, "but quite another to show that level of granular data over a period of years. As far as where the industry is going, it's very easy for us to look at where electrical utilities are going, and we tend to adopt many of the technologies and products and services that electrical utilities offer."

The electrical utilities may have earned a smarter profile with consumers, but that could change quickly, according to John Galloway Executive vice president of business development and marketing at meter data management systems provider, Ecologic Analytics, Bloomington, MN. "We've seen a lot of focus on the electrical distribution infrastructure, but the water infrastructure is an equal if not more actionable platform," says Galloway. "We are concerned with meter data and the technologies to capture and interrogate this data, identify anomalies, and initiate connections into whatever the utility has existing within that system to communicate the action, either automated or manually."

Galloway notes that meter data can also reveal patterns and trending. Ecologic's system shows a history of consumption and gallons or kilowatt-hours against time. It's even possible to program predefined actions to be executed should a pattern or trend appear. Predefined actions could include notifying a customer, or in a critical situation sending a work crew to a location. But what if the customer didn't respond or the situation required a shut down of the location's water?

LESS STAFF, MORE PRESSURE

That's no problem, according to Scott Williamson, president, Capstone Metering, in Carrollton, TX. Williamson invented the IntelliH2O meter, an intelligent water meter with an integrated ball valve. "We built in features like an integrated ball valve and the ability to recalibrate and manage water so a utility can save on operating costs," he says. "We measure pressure and other things at the meter level, so the utility can adjust its pressure and lower cost by reducing leaks and energy consumption."

Pressure management has other advantages beyond leak reduction. For example, Williamson recalls a water district in Texas that had to maintain a minimum pressure at the meter just to keep up with compliance standards. In the past, a pressure test required sending utility staff to test multiple locations, but the IntelliH2O automates the process so it can be done from a central location without sending staff out to the field.

As with other AMI products, a dashboard style user interface monitors low-pressure or particular issues within the system and shows a snapshot of the meter network. Other features include detection and flagging options for problems. "If the meter starts flowing in full volume for an extended period of time, it can notify the utility or the homeowner of a potential leak, and from that point it can be flagged and programmed to shut itself off," says Williamson.

In this age of environmental awareness, the issue of a carbon footprint, points to another trend boosting the rapid growth of AMR/AMI technology—sustainability. In fact, one of the most visible of corporations waving the sustainability banner, General Electric, chose Capstone for a $100,000 award in the GE Ecomagination Challenge Award for 2010.

SUCCESS WITH CUSTOMER COMMUNICATION

It's more than safe to say that demonstrating a sustainable philosophy to the public is important to the water industry, and that brings up another contributor in the growth of AMR/AMI—good communications with the utility's end users. Yes, it's a critical factor, explains Karen Mills, CPA director of finance, Town of Cary, NC.

"I wouldn't say this is the biggest thing we've done, but the thing that's different about it is that it's such a large operations project," says Mills. "We are touching every single customer, and for most of those customers, we are interrupting their water service to change out their meter over a course of 18 months, where normally it would be a 12- to 15-year span."

In November 2010, the Town of Cary selected Sensus, Raleigh, NC, a supplier of utility infrastructure systems, as the technology provider for a program utilizing smart grid technologies for water management including AMI two-way communications and smart metering. The project encompasses a network of almost 60,000 meter end-points that will communicate on the Sensus FlexNet AMI network.

"We had been looking at meter reading alternatives in the early 2000s, but didn't think that it was cost-effective at the time, although it would be the right thing to do sometime in the future," recalls Mills. "We looked again 'round 2005, yet there were still some issues that prevented us. In 2009, we started again in earnest with an evaluation that took about a year. It included a cost-benefit analysis and covered all the details. The technology has come down in price, and the battery life is better. The systems were more reliable and more utilities had adopted the technology, so there was a track record, and that made it more attractive."

Considering the fact that the new system would be, "touching every single customer," Mills says an extensive public outreach was important and included community meetings, announcements in utility bills, signs in public buildings, advertisements in newspapers, plus announcements on the town's website and the public access channel. A door hanger arrives a day or two before the installation and again on the day of the installation.

Mills expects the system to help keep cost down for both the Town of Cary and its customers. "Utility bills are rising because of requirements and environmental regulations, so folks are paying a lot more attention to their bills," notes Mills. "If we can help our customers detect leaks early so they don't get a high bill, that's our goal."

The Town of Cary opted for meter readings once per hour, and long-term plans include a website that customers can access to see their usage.

According to Mike Tracy, vice president of North American water for Sensus, the frequency of readings requires the support of a strong and reliable communication network. "The FlexNet system uses a dedicated, primary-use FCC [Federal Communications Commission]-licensed spectrum," says Tracy. "It communicates with two watts of power, and that means that we can go to a town like Cary, and, rather than put a collector every square mile or so depending on the topography, we often can cover about 10 square-miles with one tower-based collector unit. Environmentally, it's more acceptable to communities like Cary that don't want devices strung up on towers every square mile."

As for cost savings, Tracy cites the results of a project at Redwood City, CA, where the utility serves about 83,000 customers. "They had experienced a three-year drought, and there was a lot of pressure to take proactive measures to conserve water," he recalls.

A Sensus AMI system collected data every four hours, and, as a result, they established water budgets for their customer base along with programs to address agricultural irrigation sites that consumed large volumes of water. "The pilot program was a great success and saved more than 80,000,000 gallons of water, which represented about a 15% of their consumption from 2009, compared to 2008, "says Tracy. "Some irrigation customers reduced their bills by as much as $75,000."

FAST PAYBACK VERSUS PROJECT LIFE

Such savings are an important consideration when a utility is evaluating the financial impact of a decision to improve their water infrastructure, but in the case of the Town of Cary, A fast payback wasn't a major issue in their decision, and it provides evidence of another factor driving the accelerated growth of AMR/AMI.

"The benchmark of three to five years for a return on investment is fair for decisions where markets change and there's competition," says Mills, "but it's a safe bet that we are going to be in this business for another 20 years, and our payback is about nine years on a 17-year project life. We feel that's adequate."


GLOBAL WATER

A low-water-use landscape managed with Irrometer's technology

Another safe bet is that no matter the payback time, some utilities are under severe budget constraints, yet still need to address their leakage problems. However, Transparent Technologies, in Boulder, CO, has a solution that can extend the life of a utility's existing meter network, and add the benefits of AMR and AMI. The idea uses an electronic register with built-in AMR that can attach to existing meters and restore accuracy. Utilities can start with a drive-by system and later migrate to a two-way wireless broadband network using Transparent's NexusNet product.

Transparent's sending unit is embedded in the electronics along with the antenna and it's targeted for southern and western parts of the US where meters are typically in shallow pits, though above-ground installations also work. "If you look at the country, the northeastern utilities have adopted AMI, because they have such great performance with equipment mounted on walls and buildings that can send information miles away to collectors," says Ted Worth, president of Transparent Technologies. "But if you try that in Florida, you're going to miss 40% of your meters, because these are below-ground and often filled with water."

As for the economics, swapping a register can save substantially over swapping an entire meter. "To give you an idea, radios are going to cost about $100 a unit, but if you can save the cost of not having to replace a $35 water meter, you cut your installation costs by about $15 and you restore the accuracy, which is typically about a $5- to $10-year edition in revenue," he says. "And then, you add the typical labor and expenses of a meter read. Typically it's about one dollar per meter, but when you go to AMR, it's reduced to about five cents a meter read. So it all adds up to a substantial savings and quicker payback."

TRACING THE ROOTS OF AMI

Worth referenced the substantial impact of AMR/AMI in the northeastern regions of the US, and Trevor Hill, CEO, Global Water, Phoenix, AZ, agrees, but notes that the trend is heading west at a fast clip. "Remember that AMI tracks its roots back to difficulties in meter reading on the East Coast during harsh weather," says Hill. "It's only in the last decade that we have seen it migrating to use as water scarcity management tool."

An owner and aggregator of 16 utilities around the Phoenix area, Global Water began deploying AMI solutions and quickly found itself dealing with the same volumes of overwhelming data that others have seen. The company's Information Technology (IT) department set about coming to a solution and developed FATHOM, an AMI software product that incorporates an array of MDM analysis tools that demonstrate the baseline for any competitive AMI technology. These include: hourly reads, real-time presentment, live customer interface, usage alerts, leak notifications, consumption comparisons, and ordinance enforcement.

"We did this for ourselves because a single volumetric data point tells very little information," explains Hill. "There's nothing about trends, or the customer, or where you're flow is occurring. So we built these databases over the past five years that are totally useful for endpoint customers. If you sign up for one of our systems, you can specify that you get a text message on your cell phone when your bill surpasses $100 in a particular month, or for any day you exceed 300 gallons, or when usage exceeds the average mean for your neighborhood. Now we are parsing the data in specific ways for endpoint customers and also creating a means for discovering leaks and water efficiency problems inside communities."

Hill says he has seen a slow uptake for AMI among utilities with less than 100,000 customers, and that much of the blame falls on their limited access to sophisticated IT departments. "By hosting all that data for them in our cloud environment, cities like Grass Valley and Covina can access the data in useful ways," says Hill.

In November 2010, the City of Grass Valley, CA, selected Global Water to manage its growing AMI network. Grass Valley currently bills 4,200 service connections. Also in 2010, The City of Covina, CA, began using FATHOM's customer information system and contracted for advanced metering infrastructure and asset management products. In January 2011, Covina added Global's 24-hour call center and certain customer billing functions. Covina currently bills 8,600 service connections.

An interesting facet of Covina's purchase, and another factor that bodes well for the growth of AMR/AMI, is the team effort involved in the financing. Funds were provided through a syndicate of underwriters led by Clarus Securities Inc. and CIBC World Markets Inc. Other members include RBC Capital Markets, TD Securities Inc., GMP Securities L.P., and National Bank Financial Inc.

Hill notes that another area of growth is the evolving transition between the past and future chain of sales for water meters. Says Hill, "There is a dichotomy in the sector right now because historically water meters were sold by representatives and distributors to tens of thousands of municipalities. The meter was a low-tech device that didn't require

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much aftermarket support, and AMI vendors initially perhaps assumed that this new technology could be sold in a similar way. But, when you think about it, you realize that AMI endpoints are really just a part of a complex met network. And it's the network that has the value, and how the data is sliced and diced."

CHANGING CUSTOMER USAGE HABITS

In drought-challenged states throughout the West and Midwest, Hill predicts that much of the network's value will come from conservation efforts that target end users directly. With an AMI system's capability for real-time usage data, utilities and districts can develop plans with incentives to modify customer usage habits. Global has developed and implemented a rate design plan called "Rebate Threshold". The plan establishes a mean average point for a community, and if a customer's usage rises above that point, their cost for water rises correspondingly. If a customer stays below the mean average, they qualify for a partial refund or rebate funded by the high-usage customers.

"We see this moving into complex rate designs that motivate customers and supply them with alerts and warnings, so they have feedback in near real time," says Hill. "It gives cities tremendous flexibilities. And cities are asking us about the most effective rate designs. They want to know if the AMI program could be funded by egregious water users, and we say absolutely."

Accessible funding for smaller utilities and water districts should add even more momentum to the AMR/AMI marketplace. Whether it grows at the same healthy rate observed by the *Scott Report* in 2010 remains to be seen. But the industry is making technical strides in many different areas. Meters are improving in accuracy and reliability, and battery life expectations are rising to 20 years. Prices have fallen, and then, too, there are economical options for upgrading legacy meters with "drop-in" registers.

Numerous manufactures and software developers now offer powerful meter data management software, and the industry's track record in reducing leakage will further help utilities gain confidence in the financial benefits of investing in new technology. And, finally, there is the continued success of companies that offer performance contracts with guaranteed paybacks. All told, it appears safe to say that the industry and technology has certainly reached a state of critical mass. Yet, as Hughes of American Water is quick to observe, there are hundreds of potential applications for the technology that have yet to be implemented. So, for utilities from large to small, the accessibility of a wide variety of AMR/AMI technologies looks very good. **WE**

Ed Ritchie *writes on water, energy, transportation, and communication technologies.*

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WHY DO WE PAY FOR WATER?

Sustained water conservation by combining incentives, data, and rates to affect consumer behavioral change

BY TREVOR HILL AND G. SYMMONDS

ISTOCKPHOTO.COM/F

Water scarcity is a looming problem and changing individual behavior to compensate is a key constituent of sustainability. Behavioral change is a complex task requiring a combination of appeals, information, financial and social influences, and barrier elimination efforts. Implementing these concepts has been notoriously difficult, and it is only recently that advances in data access and presentment have allowed for a program that encourages behavioral change—providing a detailed, highly granular personalized understanding of consumption patterns, which, combined with financial incentives and social pressures, results in sustained resource conservation. Developing a rate design to complement the demand destruction and ensure the financial health of the utility is a vitally important component in achieving sustainability.

WHY DO WE PAY FOR WATER?

In the 13th century, the City of London embarked on the construction of 12 "conduits"—designed to bring water from springs to cistern houses. From these cisterns, the water was piped to larger storage facilities equipped with cocks or taps for dispensing the water. In the early 14th century, it was decided that brewers, cooks, and fishmongers should pay for the water they used at the discretion of the keeper of the conduit, whose chief duty was to ensure that the water was not stolen for commercial purposes (Hansen). Water "cobs" hand-delivered water on a fee-for-service basis from the cisterns to the City's residents. Water had acquired "value."

The growing population soon outstripped the existing conduits, and the polluted Thames River was increasingly less desirable as a source. The solution was to construct the "New River" aqueduct system to bring water from springs in the countryside to the City. This 60-km aqueduct was enormously expensive, requiring significant investment. The king provided half the funds (for which the royal household would receive "for ever the one halfe of the benefitt profitt"). A further 29 investors completed the funding and the aqueduct and distribution system was completed in 1613. Water had become a "business."

But it was not until 1633 that the New River Company began distributing profits to its shareholders. The infrastructure costs far exceeded the carrying capacity of the revenue derived from the system.

These examples demonstrate—from a very early point—the financial complexity of water service provision: Infrastructure is massively expensive; investors demand returns; and ensuring the cost recovery of operating and maintaining delivery systems are essential in sustaining service.

The same holds true today. Water remains the most capital-intensive utility business in which to operate. The National Association of Water Companies notes that, "for a water utility to earn a dollar, nearly $3.40 must be invested in infrastructure, an intensity that approaches an average of three times that of other utility sectors" (*Price, Cost, Value*).

THE CERTAINTY OF DEMAND DESTRUCTION

While most municipalities have means for recovering costs for the provision of water service, the underlying rate structures and the principles and goals vary widely. Today, water utilities must operate in the reality of decreasing supplies, increasing costs, and revenue reductions.

Water utilities must now permanently destroy demand to survive resource scarcity. How to do this without also destroying the financial viability of the utility will be the fundamental problem of 21st century utility management. Particularly since the infrastructure requirements for water sustainability (water reuse, dual water mains, control systems, treatment) and water suitability (treatment, etc.) will continue to increase the cost of providing service to consumers.

BEHAVIOR MODIFICATION TOOLS FOR FINANCIAL AND WATER RESOURCE SUSTAINABILITY

Changing behavior is a complex task. Dietz, et al. described this when referring to behavioral changes associated with carbon reduction (Dietz, et al.

2009). The applicability to water conservation is equally as strong. To be successful, water managers will need to touch consumers many times and in many ways:

> Mass media appeals and informational programs can change attitudes and increase knowledge, but they normally fail to change behavior, because they do not make the desired actions any easier or more financially attractive. Financial incentives alone typically fall far short of producing cost minimizing behavior. . . . However, *interventions that combine appeals, information, financial incentives, informal social influences, and efforts to reduce the transaction costs of taking the desired actions have demonstrated synergistic effects beyond the additive effects of single policy tools* (emphasis added, Dietz, et al. 2009).

It is clear that to be successful, it is imperative to use the influence of education, information, and incentive packages to change behavior. And they have to be easy to implement and use for the consumer.

While the majority of the reasons to conserve have historically been altruistic, there now exist powerful tangible reasons for conservation, including real scarcity, growing populations, and a desire to reduce costs. Further, if a financial incentive can be developed such that consumers are rewarded for conservation, the untapped power of positive reinforcement can be brought to bear on water use.

However, in many cases, rate designs are such that achieving conservation via increased consumer costs inevitably result in decreasing revenues for the utility. Establishing a rate structure that destroys demand without destroying the utility financially is critical for our water utilities to continue to manage this vital resource.

THE CERTAINTY OF INCREASING RATES

Increasing demand, decreasing quality, increasingly stringent water-quality requirements, deteriorating infrastructure, and the future impact of climate-induced variability are straining water resources and the utility's financial capacity to address them. The cost of acquiring, producing, treating, and delivering water is going up. The result: higher prices for consumers. Ironically, conservation does not mean prices will decrease for all consumers. Properly capitalized, financially solvent utilities are the cornerstone for the investment we need in a sustainable water future.

The question is whether regulators, or city councils, have the will or the ability to execute on a strategy that brings both financial stability and conservation at the same time. As we know, the result of price increases will be public outcry —but does it have to be? As Scott Hempling of the National Regulatory Research Institute (NRRI) points out, those years-long rate freezes lull the public into thinking rate stability is an entitlement. When, after 10 years of below-cost rates, the commission realigns rates with cost, the following happens:

1. Voters don't offer thanks for the prior windfall; they protest the new levels, loudly.
2. Politicians fan these flames, making rational policymaking difficult.
3. The compromise arrives, usually more pain deferral than pain sharing, thus skirting the underlying problem (the public's lack of acceptance that utility costs, like all costs, rise). What works in politics —mediating between positions— rarely works in regulation, where the midpoint between two wrong answers is a third wrong answer.

The problem is that regulators (be they public utility commissions or City Councils) do not regulate consumers, but utilities. And if conservation is a public interest goal, they must provide the incentives to consumers *through utilities*. Part of that program is getting the prices and price signals right so as to eliminate waste, but also to serve the competing goals of consumer protection, utility financial stability and achieving water sustainability.

Hempling continues: "Rate design is the key to consumer protection. To moderate cost increases, we must moderate the demands that cause costs. Rate design offers the double anti-oxymoron: price increases are consumer protection, because (1) price increases change behavior, and (2) behavior change yields lower total costs" (Hempling 2009).

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PRICE ELASTICITY OF WATER

One of the conundrums of developing conservation oriented rates is the fact that at current prices, demand is unresponsive to price. However, Olmstead notes that any estimate of price elasticity "represents an elasticity in a specific range of prices." That is, if the total cost is low, the response to increasing costs will be low. As prices increase—and they surely must—responsiveness increases. This presents some interesting rate design issues, as elasticity will begin to occur at higher tier levels within the same classes of consumers.

In general, the long-term impacts of price elasticity are greater than the short-term elasticity. This is a result of the time required for consumers to react to the implementation of higher rates and to the completion of the necessary modifications (behavioral and infrastructure) to achieve reductions in consumption. For example, if a large step-function increase in rates is applied, consumers may immediately be able to reduce some discretionary consumption, resulting in a dip in demand. However, to complete the reaction, in some cases retrofitting fixtures, replacing landscaping, increasing internal water reuse will occur, and that process will take time.

On average, a 10% increase in the marginal cost of water can be expected to reduce residential demand by 3-4% in the short run. In the long term, such an increase could be expected to yield a 6% decrease in demand (Olmstead).

Clearly, price sensitivity to water resulting in demand reductions will reduce utility revenue. A true conservation-oriented rate structure must take into account this revenue destruction that is concomitant with demand reduction.

RATE TUNING—THE CARROT AND STICK

The Rebate Threshold Rate (RTR) structure allows for utilities and regulators to tune rates to achieve specific objectives. For instance, the rebate threshold can be incrementally lowered to drive consumption down. Or the granularity of tiers can be altered to ensure that lifeline water supplies always remain within access for

Continued on pg. 51...

Rebate Threshold Rate Structure

Today, the altruistic desire to conserve is being overtaken by real practical requirements. Water scarcity, dwindling historic supplies, environmental diversions, population growth, and regulatory requirements are all conspiring to send a clear message—use less water tomorrow, and even less the day after that. However, the decisions that drive conservation are most often based on economic factors at the household level. The Rebate Threshold Rate (RTR) structure is designed to reflect this reality and to maximize the behavioral change opportunities for consumers. This is achieved by the adoption of three basic elements in the RTR:

- Volumetric Rebate and increasing volumetric charges in higher tiers to compensate;
- Increasing the number and granularity of tiers; and
- Achieving some measure of rate decoupling by increasing the fixed-rate component.

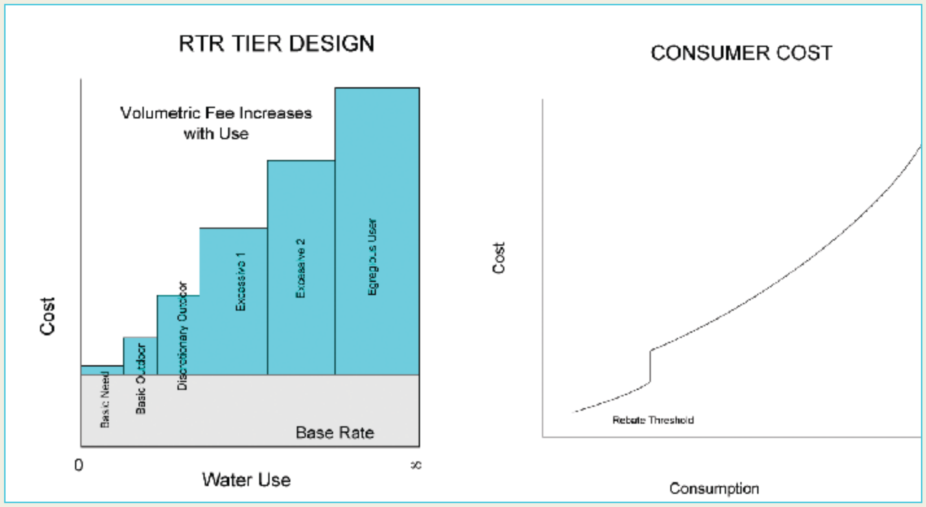

Figure 2: Rebate Threshold Rate structure

VOLUMETRIC REBATE

The volumetric rebate allows for residential customers who achieve real, immediate reductions in water consumption to realize an immediate reduction in their volumetric charges. Any time a customer achieves a consumption level below the Rebate Threshold, the customer is entitled to receive a reduction in volumetric charges (commodity charges). That reduction is typically 45% to 65% (figure 2). This reduction is shown as a "conservation rebate" on the consumer's invoice.

The rebate threshold is established at a percentage of the average residential consumption for a specific period, and remains static between changes in rates, but it could easily be tuned annually or as desired. As water elasticity occurs over longer timescales, it is important to allow people sufficient time to develop personal water management techniques and practices to maximize their benefit.

A key supporting element of the RTR rate design is consumer feedback with sufficient granularity for the consumer to make changes in near-real time to control their costs.

> The decisions that drive conservation are most often based on economic factors at the household level.

VOLUMETRIC TIERS

An increase in the number and granularity of tiers in the RTR structure allows customers to manage their usage, even if they are not below the Rebate Threshold and still achieve meaningful cost reductions. Further, it ensures that there are greater financial disincentives as water use increases.

Today, utilities typically employ a two or three-tier rate structure in an IBR design. The downside is that by limiting rate design to two or three tiers, those tiers are by necessity broad, limiting the ability for customers to manage their consumption in a cost avoidance manner. This means that customers have fewer opportunities to manage themselves to a lower tier. In addition, the financial incentive for conservation in an IBR design ends far below a customer's consumption, meaning there is no increased marginal cost to carry on with that behavior-modifying activity.

Increasing the number of tiers offers a number of "gates" through which the consumer has the option of passing, or not, placing the control of the consumer's volumetric costs squarely in the hands of the consumer. In the case of a two- or three-tier system, the gates are passed too quickly and with little fanfare. The incentive to conserve through the traditional two- or three-tier price points is lost immediately upon entering the final tier. With a six-tier design, customers have an incentive to think about different water price points throughout the consumption spectrum (figure 2).

In a six-tier RTR system, with the tiers established across effective thresholds, the customer has an opportunity, through active management, to maintain his or her consumption in a lower tier, and receive the benefit of the lower rate. Also with a six-tier system, finer modifications to rates can be achieved, saving

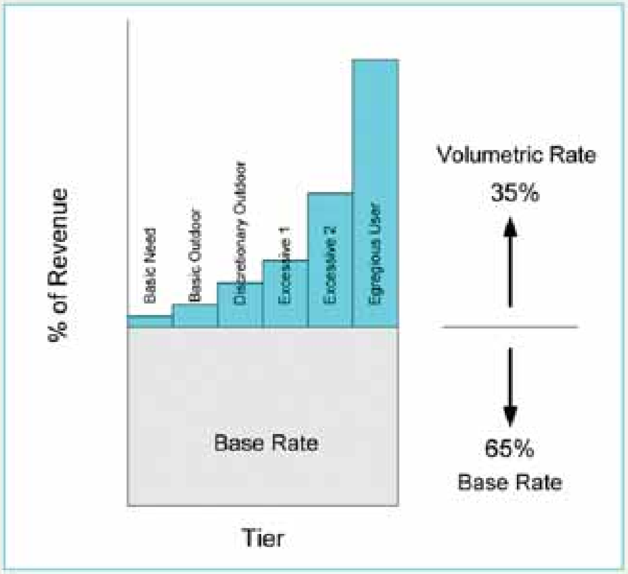

Figure 3: Rebate Threshold Rate structure revenue allocations

customers money, and reinforcing the conservation message. Tiers can also be tuned to specific users, if desired, building on the "individuality" of the water budget-based rate structure.

REVENUE DECOUPLING

The Monthly Minimum Charge (or base rate or basic charge) allows the utility to effect meaningful, measurable and repeatable resource conservation without the implosion of utility revenue. Historically, support for conservation in the water utility business has been suspect: the utility knows that by encouraging its customers to use less, there is a real chance of revenue reduction, and potentially a conflict with "used and useful" doctrines as infrastructure may be seen as "unnecessary" in the context of a reduced demand.

To achieve conservation goals, we must break the cycle of selling more water. By allowing for the recovery of fixed costs with a bias toward the monthly minimum, we can achieve both goals.

From a theoretical economic perspective, the provision of water service can be separated into infrastructure (fixed) and delivery (variable) costs. In practice, the dividing line is not as neat. Nor should it be, particularly as the goal of rates shifts from specific cost recovery, to behavioral modification for the purposes of resource management.

Attempting to definitively separate infrastructure and delivery costs can lead to some unintended consequences. As utility plant depreciates, there can be a tendency for regulators and city councils to reduce the "fixed" component of water rates (with the belief that full cost recovery has been achieved) and recover more utility costs through the "variable", or volumetric component. Under this condition, the utility loses its incentive to encourage conservation, because a reduction in use means an immediate reduction in revenue. Further, there is no incentive for the utility to invest in replacing aging infrastructure.

Clearly, if the bias is toward 100% cost recovery via monthly minimum charges and no increasing commodity rate, there is no incentive for the consumer to conserve. Conversely, biasing rate structures to recover all costs via the commodity rate creates a strong economic disincentive for the utility to promote water conservation. By establishing a reasonable apportionment of costs to the monthly minimum and the commodity costs, both goals are achieved.

By generating approximately 65% of the revenue from monthly base fees (figure 3), the financial viability of the utility can be assured. This is a key differentiator between the RTR and standard rate designs. The RTR design requires that the higher users contribute more as a function of consumption, but also that more of the revenue is achieved through the fixed component. This is a recognition that the fixed costs do not simply represent infrastructure, but the "operational availability" of infrastructure.

Rate Design

The primary purpose of any rate design is that it generates the necessary revenue for the utility in a manner that is fair and based on the cost of providing service (Rubin 2010).

Various forms of rate structure have been developed and employed, not all of which satisfy Bonbright's and Phillips' effective rates criteria. In municipal applications, water service has been provided under many differing cost recovery mechanisms, notably:

- Free
- Fixed Fee (no volumetric rate)
- Uniform Rates (fixed base rate + static volumetric rate)
- Declining Block Rates (fixed base rate + decreasing volumetric rates)
- Pyramid Rates (fixed base rate + increasing volumetric rates for small users and decreasing volumetric rates for larger users)
- Inclining Block Rates (fixed base rate + increasing volumetric rates)
- Water Budget-Based Rates (based on housing population and landscaping)

All of the "standard" rate designs suffer from significant shortfalls when it comes to encouraging conservation while preventing utility financial distress.

Free Water

Clearly free water is no longer an option —although it still exists in many jurisdictions. And in reality, it has never been free to constituents as the costs of operating any municipal infrastructure are recovered through some revenue stream. The primary problem with free water is that it perpetuates the invisibility of water while simultaneously reinforcing the myth that water is ubiquitous and continuously available.

Fixed Fee

Prior to metering (and in some cases even with metering), water charges were assessed on a flat fee structure. All consumers paid the same fees regardless of usage (e.g., $20 per month). While this has the benefit of generating revenue for the utility and increasing the awareness of water for the general public, there is no incentive for the consumer or the utility to reduce usage.

Uniform Rates

Uniform rates provide for a small "fixed" fee with a non-variable volumetric charge. This rate structure provides no incentive to conserve (that is, there are no additional charges for using more), and the small fixed component drives the utility to encourage consumption as a means to ensure revenue or even to generate incremental revenue.

Declining Block Rates

Declining block rates are employed to provide volumetric breaks to large consumers under the premise that the marginal cost of providing large amounts of water to a small number of users is lower than providing the infrastructure, operations and maintenance for a large number of lower consumption users.

However, in many cases, large water users can actually define a system's necessary capacity (and thus the cost of the system's infrastructure.) As an example, if you consider that a large industrial consumer may demand short periods of 2000 gallons per minute, this is the equivalent of the peak hour flow from 3400 single family dwellings. Notwithstanding that the demand may be intermittent, the infrastructure needs to be there.

Regardless, the declining block model encourages the consumer and the utility to increase consumption—the consumer because his or her marginal cost declines with use, and the utility must sell more water at a lower cost to ensure the revenue requirement is met.

Pyramid Rates

Pyramid rates combine Inclining Block Rate structure and Declining Block Rate structures in an attempt to eliminate the detrimental aspects of each. In this case, consumers are charged higher volumetric rates as consumption increases to a specified point, and then volumetric costs decrease.

Such a system does not promote conservation for the higher consumer. Wang notes "It is likely not accurate, however, to consider pyramid block rates to be water conservation-oriented rates, as they result in the highest consumers within the commercial class paying less per unit that those who use less" (Wang, Smith, and Byrne 2005).

Inclining Block Rates

With inclining block rates, more consumption means higher cost. While recognized as a water conservation rate structure, the Inverted Block Rate (IBR) structure encourages the utility to maintain consumption levels because the marginal revenue decrease from conservation occurs at the higher rate. In addition, IBRs are typically designed with low price signals (that is small tier increments) and broad tier ranges that lose effectiveness quickly in the consumption spectrum.

Water Budget-Based Rates

Water budget-based rates define "normal" usage for a particular property based upon actual water use, size of meter and the customized water budget for the property. Consumers whose water use remains within their water budgets are billed the lower rates, and consumers who exceed their budgets are billed at higher consumption rates.

The water budget is calculated for residential customers based upon surveys conducted of each customer's lot size and landscaped area, the number of residents in each home and localized weather data. Water budgets change with seasons. For commercial applications, water budgets are established on rolling averages of use.

A key difficulty in establishing water budgets is the necessity to frequent and up-to-date property information with respect to population and landscaping, increasing manpower commitments to manage the program.

SUMMARY

All of the "standard" rate designs suffer from significant shortfalls when it comes to encouraging conservation while preventing utility financial distress. A new form of rate design, the tunable RTR structure, alleviates these problems.

low-income households. Or the utility can establish tier levels to derive more revenue from egregious users to fund conservation infrastructure projects. Or the utility can fine-tune the "gates" for individual users.

As an example, if a utility desires to fund conservation infrastructure (e.g., recycled water distribution systems, Smart Grid for Water installation, etc.), it can increase the cost of higher tier water (tiers 4, 5, and 6) while maintaining lower tiers to ensure accessibility to water for all.

Alternatively, a utility may wish to reduce overall demand due to dwindling resource availability. In this case, the utility can shift the rebate threshold to a lower volume, providing an economic incentive for all users to reduce demand. Users around the rebate threshold will adjust usage to maintain their economic incentive, and users above the threshold will adjust usage to remain in lower cost tiers (figure 1).

DATA REQUIREMENTS

To be effective, the RTR structure requires that consumers be afforded access to highly granular, near-real-time data. The consumer needs to have the opportunity to review daily consumption, and make an economic decision based on that information. But equally important is the data presentment or in Dietz's parlance, "informal social influences." To be successful, a conservation program must get the data out to customers and make the change financially beneficial to the consumer. But even further, people must be given the "geotemporal" context of their consumption:

- How much water do I use?
- How do I fare compared to my street, my neighborhood, my city?
- How much water should I use?
- Based on weather data and evapotranspiration calculations—how much should I have used outside?

Robert Cialdini, a psychologist at Arizona State University, recently notes, "People don't recognize how powerful the pull of the crowd is on them. . . . We can move people to environmentally friendly behavior by simply telling them what those around them are doing" (Simon 2010).

A recent study completed by California State University indicated that through the provision of instantaneous feedback on water consumption, average water consumption reductions in the order of 14% can be achieved (Schultz).

Combining price structure and appropriate signals, financial incentives, information, and subtle societal pressures, consumer behavior can be altered to the point where he or she asks the questions: "Do I need to use that gallon of water? And, "Am I prepared to jeopardize my financial incentive to use the next gallon of water?"

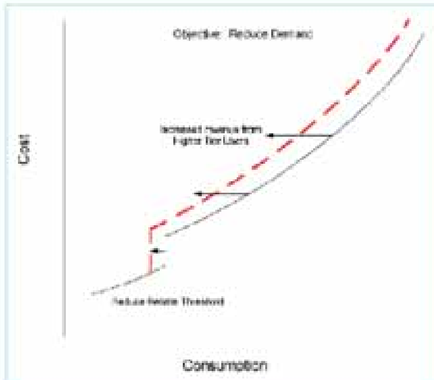

Figure 1: Adjusting demand with the Rebate Threshold Rate structure

CONCLUSIONS

The cost of water is going up while the availability of the resource is declining. In order to facilitate the survival of our natural resources, and our water utilities, a new pathway on rate design and cost recovery needs to be developed. The RTR structure allows communities to determine conservation goals and tune rates to achieve them, while ensuring the financial stability of the water utility. By employing education, incentives, and information in easily digestible and actionable forms, utilities can achieve sustained, meaningful reductions in demand, water sustainability, and financial sustainability. **WE**

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REFERENCES

Bonbright, J. C. 1961. *Principles of Public Utility Rates*. New York, NY, p. 291.

Dietz, T., G. Gardner, J. Gilligan, P. C. Stern, and M. P. Vandenbergh, 2009. Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. *Proceedings of the National Academy of Sciences* 106 (44): 18452–56.

Hansen, R. D., Water-related Infrastructure in Medieval London. ***www.waterhistory.org/histories/london/london.pdf***, pp. 4–5.

Hempling, S. 2009. Low Rates, High Rates, Wrong Rates, Right Rates. National Regulatory Research Institute. ***http://nrriservices.org/index.php?option=com_content&task=view&id=179&Itemid=38***.

Olmstead, S. M., R. Stavins. 2009. Comparing price and nonprice approaches to urban water conservation. *Water Resources Research, 45*, W04301.

Phillips, C. F. Jr. 1993. *The Regulation of Public Utilities: Theory and Practice*. Arlington, VA, pp. 434–435.

Price, Cost, Value. National Association of Water Companies. ***www.nawc.org/resources/documents/pdf/price-cost-value_brochure.pdf***.

Rubin, S. J. What Does Water Really Cost? Rate Design Principles for an Era of Supply Shortages, Infrastructure Upgrades and Enhanced Water Conservation. National Regulatory Research Institute, July 2010.

Schultz, W., W. DeCianni, and A. Roldan. Water Conservation Pilot, California State University, San Marcos, ***www.kysq.org/docs/Aquacue.pdf***.

Simon, S. The Secret to Turning Consumers Green. *Wall Street Journal*, October 18, 2010.

Wang Y. D., W. J. Smith, and J. Byrne. 2005. *Water Conservation-Oriented Rates: Strategies to Extend Supply, Promote Equity, and Meet Minimum Flow Levels*. Denver, CO: American Water Works Association, p. 12.