Can the Cost of Smart Meters be Offset by Insurance Benefits to Customers?

John P. McCary

John P. McCary, Ph.D., P.E., is engineering team leader for potable and reclaimed water planning for Hillsborough County Public Utilities Department in Tampa.

Recent advancements in the utility industry have made high-frequency water use data more readily available as the use of automatic meter reading (AMR), Advanced Metering Infrastructure (AMI), and smart meters become more prevalent. Since these terms have been used referring to a broad range of applications, a definition is presented for each that defines their capabilities for use in the current research.

- The AMR allows local storage of data, where a human activity is necessary to download it. This typically involves driving by and downloading data with short-range wireless equipment.
- The AMI allows this data transfer to occur without human intervention, using telemetry systems, where the local data can be transmitted to a centralized data storage system.
- Smart meter systems go beyond the transmittal of data and involve some level of analytics, either at the local meter itself or at the centralized operational system.

Historically, most utilities read a customer's meter at monthly (or longer) intervals. Both AMR and AMI are making it possible to have high-frequency (one second to one day) meter reads for every customer in the water system. The AMI is allowing communication between the meters and operational systems that can store and use these high-frequency reads for decision support services. This transition from monthly to high-frequency water use data allows operating decisions to be made with near real-time demand analysis; however, serious consideration needs to be given to the value added by such data and systems. Analyses need to be performed to determine the potential savings of installing such systems prior to utilities making major investments to upgrade telemetry networks, decision support infrastructure, and customer meters.

An untapped application of smart meters has the potential to provide significant savings to customers if pipe breaks in residential plumbing can be detected and the customer notified prior to significant damage occurring. Intended event ranges must be defined so that rapid notification can occur through "report by exception," where the flow data are monitored at the local device level and reporting only takes place if there is an exception to the expected data within the ranges. For this to be successful at the individual customer level the event must be detected and notification provided as quickly as possible.

Emerging Uses for Customer Smart Meters

As the use of AMR, AMI, and smart meters has become more prevalent, multiple studies have emerged documenting savings to utilities and customers. The initial utility focus of these systems was on reducing the staffing needed for meter reading. For AMR systems, this would involve driving by and downloading the data using short-range radio communication, as opposed to manually reading each meter; for AMI systems, this would involve the data being automatically uploaded to a central database system used for billing. The Kansas City (Mo.) Water Services Department was able to eliminate 33 meter reading positions and use daily AMI reading to reduce meter rereads and leakage inspections by 90 percent, as well as reduce meter shutoffs by instead monitoring and billing vacant home use (Thiemann et al., 2011). In addition, the customers could view their own water use via a website, with future plans to allow customers to receive automatic notifications of high consumption via email or phone. Daigle and Jackson (2013) noted the benefit of the utility being able to detect irrigation events for code enforcement purposes, and this could eliminate the need for an employee to drive to multiple locations to inspect irrigation behavior when it can be detected by a smart meter.

Smart meters can also provide conservation benefits through the detection of continuous leaks. Because normal residential water use is intermittent, it's easy to identify continuous leaks, as they can be identified through continuous flow data. Cardell-Oliver (2013) indicated that alarms were set to notify the utility for continuous customer use at a utility in Kalgoorlie-Boulder, Australia. These alarms were based on data collected at one-hour intervals, and the alarms trigger interaction with the residents from the utility as appropriate for the amount of the flow. For high flow rates, the residents can be contacted immediately by phone, while medium flows may trigger a letter, and the least significant flows may simply receive advice in the regular water bill.

Table 1. Insurance Claims by Type of Damage Events

Type of Event	Annual Claims per 100 Houses	Claim Frequency per House in Years	Percent of Total
Wind and Hail	3.37	29.7	47.1%
Water Damage and Freezing	1.79	55.9	25.0%
Other Property Damage	1.04	96.2	14.5%
Theft	0.52	192.3	7.3%
Fire, Lightning, and Debris	0.43	232.6	6.0%
Total	7.15	14	100.0%

(Source: Insurance Services Office as reported by www.valuepenguin.com/average-cost-of-homeowners-insurance)

Beyond leak detection only, additional research has focused on the "self-awareness" factor, i.e., that water use awareness brings customer-initiated conservation. This self-awareness is noted by Davies et al. (2014), who investigated the impact of smart meters on reducing residential water use in the long term. A key finding was that households with an in-home display that could be used to track water usage reduced their usage by an average of over 6.8 percent when compared with the control group that did not have an in-home display. The self-awareness factor was also used to support the long-term conservation goal of the Albuquerque (N.M.) Bernalillo County Water Utility Authority, as indicated by Daigle and Jackson (2013), who described the implementation of AMI, meter data management, and customer engagement software that put the power in the hands

Continued on page 8

Continued from page 6

of the consumers. It was used to identify leaks and also allowed customers to view their consumption patterns on a near real-time basis; customize and receive usage reports via email, text, or phone; create personal conservation goals and water budgets; and download targeted educational material regarding conservation.

Potential Insurance Benefits and Overall Cost Framework

A potential application of smart meter systems is the rapid detection of pipe breaks within residential plumbing. Approximately 25 percent of insurance claims are the result of water damage (Table 1), with claims from faulty plumbing averaging over $17,000 per claim (Table 2). If plumbing breaks can be detected early during the break event, and smart meters can provide notification to customers and automatic shutoff valves, then the damage from these plumbing breaks can be minimized.

The use of automatic shutoff valves in homes has become more prevalent in recent years; however, they are typically linked to sensors in the home that have to detect the presence of water (e.g., a sensor in a laundry room that detects water on the floor). Prior to evaluating the cost- and water-savings potential, a basic framework needed to be established to compare savings to costs. The cost framework is based on actual costs for Hillsborough County Public Utilities Department. The cost for each AMI data logger with smart meter capability is $250, which covers the data storage and reporting to both customers and utilities for 10 years, with data accessible at five-minute intervals.

For the cost comparison, the $250 is assumed to take the place of any meter-reading cost for 10 years. The AMI data loggers replace the analog registers on the meters; however, no internal mechanical components of the meter are replaced or impacted in any way. As such, the addition of the AMI data loggers doesn't impact the normal replacement schedule for the meters, so no additional costs or savings are included with the addition of the AMI data loggers. Table 3 shows how this cost breaks down from the 10-year total to annual, monthly, and daily costs. For comparison, actual cost for the utility per-meter read ranges from $0.56 to $0.99. The low end of these costs is for contract meter reading (with no other services provided), while the high end of these costs includes overhead and other services by utility workers, like reporting and fixing anomalies in the field. The normal meter-read frequency based on standard meters is once per month.

Table 2. Repair Costs for Different Types of Water Damage

Cause of Leak	Average 2013 Repair Cost
Water Heaters – Internal Leaks	$3,642
Water Heaters – Valve Failures	$4,218
Washing Machine Failures – Occupied Homes	$4,959
Water Heaters – Supply Line Failure	$5,825
Flooded House – 1 to 4 In. of Water$^+$	$7,800
Frozen Pipe-Related Failures	$8,189
Bathroom Fixtures	$10,799
Washing Machine Failures – Unoccupied Homes	$12,308
Appliance Leaks – Overall	$13,467
Faulty Plumbing	$17,250

$^+$Water may be from leak or flooding

(Source: www.waterdamagedefense.com/pages/water-damage-by-the-numbers)

Table 3. Comparison of Advanced Metering Infrastructure to Standard Meter Reading Costs per Single-Family Residential Customer for Hillsborough County Public Utilities Department

Costs	10-Year Total	Per Year	Per Month	Per Day
AMI Installation Cost	$250.00	$25.00	$2.08	$0.07
Meter Read Cost, Option 1	$67.20	$6.72	$0.56	$0.02
Meter Read Cost, Option 2	$118.80	$11.88	$0.99	$0.03
Cost Difference, Option 1	$182.80	$18.28	$1.52	$0.05
Cost Difference, Option 2	$131.20	$13.12	$1.09	$0.04
Water Savings	10-Year Total	Per Year	Per Month	Per Day
Option 1, Block 1	50,497	5,050	421	14
Option 2, Block 4	16,973	1,697	141	5

Table 4. Monthly Conservation Block Rate for Hillsborough County Public Utilities for 2016

Block	Gal per Month	Rate per 1,000 Gal
1	0 to 5,000	$3.62
2	5,001 to 15,000	$4.85
3	15,001 to 30,000	$6.14
4	30,001 and higher	$7.73

Table 3 shows the costs and differences when comparing the range of standard meter read costs to the AMI costs; the resulting range of cost differences shown in Table 3 would be passed on to the customer to result in cost neutrality for the utility. While the utility could realize other potential savings, which would reduce these differences, those are not being discussed in the current study, so no additional savings are being included. Assuming that the smart meters could be used to detect plumbing breaks and notify the customer in order to prevent or reduce damage (thereby reducing the risk for significant property damage), there is potential for insurance companies to incentivize the use of smart meters. Insurance policies are typically written on an annual basis, and the required annual premium reduction would need to range from $13 to $18 (Table 3) in order to result in cost neutrality for the customer without any other savings considerations.

Aside from a pipe break or leak detection, the customer can realize other potential savings through conservation. Hillsborough County uses a conservation block structure for water rates (Table 4). Assuming that no savings are realized through the insurance premium reduction, Table 3 shows the resulting water savings that would be required in order to result in cost neutrality for the customer. In order to show a high and low end for the range, it was assumed that the highest cost difference for meter read options was applied to a customer with water use in the lowest range, thereby paying the lowest block rate; comparatively, the lowest cost difference was used assuming the savings would occur in the highest block rate.

The resulting water savings required in order for the customer to result in cost neutrality ranges from 5 to 14 gal per household per day (gphd). A key question is if actual leakage quantities are in this range so that leakage reduction can potentially result in cost neutrality for the customer. A recent study in the United States (DeOreo et al., 2016) that built upon an earlier nationwide study (Mayer et al., 1999) showed that average leakage was 17 gphd, so there is data to support the potential for these savings.

High-Frequency Water Use Data Collection

The current study builds upon an earlier evaluation for three homes where aggregate event outliers were quantified based on volumetric ranges (McCary and Heaney, 2018). This requires an understanding of intended event ranges obtained through the analysis of high-frequency databases. Figure 1 shows the intended and unintended event ranges, along with an entire year of events for one of the homes presented in the study. The aggregate events shown in Figure 1 are based on aggregating continuous periods of water use using one-minute data.

The current study focuses on the evaluation of a 128-home subset of an overall AMR pilot program that included a 191-home study area and the three homes previously evaluated. For the 191-home study area, the data were collected at either one- or five-minute recording intervals, and while the period of record was different for each home, each had at least one year of data in the range from June 2013 to August 2015.

The AMR data loggers used in this study only replaced the analog registers on the meters; no internal mechanical components of the meter itself were replaced, and the resolution of the gal reported by the AMR data loggers was as accurate as the registering capability of the mechanical components of the meter. The internal mechanical components of the meters use nutating discs capable of reading in increments of 0.017 gal. The local data storage on the AMR was limited to 32,000 data points.

The data in this study were collected by driving to each meter and downloading the data from the loggers through short-range wireless communication. The vehicle used was equipped with a radio that communicated with a local radio transmitter on each of the data loggers and each data file took approximately five minutes to download. A database was built that allowed each data file to be uploaded to the appropriate dataset for each meter. The resulting database allowed easy access to water use data by time of day, day of week, and any combination of these two.

Within the 191-home study area, there were 166 homes programmed with a five-minute recording interval, and at this interval, the data must be downloaded every 111 days in order to avoid gaps in the data. The other 25 homes were programmed with a one-minute recording interval, with the data needing to be downloaded every 22 days. An aerial map of the pilot area is shown in Figure 2. The blue parcels indicate the 166 homes with five-minute recorded intervals, and the orange parcels indicate the 25 homes with one-minute recorded intervals.

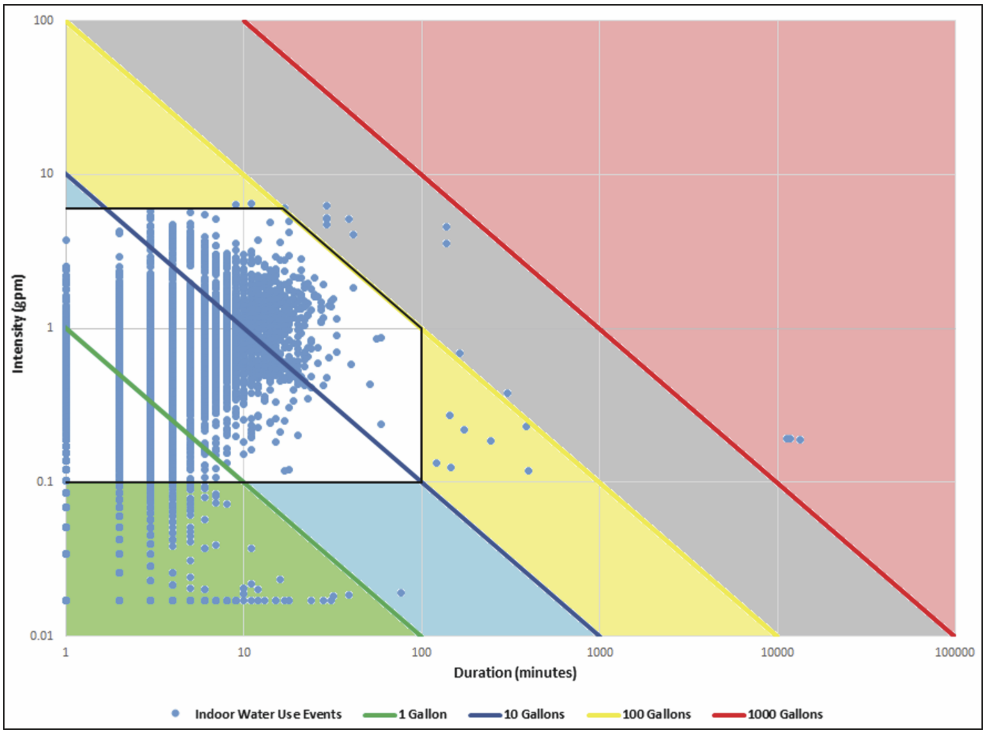

Figure 1. Aggregate Events for Indoor Water Use *(McCary and Heaney, 2018)*

A reduced dataset was used to limit the evaluation to one year in order to evaluate continuous data and develop a report based on annual statistics. Over 20 million data points were collected for the 166 homes (with five-minute data), and over 13 million data points were used for the final dataset of 128 homes that had continuous water use data for a one-year period. Likewise, over 17 million data points were collected for the 25 homes with one-minute data, although these data aren't presented in the final dataset.

Results and Conclusions

The 128-home dataset was summarized based on the criteria from McCary and Heaney (2018) to develop statistics on a per-home basis at different levels of temporal aggregation of the data. The different levels of aggregation allow for a comparison between the detection capabilities of increasing time steps from five minutes to one hour. Table 5 shows the statistics for aggregate event outliers on a per-home basis, where the aggregate event outliers are quantified based on volumetric ranges. The color coding of the unintended events that are summarized in Table 5 match the ranges that are shown in Figure 1.

For each volumetric range, there is also a percentage breakdown showing the volume contributed by individual data points within intended and unintended intensity ranges. The purpose of this percentage breakdown is to show the potential that the larger aggregate events might actually be comprised of intended uses with longer durations than normal, or more likely, that the larger time steps are combining many smaller events into what appears to be longer, unintended events. The overall process is described by McCary and Heaney (2018) in more detail.

From looking at only the conservation perspective, Table 3 indicates that an annual water savings of 1,697 to 5,050 gal per home is required to result in cost neutrality for the customer. This could be achieved by preventing only the larger events greater than 1,000 gal; however, aside from the conservation perspective, the cost of damage prevention could be the most attractive benefit. If these large events are internal pipe or fixture breaks within the home, being able to mitigate these events as a result of early detection could more than offset the cost. As an example, Table 3 indicates that an annual cost savings of $13 to $18 per home is required to result in cost neutrality for the customer.

Table 1 indicates that there are approximately 1.79 water damage clams per 100 homes, resulting in approximately 2.29 claims per year in the 128-home study area. Table 2 indicates that the lowest cost of claims caused by leaks averages $3,642 for damage from internal water heater leaks. If only one of these average events could be detected and

Continued on page 10

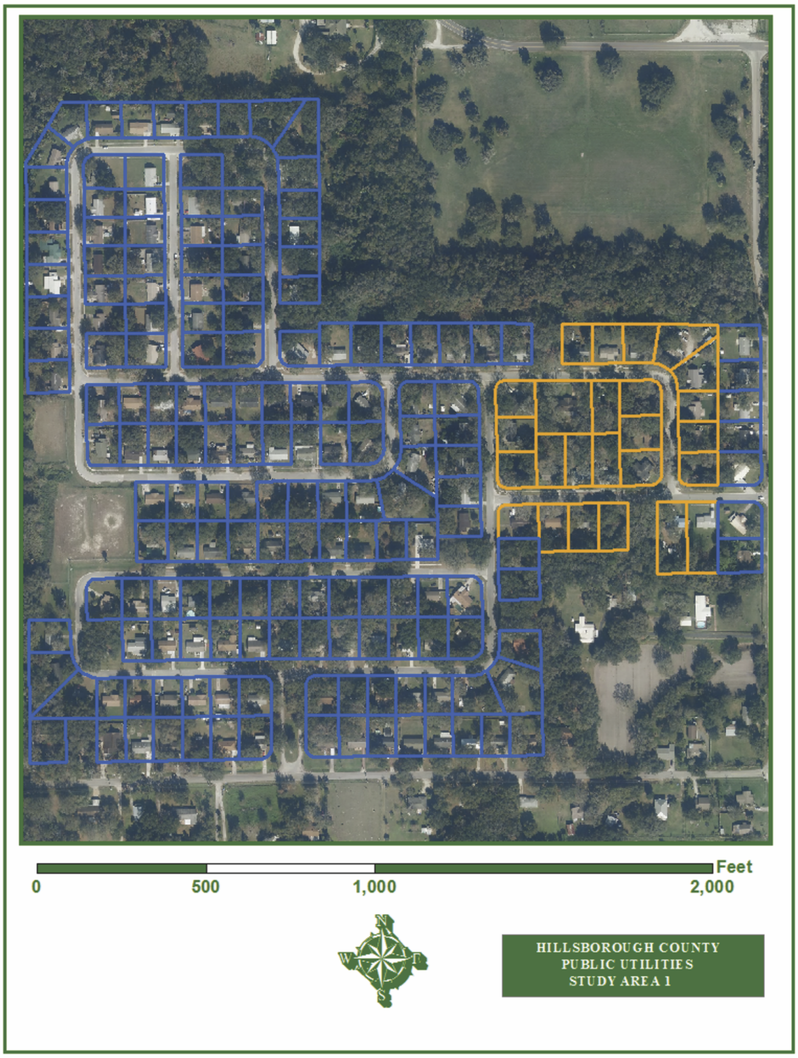

Figure 2. Aerial View of the Study Area With 191 Single-Family Residential Parcels

Table 5. Summary of Unintended Events at Varying Time Steps for 128 Homes Within Study Area

Volumetric Ranges Units in Gal		Five Minutes	15 Minutes	60 Minutes
V<1	Events per Home	3,498	1,107	127
	Total Volume per Home (gal)	483	245	29
	Percent of Volume Within:	-------------	-------------	-------------
	Intended Intensity Ranges	19.2%	0.0%	0.0%
	Unintended Intensity Ranges	80.8%	100.0%	100.0%
1<=V<10	Events per Home	151	576	312
	Total Volume per Home (gal)	319	1,496	1,232
	Percent of Volume Within:	-------------	-------------	-------------
	Intended Intensity Ranges	74.8%	58.3%	8.1%
	Unintended Intensity Ranges	25.2%	41.7%	91.9%
10<=V<100	Events per Home	37	233	333
	Total Volume per Home (gal)	1,780	10,590	13,218
	Percent of Volume Within:	-------------	-------------	-------------
	Intended Intensity Ranges	93.5%	95.4%	81.6%
	Unintended Intensity Ranges	6.5%	4.6%	18.4%
100<=V<1000	Events per Home	40	76	117
	Total Volume per Home (gal)	8,972	15,424	26,342
	Percent of Volume Within:	-------------	-------------	-------------
	Intended Intensity Ranges	85.6%	92.9%	92.1%
	Unintended Intensity Ranges	14.4%	7.1%	7.9%
V>=1000	Events per Home	2	3	4
	Total Volume per Home (gal)	13,900	17,369	23,203
	Percent of Volume Within:	-------------	-------------	-------------
	Intended Intensity Ranges	87.5%	89.1%	89.6%
	Unintended Intensity Ranges	12.5%	10.9%	10.4%

Continued from page 9

prevented in the 128-home study area, the average cost savings per home would be $28. From reviewing the five-minute data in Table 5, there are two events per home greater than 1,000 gal, with an average event volume of 13,900 gal. If only one of these events for one home was an internal fixture or pipe-break event, and the damage was mitigated from the use of a smart meter, the average cost savings per home would cover the cost of the smart meter installations across the entire study area.

The results show that as the time step increases, there is an overall decrease in the number of events, which is intuitive, as the larger time steps capture many smaller events within a single larger event. Likewise, the larger time steps result in an increase in the number of unintended events, although the extreme events (greater than 1,000 gal) are only slightly more prevalent. While the smaller time steps capture many more of the smaller events, these are not significant in terms of overall volumetric contribution.

The current study makes a case for a framework where smart meter systems can directly benefit customers by detecting these larger events. This should be evaluated in future smart system evaluations instead of using the traditional benefit analysis for utility savings only.

References

- Cardell–Oliver, R., 2013. "Water Use Signature Patterns for Analyzing Household Consumption Using Medium Resolution Meter Data." *Water Resources Research*, 49:12:8589.
- CDaigle, N.; & Jackson, A., 2013. "New Mexico Utility Rolls Out Smart Grid Infrastructure." *Journal of the American Water Works Association*, 105:2:51.
- CDavies, K.; Doolan, C.; Van Den Honert, R.; & Shi, R, 2014. "Water–Saving Impacts of Smart Meter Technology: An Empirical 5-Year, Whole–of–Community Study in Sydney, Australia." *Water Resources Research*, 50:9:7348.
- CDeOreo, W.B.; Mayer, P.W.; Dziegielewski, B.; & Kiefer, J., 2016. "Residential End Uses of Water, Version 2." Water Research Foundation, Denver.
- CMayer, P.W.; DeOreo, W.B.; Opitz, E.M.; Kiefer, J.C.; Davis, W.Y.; Dziegielewski, B.; & Nelson, J.O., 1999. *Residential End Uses of Water*. Water Research Foundation, Denver.
- CMcCary, J.P., and Heaney, J.P., 2018. Use of High-Frequency Data to Detect Household Leaks as Event Outliers. *Journal of the American Water Works Association*, 110:12:E70.
- CThiemann, R.; Haas, J.; & Schlenger, D., 2011. Reaping the Benefits of AMI: A Kansas City Case Study. *Journal of the American Water Works Association*, 103:4:38.