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A literature review: developing an information feedback interface to encourage water conservation behavior among utility customers

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Abstract: Water conservation behavior among water utility customers can be encouraged by engaging and educating customers about their consumption habits. To be successful, the information used to engage and educate must (1) be comprehensive, including both broad and narrow information, so that individuals understand where they fit into water management and how their actions impact water management and their community, and (2) help them make decisions about their use.

This article is a literature review of elements that can be incorporated into a customer-friendly information feedback interface. Some elements discussed are billing features, information about the water cycle, and local water sources, and local partnerships. The use of data is also addressed, and to that end, benefits of advanced metering infrastructure systems are mentioned. The details of these systems are not addressed. The intent of this research is to provide types and styles of information that can be combined to create an effective and meaningful information feedback system for water utility customers to encourage conservation.

Keywords: information customer feedback, water conservation interface

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[3]The research presented here is not associated with any research currently being conducted by the Alliance for Water Efficiency, nor is it necessarily reflective of any opinions held by the organization, its members, or associates.

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Terms used in paper

Short name or acronym	Descriptive name
AMI	advanced metering infrastructure
EPA	U.S. Environmental Protection Agency
JEA	Jacksonville Electric Authority
SAWS	San Antonio Water System

INTRODUCTION

Providing customers meaningful water use information can encourage conservation behavior and can help customers become more educated about their consumption habits and the impacts of these habits (Aitken 1994). To be successful, the information used to engage and educate customers should (1) be broad and comprehensive so that individual customers understand where they fit into water management and how their actions impact water management and their community, and (2) help them make decisions about their use.

This article is a literature review of elements that can be incorporated to create a customer-friendly information feedback interface. Some elements discussed are billing features, information about the water cycle and local water sources, and local partnerships. The use of data is also addressed, and to that end, benefits of advanced metering infrastructure (AMI) systems are mentioned in conjunction with data feedback and in other ways, though the details of AMI systems are not addressed. Although these and other elements are discussed, this literature review aims only to provide types and styles of information that be combined to create an effective and meaningful information feedback system for water utility customers that will encourage conservation. This research does not propose that every element is required for success. Ultimately, utility managers interested in a feedback system should rely on their sense of what will resonate with their customer base in selecting elements.

The mechanism for sharing data and information is generally through an interface such as a unique webpage, landing pages for billing for each customer, and applications or other features for cell phones.[1] This review sets out types of information and features that are most useful in the interface for the target purpose of changing consumptive behavior. The interface elements discussed here may be mixed and matched to develop an impactful interface. Appendix A offers some examples of elements and features that may be included in an interface; however, there are more elements that may be included. A customer base, utility needs, and the service area should be profiled thoroughly before developing an interface in order to ensure its success.

ELEMENTS OF INTERFACES

Marketing Campaigns

In 2001, the United Kingdom's Environment Agency and the Thames Water Company conducted a £73,000 ($113,668 USD) joint research project evaluating "The Effectiveness of Marketing Campaigns in Achieving Water Efficiency Savings" (Howarth et al. 2004). The project's primary goal was to assess the effectiveness of a water efficiency campaign on 8,000 residences in a specific area (Howarth et al. 2004). The research was conducted for just over 1 month (Howarth et al. 2004). The research project used newspaper and radio advertisements and sent mailers to the homes in the target area (Howarth et al. 2004).

After the campaign, a survey was conducted to assess the extent of the campaign message's reach. Responses to the survey questions showed that only 5% of the residents noticed any of the campaign communications, even though 25% of residents claimed to read the newspaper and/or listen to the radio (Howarth et al. 2004). Overall, the results indicated that the campaign had no impact on decreasing water use among residences. The research also noted case studies in Phoenix, Arizona; Copenhagen, Denmark; and Singapore, in which broad media campaigns did little to impact water consumption behavior (Collins et al. 2003). Ultimately, the 2001 study concluded that while an important first step in changing behavior, communication alone, through media or literature, does not have meaningful impact on water conservation behaviors (Howarth et al. 2004).

However, the Silva 2010 study that assessed media campaigns conducted over longer periods of time and with a consistent

[1] See *Appendix A* for images of a currently used interface.

message had more promising, although inconclusive, results (Silva et al. 2010). The Silva 2010 study reviewed Tempe, Arizona's cooperative media program called *Water – Use It Wisely.* The program has been in place since the early 1990s and includes messages from 20 other water providers in the same region. Social media, along with standard media (TV, radio, etc.), was most heavily used in drought conditions, based on the conservation department's belief that "the media is our best avenue for getting information to the public." (Silva et al. 2010). Surveys from the Silva 2010 study reflect that 75% of respondents were familiar with Tempe's main water conservation slogan and had seen it more than 10 times.[2] Overall, the report found that some of Tempe's media approaches were statistically significant in influencing water conservation, though the study made no projections as to how much water was saved by the media efforts alone (Silva et al. 2010).

Another subject in the Silva 2010 study is the Jacksonville Electric Authority (JEA)[3] in Jacksonville, Florida, which has an on-going media campaign that includes TV sponsorships, Public Service Announcements, print, and radio. Using a survey, the study found that more than 80% of respondents were familiar with 1 of JEA's primary conservation messages, but again there was no quantitative information about the impact of the media campaign on volume of water saved.[4] Examples from Durham, North Carolina, and Orange, Florida, yielded the same results.[5]

A study of Phoenix, Arizona, for the same Silva report found a decrease in water consumption and an increase in customers self-reporting their conservation activity from the period of 1996–2007, but could not establish whether the decrease had a direct relationship to a media and messaging program that occurred during the same time frame.[6] The same was found for a study of Seattle, Washington. [7]

At the time of this review, the authors could not find any publicly available or peer-reviewed data that shows the correlation between a media campaign in isolation and volumes of water saved. This point is made only to emphasize the need for a feedback interface that is more than just the arm of a media campaign. It is not made to undermine the role or value of a serious media campaign. (Media campaigns on their own serve a very distinct and critical purpose.) As the above case studies indicate, a sustained media campaign becomes recognizable to the public and is an important step in changing behavior due to its raising awareness (Silva et al. 2010), and is necessary to on-going efforts in calling attention to the importance of water conservation.

Moreover, media campaigns may become increasingly impactful as more avenues for communication with customers emerge. For example, social media outlets are the latest opportunity for utilities to communicate conservation messages. A recent study that surveyed Texans across all age ranges shows that 51% of respondents have a Facebook account and 17% have a Twitter account (Baselice 2015). For these reasons, incorporating a media campaign, with links to social media platforms, into a feedback interface is still strategically important.

Additionally, a critical relationship can exist between a media campaign and an effective interface, as media campaigns can help develop awareness among a customer base that, in turn, helps create customers that would actually use a feedback interface. Therefore, media campaigns and media messaging should be carried out in conjunction with other information feedback options, all of which can be incorporated into a singular feedback interface.[8]

Water and Natural Cycles

Actively engaging customers so they develop both an interest and understanding regarding hydrological, seasonal, and climactic cycles; local water sources; and the necessity of conservation are the most important parts of changing behaviors to promote conservation (United Nations 2002; Hassel et al. 2007). Feedback data available to customers is often specific to their location, and their use can have the effect of undermining the need to conserve. Additionally, many people do not know what their local water source(s) is/are (The Nature Conservancy 2011). In fact, a survey conducted in Texas revealed that in 2014 only 28% of those surveyed were confident they knew where their water came from; this was the same percentage achieved in the same survey when it was conducted in 2004 (Baselice 2015). Failing to illustrate how the water cycle works or to educate customers about the source of their water is a missed opportunity to emphasize the need to conserve. This oversight is significant because a lack of understanding of natural cycles and the interaction between natural water cycles and infrastructure creates a significant hurdle in successfully promoting conservation efforts (Department of Sustainability and Environment 2005).

In fact, the market research conducted after a 2001 study and survey suggested that customer response to a conservation project was poor because water-related matters ranked

[2] The total number of customers surveyed was not stated.

[3] JEA is responsible for electric, water, and sewer services.

[4] The total number of customers surveyed was not stated.

[5] The total number of customers surveyed was not stated.

[6] The total number of customers surveyed was not stated.

[7] The total number of customers surveyed was not stated.

[8] Incorporation of various forms of feedback into a singular interface is important in creating an effective interface. However, this literature review does not suggest that the interface should be the only way to interact with customers.

lowest of all environmental concerns held by the public. Furthermore, feelings of insignificance about independent actions contributed to non-action (Howarth et al. 2004). This attitude is common, especially in water-rich areas of the world. However, importantly another study found that "participants who understood the environmental impact of their water consumption were much more motivated than others to reduce their water consumption and saved as much as 23% relative to normal levels" (Jeong 2014). It can be inferred from these 2 studies that an increase in knowledge and awareness of water issues could have a positive impact on willingness to conserve and support of conservation efforts.

In Roseville, California, the water department had a difficult time getting residents to conserve water. The historical abundance of water in the area dampened awareness efforts, and most customers were unaware of their own consumptive habits and the impact of those habits to their community (West Governor's Drought Forum 2015). However, the record-breaking drought in California in recent years reduced the community's water supply drastically, compelling the water utility to implement a customer education plan quickly in order to force the issue of awareness as a means to reduce residential water consumption. The water department implemented a feedback interface that allowed it to push highly customized and tailored information to its customers (West Governor's Drought Forum 2015).

The information used by Roseville in its interface emphasized the dynamics between how the change in climate conditions and other factors were impacting the amount of available water and, in turn, impacting the cost of water supply in the future (West Governor's Drought Forum 2015). The interface also included future projections of water supply and the likelihood of drought; these proved to be powerful motivators[9] for water conservation activities among Roseville's customer base[10] (West Governor's Drought Forum 2015). Getting customers to understand the cost associated with supplying water as it relates to natural systems is a major challenge, but Roseville found that drought and the threat of drought are very strong motivators relating to natural cycles and systems (West Governor's Drought Forum 2015).

Partnerships

Demonstrating partnerships with relevant and well-respected organizations in customer feedback information can be effective because it signifies third-party independent approval with a utility's promotion of conservation (Hassel 2007). Demonstration of a partnership could be as minor as a logo appearing on an interface or as major as a public endorsement or the development of a jointly promoted conservation program. Such an announcement could be included in the interface, as could an advertisement for a partnership event. Organizations that seem to lend the most credibility are niche organizations, specialty institutes, and governmental authorities. Some examples of these types of partnerships are:

- The San Antonio Water System (SAWS) and Master Naturalists and/or Master Gardeners. SAWS and these organizations have a successful history of promoting native landscapes, DIY efforts, and a deeper understanding of water issues in South Central Texas. They garner more public engagement and reinforce the idea that the community must work together to conserve.
- The Texas Water Resources Institute is working with the cities of Round Rock and Arlington, Texas, to develop a customer interface that helps both utilities and customers understand volumetric usage and communicate conservation messages (Kalisek 2015).
- DC Water partnered with the U.S. Environmental Protection Agency (EPA) to promote its WaterSense program and encourage the replacement of high use fixtures as well as other conservation behavior (DC Water Authority 2016). Because of the EPA's strong base in the capital city, this program resonates strongly with the residents of Washington D.C. and encourages changes in fixtures since the message to change is coming from the highest environmental governing body in the country.

These kinds of joint efforts should be touted on an interface.

Billing Features

Customers appreciate direct access to billing and use information (Moore et al. 2008; National Energy Technology Laboratory 2008). Largely, with enough data included in the interface in easy-to-understand formats, customers can answer their own questions and spot problems that may be affecting their bill (National Energy Technology Laboratory 2008). Additional features, such as prepayment programs and select time of month billing, provide flexibility to the customer (National Energy Technology Laboratory 2008). Many of these billing features can be included in an interface.

The Silva 2010 survey reflected that only 64% of customers tracked their usage over time from their water bill (Silva et al. 2010). However, many customers said that bill tracking would be useful if there was an easier way to do it (Silva et al. 2010). Including a tool in the interface that helps customers manage and track their billing information would be a great way to encourage awareness and, in turn, conservation behav-

[9] This type of information was also found to be motivating in the Silva 2010 Study.

[10] Additionally, this information can also relate to the expenses of supplying of water as reduced supply can increase the cost to the customer.

ior. Adding interactive elements to the interface also increases the likelihood of continued use of the interface.

One way to allow for tracking is to include a graphic feature that will track both billing and use over time simultaneously. Another option might be comparison displays of billing and use for periods of time the customer can select. Allowing them some control over what they view may interest them more than just reviewing a chart.

Incorporating a bill pay option in the interface that would provide graphical or informational displays adjacent to the actual amount owed would also be a welcome addition. Though this is sometimes a challenge because of utility billing systems, it is an important consideration because it reinforces the connection between volumetric use and billing and would force customers to see their use when paying their bill.

One challenge with billing in general is a tendency for customers to set up automatic bill payments so that they are not obligated to even look at their bill or consumption if they do not want to. However, there may be some creative work-arounds. For example, a utility might elect to send an email notification to customers informing them that their bill is ready but without stating the amount up front. Instead, to find out the billed amount and volumetric use, the customer may have to check the interface. Of course customers with relatively steady bills may be less inclined, but many people want to know what they are paying and what they are paying for. Another option may be providing a discount or credit for every month they review the data or answer a question through their interface.

Related Programs

Including a pre-developed campaign or program within the interface (such as Texas' Water IQ or the Seattle 1% Program) helps to maximize information sharing with interface users (Silva et al. 2010). This allows a utility to send specific messages or establish priorities among its customer base (Silva et al. 2010). For example, if the utility is focusing its efforts on outdoor water use, the interface could be a place to explain why outdoor water use is important and to tie in links for native landscapes, landscape workshops, irrigator licensing programs, or applications for rebates and information for other incentive programs.

Including this variety of relevant information also helps the customer to view the interface as a well-rounded resource, which is important since in some communities many customers do not view their utility website or utility emails as a worthwhile resource (Silva et al. 2010). The Silva 2010 study made this finding but did not provide any suppositions as to the reasons for this. It may be because customers find the information to be too broad to be useful to them individually. It may also be because of uncertainty as to the origins of the information and therefore its usefulness (for example, if it is a press release it may have outdated or inaccurate data), or it may simply be that the customers do not have the time to read the email or visit the website and would prefer a more succinct presentation of information.

New Technology

Advertising new products or upgrades to commonly used products and services is another great way to promote water conservation (Deni Greene Consulting Services 1996; Hassel et al. 2007). Of course, utilities cannot tell customers which appliances or fixtures to buy or exactly when they should, but there is an opportunity to promote the benefits of water efficient fixtures and appliances. Most importantly, this is one of the easiest ways to help a customer make a decision that will leave them feeling vested in water conservation. For example, they can learn whether it is time to replace a low efficiency washing machine and how it will benefit them and their community. In making this purchase, they are now participants in conserving water in their community. Promotion of the EPA's WaterSense program would be useful here or similar product reviews and reports that most customers do not have the time or interest to find on their own. Moreover, those customers who do will certainly appreciate the resource.

Dynamism

Utilities are chronically trying to keep up with their customer base by developing rapport, engaging them, and keeping up with the service area demographics and customer needs and concerns. Developing information fields in which customers can send direct emails to their billing departments or conservation staff from the billing portion of their interface can help create a sense of more personalized service and recognition. In addition, depending on the format of the fields, there is potential to capture common questions and problems with bills or other information in the interface and get ahead of them, i.e. find patterns of concern among the customer base and head them off.

A related tool might survey what household appliances customers have. If a customer indicates they have an older washing machine, then a pop-up message connecting them to rebates or incentives could encourage them to make a change. Information on how much of their water bill is associated with the older washing machine might also be useful, though it requires additional questions such as how frequently they wash their clothes and possibly some back-end calculations the interface must be set up to perform.

Similarly, tools that may help customers determine information such as the appropriate amount of water use for their household size could include fields that capture house-

hold demographics, water features (pools, fountains), and square footage. Adding inputs to the interface to account for demographic elements such as the number of people in the household, the number of bathrooms (specifically the number of toilets), and whether there is an irrigation system present in the home may help customers understand their consumptive habits and identify areas of improvement (McKenzie-Mohr et al. 1999; Faruqui et al. 2010; Silva et al. 2010).

Dynamic features such as these require a mutually beneficial exchange of data but are ideal for managing customer needs and expectations, and for planning. With household demographic information, utilities can start to develop a sense of how much water children versus adults use or how transient the service area is. Another way to capture this kind of information for utility use only might be a local water census issued every few years by the utility in exchange for billing discounts or other financial incentives (though it is always best to develop a tool that the customer benefits from as well because participation occurs more easily).

Using Consumption Data

Uses

Consumption data can be used in 2 ways (though sometimes it can serve both purposes): 1) to enable the customer to make data-driven use decisions and 2) to enable the utility to make data-driven management decisions. Either way, the availability of individualized consumption data has been linked to a reduction in use. This was the case in the Sacramento County Water Agency where 2 water conservation programs were proven effective, but where the Data Logger Program resulted in greater water conservation (Tom et al. 2011). This difference in results was attributed to the Data Logger Program providing more detailed information about customer use, thereby enabling the customer to make more educated decisions about their use (Tom 2011). Notably, success with data feedback in particular comes from the data being relatable and easy to navigate and interpret.

Another example is Roseville, California, which experienced a 4.6% reduction in water use. This reduction was largely attributed to a combination of the municipal utility being able to drill down to single-customer use patterns and then using that information to focus on broad education efforts for its 36,000 customers, and tailoring information for the 18,000 residents receiving Home Water Reports and information about their consumptive habits (West Governor's Drought Forum 2015). Although 4.6% seems low, it is a strong beginning for the utility as it continues to refine its interface.

Efficacy

Much like media campaigns, the exact efficacy of data sharing as it relates to volumetric savings is unknown. Additionally, research has not yet identified the exact amounts of data required to trigger water conservation behavior. However, 1 energy conservation study did find a connection between AMI data feedback and a reduction in energy use (Faruqui et al. 2010). Although energy and water utilities are very different, water managers can benefit from the research conducted by the energy industry since similar challenges and technologies exist. Also, at least 1 water utility is studying the same connection (Faruqui et al. 2010).

The energy study conducted in 2010 by Ahmad Faruqui reviewed how direct feedback of real-time information influenced energy consumption (Faruqui et al. 2010). Faruqui specifically explored energy saving behaviors and customer attitudes about the direct feedback of information provided to them (Faruqui et al. 2010). The feedback instrument for all of the subject studies was an in-home display device. These devices are roughly the size of a residential thermostat screen, and are registered to a smart meter and can be placed virtually anywhere in the home.

Depending on the make and model, the in-home display devices can perform functions such as showing real-time energy use, day-to-day comparisons of energy use, use trends over time, and in some cases, they can be used to pinpoint what rooms or appliances in the home use the most energy. The study concluded that consumers who actively engaged with the feedback interface reduced their energy consumption by 7%, on average (Faruqui et al. 2010). Where time-of-use rates were used, the presence of rates and what customers will pay based on real-time data caused a reduction in energy consumption (Faruqui et al. 2010).

In 2014, the water utility in Duluth, Minnesota, deployed AMI to approximately 5,000 distinct customers in a pilot program to test its effectiveness. Officials at the utility evaluated whether customers viewed the AMI-enhanced consumption information and other information promoted on the interface more than they would review a standard monthly bill that was available to them online (Bensch et al. 2014).

The Duluth study is on-going in that participants are still being monitored to ascertain any long-term trends in data views and long-term changes in behavior and consumption. Interestingly, not long after the pilot study was underway, some participants in the pilot revealed that the enhanced feedback prompted them to examine their own behavior and heightened their awareness of other ways in which they waste water, such as through inefficient home appliances (Bensch et al. 2014). Self-reports from pilot participants showed that those already taking small measures were motivated toward more efficient behaviors and those who were simply preparing to

take efficiency measures were pushed to carry out their plans (Bensch et al. 2014). The direct relationship between AMI data and changes in behavior is still being evaluated in this study. However, based on the responses of the participants, the data is raising awareness about personal consumption habits, an important first step in promoting conservation behavior.

A note on AMI

Data is collected in a variety of ways, but this review notices that much of the data used in feedback interfaces is derived from AMI systems. If set up correctly, AMI systems provide one of the most efficient methods of collecting data in a way that makes data easy to analyze. The largest benefit of an AMI system is that it collects data in real-time and can collect data in increments as small as 15 minutes. This creates a rapid precision not yet experienced by data collectors. It also provides utilities an opportunity to communicate data to their customers much more quickly and accurately through a variety of interface features such as prompts and reminders, high-use alerts, leak alerts, and other types of near-instant notifications. Also, many other technologies can now be connected to AMI systems such as leak loggers, which help a utility discover leaks and their locations.

Presently, the energy industries have led the way in making changes or conversions to meter systems so data can be collected more efficiently and expeditiously. In fact, the number of these types of changes, particularly the implementation of AMI systems, within the gas and electric industries is constantly increasing around the United States (Federal Energy Regulatory Commission 2014). Between 2011 and 2012, some 5.9 million AMI systems were installed and operated, amounting to nearly 30% of all gas and electric meters in the United States. Because of the usefulness of AMI systems in those industries, water utilities are increasingly considering implementing AMI systems (or systems with similar features) in the model of the gas and electric industries (Moore et al. 2008). Although AMI is not for every water utility (Hawkins et al. 2015),[11] the current interest renders it a worthwhile subject for review in the context of providing data for a customer interface.

One benefit that highlights the speed and efficiency of AMI is leak detection.[12] In Park City, Utah, the water department invested in an AMI system with leak detection features; however, after installation, some problems with the leak detection features frustrated customers. In response, the utility remedied the problems and improved on the leak detection feature by adding a notification pane in the interface through which it could more directly reach customers with consumptive use information and notifications of customer-side leaks (West Governor's Drought Forum 2015). In some cases the leak detection feature not only lets the customer know there may be a problem but also the type of leak based on volume and other factors. These efforts in Park City seem to have gotten customers more interested in their water use habits and supportive of the system; the overall response to this feature was very positive after all of the related concerns were resolved (West Governor's Drought Forum 2015).

Reminders and Prompts

One of the most useful determinations made from the 2010 Duluth study was that continuous engagement with a feedback interface is critical because even those customers genuinely interested in reducing their consumption may need reminders and prompts to encourage continuous engagement with the interface (Bensch et al. 2014). Reminders and prompts help guide people to the correct course of action (McKenzie-Mohr et al. 1999; Silva et al. 2010). Frequently, customers will learn of useful information and develop an intention to take action, but over time they forget or lose motivation (Bensch et al. 2014). Including a prompt or reminder feature in the interface can help customers maintain motivation and eventually take action where they otherwise would not (Bensch et al. 2014). For example, a customer could log in to the interface and become interested in an incentive program. While the customer might not be able to take immediate action, they can request an email reminder to be sent in the future, set a reminder the next time they log on to the interface, or download information into their calendar system (likely Outlook, iCal or Google Calendar).

Similarly, customers interested in rebate programs for high-efficiency washing machines may set a notice to remind them of a deadline if they are not purchasing the washing machine immediately. Another example might be a push notification to email or a notice when the customer signs into the interface letting them know they are close to meeting a pre-set billing goal. A utility in Duluth, Minnesota, found that frequent prompts and reminders like these examples are effective for changing behavior and are valued by the customers (Bensch et al. 2014).

[11] AMI is not for every utility, and it is important for utilities to perform a cost-benefit analysis and consider how AMI may help them and their customers before investing in it. See Hawkins et al. 2015.

[12] Leak detection is not part of every AMI system, but is increasingly common.

Personal Motivators

Self-interests or personal commitments motivate people to action and can be presented in an interface. For example:

Money

Behavioral changes are more likely to occur if incentives are offered. This is especially so with regard to water conservation; because the environment and hydrological systems are so large and complex, it is difficult to convince customers that individual actions have any significant consequences (Hassel 2007). Results from a 2010 survey showed that 78% of respondents said saving money was a primary reason for taking proactive measures to conserve water (Silva et al. 2010). Only 10% of respondents had ever participated in a utility rebate program (Silva et al. 2010). A full 61% said they would have participated in a rebate program if one had been available (Silva et al. 2010).

Since money is a major motivator, it is especially important to include incentive programs in the interface (Grizzell 2003). Adding incentive information, especially financial incentives such as rebates and billing discounts associated with conservation behavior, gives customers an additional reason to interact with the interface (Deni Greene Consulting Services 1996; Hassel et al. 2007). For example, using the interface as another means to convey information about cash-for-grass type rebate programs is ideal since not every customer will come across that information through another route. Customers may be more inclined to visit the interface if the incentives change or are rotated on a regular basis. Checking in to see what benefit they may receive may keep them motivated to use the interface. Additionally, if the interface also includes billing information, there may be a significant benefit in presenting rebate or discount information for conservation efforts simultaneously with the bill.

Pre-payment for electricity also influences energy consumption when available in conjunction with real-time use information. Under pre-payment plans, customers avoid a singular large monthly bill by paying for their electric service in advance in weekly increments, or otherwise as needed (Hatch 2012). Generally, customers are motivated to stay within whatever energy budgets their pre-payment buys and the availability of real-time data enables them to do that; as a result, energy consumption could be reduced by 14% (Faruqui et al. 2010).

Commitments

Getting customers to make personal commitments to water conservation efforts or goals makes them more likely to work toward larger commitments or goals in the future and more likely to make changes in water consumption behavior when asked (McKenzie-Mohr et al. 1999; Silva et al. 2010). This may even take the form of a pre-payment plan in which customers make personal commitments to use water until a certain price cap is reached.

Societal Norms and Peer Pressure

Establishing societal norms gives customers a frame of reference and renders them more likely to change their behaviors when asked to in the future. Societal norms may be established via an interface so long as a unified message is conveyed to all those who signed up for access to it (McKenzie-Mohr et al. 1999; Silva et al. 2010; West Governor's Drought Forum 2015).

Though only 2% of respondents in the Silva et al. 2010 surveys stated that peer pressure motivated them to conserve, other studies have found peer pressure and comparison to the usage incurred by neighbors to be more effective than appealing to people's sense of social responsibility, safe guarding the earth for the future, and even saving money (Silva et al. 2010). In fact, market strategy research for energy indicates that using social norms as a motivational tool can increase household energy savings by 5.7% to 10% (Ehrhardt-Martinez et al. 2010).

One example of imposing peer pressure is providing information that compares 1 household's consumption to another of similar value, square footage, year built, and number of inhabitants. These kinds of comparisons may greatly influence conservation behaviors. Including this comparative information is increasingly popular as more individualized data becomes available. Additionally, this specific type of comparative norming has been found to be effective in getting customers to embrace conservationist behaviors, though more research is needed (Hastings et al. 2015).

A great example of societal norms at work is the Report Water Waste system used by SAWS. Through this system, customers can (and do) actively report instances of water waste. Once the report is received by SAWS staff, an alert letter is sent to whomever is responsible for the property where the instance occurred (usually the owner or property manager) requiring that they resolve any water waste at their property.[13] Additionally, local police officers working in conjunction with SAWS may issue citations for water waste they encounter. These citations have associated fines and are referred to the Municipal Court system where they may be disputed. Across the city, customers take water conservation very seriously, no doubt in large part because of the reporting system and the message that it sends about water use in the community.

[13] Sometimes staff will make phone calls to the responsible party instead of, or in addition to, an alert letter being issued.

Personal Benefits

Although peer pressure and societal norms are effective, the need for individuals to believe their actions will truly have an impact is another hurdle to changing conservation behavior. For this reason, emphasizing the personal benefits of signing up for interfaces and interface notifications is useful in getting customers to return to the interface once they have signed up (U.S. Department of Energy 2014). For example, if leak detection notices are only offered to those who sign up for the interface service, then more people are likely to sign up since leak detection can save them money. In extremely well-equipped communities that may have separate irrigation meters for commercial and Home Owners Association properties, irrigation-specific leak detection notices could lead to significant financial savings and could also be tied to enrollment. Offering billing date options for those who enroll in the interface program may also be a way to garner interest because it may be beneficial to the customer. Bill credits or discounts may also be a tool to interest people in using an interface.

PRESENTING INFORMATION

Data

The Duluth study found a disparity between the information customers wanted and needed, and the information delivered by AMI systems; specifically, the data presentation suffered from lack of clarity and the interface was not user-friendly (Bensch et al. 2014). The participants in the Duluth study said the data was the most helpful part of the pilot, but they also tended to look at the data only once because of its overwhelming presentation (Bensch et al. 2014). Additionally, customers reported high rates of interest in data feedback, but their interest was dwarfed by their time or/and willingness to actually engage with and make sense of the data (Bensch et al. 2014). Essentially, complexity of the data presentation may undermine its usefulness, particularly when utilities are seeking voluntary actions from consumers. More easily understood treatments of the data, such as comparative formats, are more useful in achieving conservation behavior and, importantly, in sustaining customer interest (Bensch et al. 2014). While simplifying the data is important for customer understanding, it is also important to have staff in at least 1 department (billing, conservation, customer service) trained to knowledgeably answer questions about the bill and the meter technology.

Credibility

Information credibility is important to successfully changing consumptive behaviors. In a survey conducted among homeowners and home renters, water supply officials were considered the most credible source for water conservation information. Officials with a financial interest in water conservation (e.g. plumbers, manufacturers, contractors) were seen as less credible, with the exception of landscapers and nursery owners and workers (Silva et al. 2010). Therefore, it may be important to enhance information in the customer feedback to reflect the perspective of water conservation officials, as opposed to the utility broadly. It may also be useful to incorporate information and suggestions from other credible sources (local leaders, respected organizations, known professionals external to the utility, etc.).

Cost Breakdowns

In an energy study, different treatments of feedback information for electricity consumption were analyzed to determine what information and what presentation of that information resulted in maximum electricity savings (Karjalainen 2011). The study results indicated that customers were most responsive to cost breakdowns over time as it related to their monetary savings (Karjalainen 2011). Customers also found savings breakdowns concerning specific appliances or services (including brand names) very helpful in demonstrating what the value of making a change would be (Karjalainen 2011).

The study also indicated that:

- people can interpret tables, charts, and graphs if they are well-designed;
- many people are overwhelmed by highly technical information and scientific units; and
- many people do not have comprehensive understanding about the electric industry (Karjalainen 2011).

Customers most appreciated:

- presentations of costs (over a period of time);
- appliance-specific breakdown, i.e. information on how much each appliance consumes proportionally; and
- historical comparison, i.e. comparison with a customer's own prior consumption (Karjalainen 2011).

Relative Information

People learn and analyze in different ways, which is why it is useful to present complex information in relative forms. For example, the Sacramento County Water Agency ran 2 water conservation programs simultaneously to discern customer preferences and response rates to data feedback (Tom et al. 2011). The first program was the Data Logger Program, in which a Meter-Master Model 100 EL data logger was attached to the customer's water meter for 1 week and provided a detailed report of water use from each fixture (Tom et al. 2011). In the second program, the Water Wise House Call Program, a water efficiency staff person spent an hour with customers issuing assessments and recommendations (Tom et al. 2011). In a

sample of 100 households, both programs were found to be effective[14] (Tom et al. 2011).

In another study, 2 different treatments of feedback presentation were compared and evaluated for 4,700 residents (Jeong 2014). The results of the study suggest that providing water consumption in gallons alongside water consumption in energy units required to deliver the volume in gallons led to a statistically significant reduction in water consumption, while providing water consumption only in gallons did not (Jeong 2014). The authors of this study provide some speculation as to the findings. First, they suggest that energy data may be presented in simpler terms and in more familiar units than water consumption data usually is (Jeong 2014). This is very possible since energy conservation is an older and more established concept in the United States. The authors also note that previous research in energy conservation demonstrated recognition of energy units and an easier time in achieving conservation by sharing data with customers (Jeong 2014). Second, the authors suggest that "By providing feedback at the intersection between water and energy consumption, the feedback appealed to both those individuals interested on water conservation and those interested in conserving energy" (Jeong 2014).

Feedback Frequency

Regarding feedback frequency, it has been found that daily or weekly feedback information generated the highest electricity savings per household at 11% to 14%, while providing real-time feedback resulted in 7% savings (Ehrhardt-Martinez et al. 2010). Although drill-down features are likely to be of interest to the customer, it is definitely a useful presentation for utilities to analyze because they offer multiple planes on which the utility can perform an analysis of consumptive use patterns. Most drill-down features present as monthly or weekly data that give the customer a sense of their use for a broad period of time. The customer can then select the data (usually by clicking or touching the icon or graph that reflects the data) to see weekly or daily information, and then again to see daily or hourly information, etc. If a drill-down feature is included because the AMI system records data at small intervals, it is important to help the customer interpret the results of the drill-down feature so they are not overwhelmed or uncertain how to improve on their consumption.

[14] While both programs were effective, the Data Logger Program resulted in greater water conservation. The difference in results was attributed to the Data Logger Program providing more information about customer use and in greater detail, thereby enabling the customer to make more educated decisions about their use (Tom 2011).

CONCLUSION

The Silva 2010 survey reflects that many customers already believe they engage in water conservation practices (Silva et al. 2010). In fact, many reported changes in their activities such as a new tendency to run the dishwasher or clothes washer only when full (Silva et al. 2010). These responses suggest a high level of awareness (Silva et al. 2010). Utilities can and should exploit this awareness by developing customer interfaces that promote increased conservation, since providing water consumption feedback for customers has proven effective in promoting conservation (Jeong 2014). In 2010, a comprehensive meta-review was conducted of 57 residential energy-feedback studies spanning 36 years and 9 countries, including the United States, Canada, Europe, Australia, and Japan (Ehrhardt-Martinez et al. 2010). The study found that across countries, feedback programs resulted in average savings of 4% to 12%, demonstrating that with the right presentation of information, people are willing to modify consumptive habits and other behaviors (Zelezny 1999; Ehrhardt-Martinez et al. 2010).

To be impactful, these interfaces must be robust and contain data, motivational materials, educational information, and content that can help the customer make decisions about their water use habits and become vested in conserving water in their community (Syme et al. 2000; Hassel et al. 2007; Ehrhardt-Martinez et al. 2010; Faruqui et al. 2010; Karjalainen 2011; Silva et al. 2010). This well-rounded approach has been proven more useful and meaningful to customers than interfaces that only use certain types of information such as education-only or data-only, which are much more typical of utility communication to customers (Hassel et al. 2007). The Silva 2010 study supports this as it revealed that feedback mechanisms are unlikely to encourage more significant household energy savings without being accompanied by additional products and services that actually help the customer make decisions about changing their consumption habits (Zelezny 1999; Ehrhardt-Martinez et al. 2010).

Examples of this comprehensive interface may be broad, such as information about conservation efforts in the customer's home region. Other examples may be more specific such as individualized consumption data, comparative information such as consumption volume of households of similar square footage and number of persons, and customizable interactive features such as pre-payment goals and do more to engage the customer (Syme et al. 2000; Hassel et al. 2007; Faruqui et al. 2010; Karjalainen 2011).

This research highly encourages the development of a feedback interface. However, consideration of development costs for these interfaces is an important element in design. Design and implementation expenses will vary depending on utility-specific qualities such as the scale of deployment (size of customer base), ease of deployment, likelihood of engage-

ment as compared to engagement experienced under current programs, the number of features, and development partners such as private consultants versus public or research entities. As a result, the relative value of water savings compared to the cost of implementation is an important consideration, but one that is not made here. It is too variable and there are not enough case studies on these points to make any firm conclusions. Utilities considering information and feedback systems are encouraged to perform these evaluations before making decisions. Talking to system developers, relevant utility departments (billing, customer service, metering, conservation, etc.), and other utilities is the best way to start. Talking to customers and asking what would help them or assessing what they do not know is another great first step.

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APPENDIX A

The following images are taken from the Meter Study Project being conducted by the Texas Water Resources Institute. The images have been used with permission to provide a visual reference for some of the elements addressed in this review. This interface is a web portal for customers to access.

Figure A, below, is a copy of the landing page. The chart and tabular information can change if the customer elects to drill down in a monthly data set. Additionally, the data may change altogether if the customer elects to use data from an irrigation meter, or additional meters tied to the account. Also, the information in the bar chart can be changed from volume to dollar amount by clicking the yellow "View Cost" button at the top of the screen.

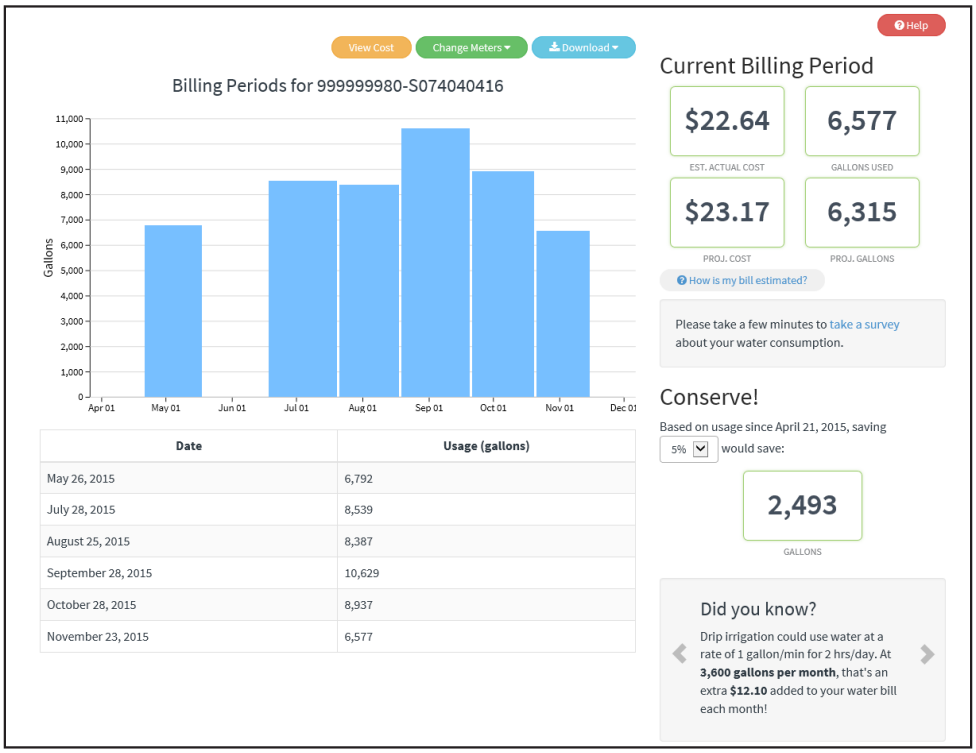

Figure A. Layout from the landing page of the web portal.

The Drill Down feature lets customers go from a broad month-to-month view of their usage as shown in Figure B to daily usage shown in Figure C to hourly usage for a given day as shown in Figure D. The customer needs only to click any bar in the bar chart to drill down to more detailed data.

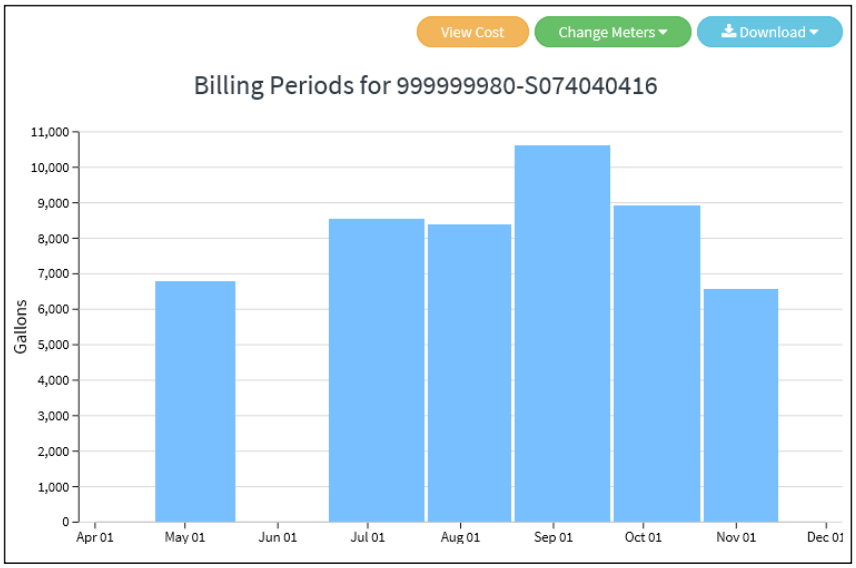

Figure B. Month by month usage for 2015 (begins in April when customer enrolled).

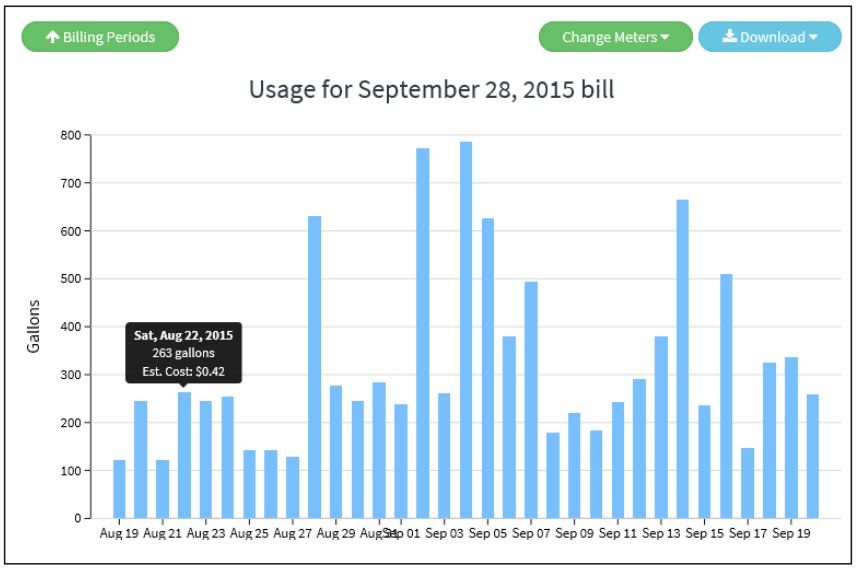

Figure C. Daily usage for the month of August 2015.

Figure E shows an informational prompt that rotates through different messages. The information in each message connects a common activity with both waste and dollar amounts.

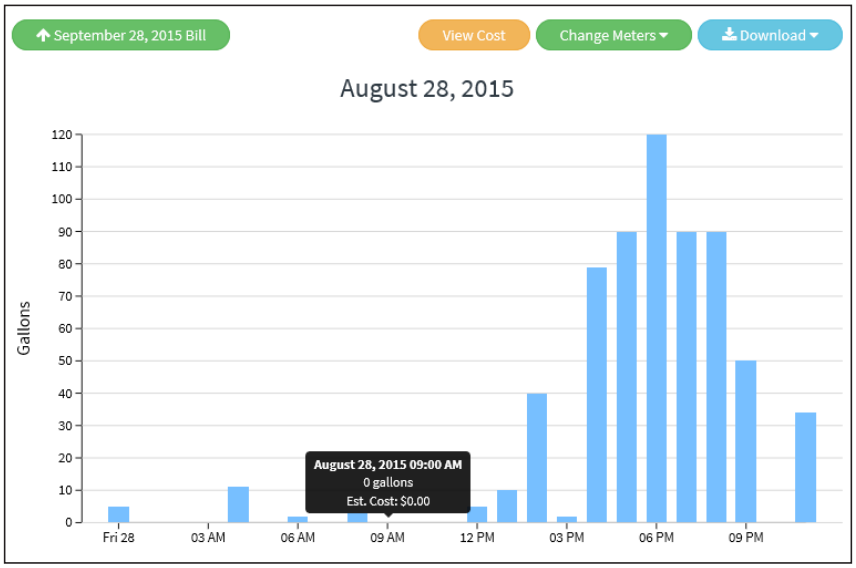

Figure D. Hourly usage for August 28, 2015.

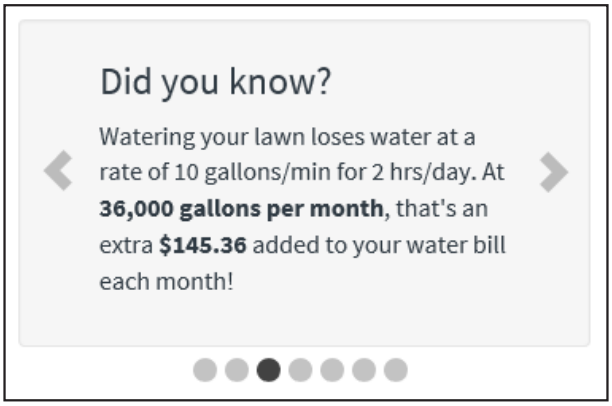

Figure E. Informational prompt.

Figure F, below, is an interactive feature that shows the customers how many gallons of water are saved based on a percentage savings of their usage. The percentages can be changed and have correlating gallon volumes based on the customer's use.

Figure G, below, is a relative and comparative information item that presents use in terms of dollars and volume and simultaneously tracks the customers use information.

Figure H, below, is a survey prompt that collects information for the utility and makes the customer reflect on their consumptive behavior.

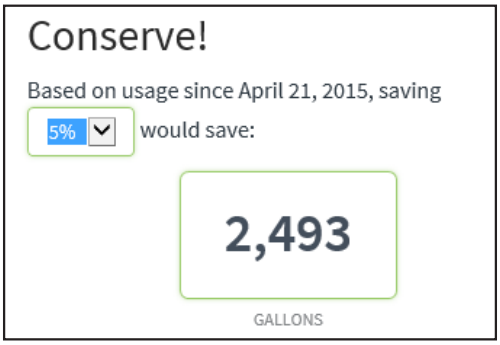

Figure F. Conserve! prompt.

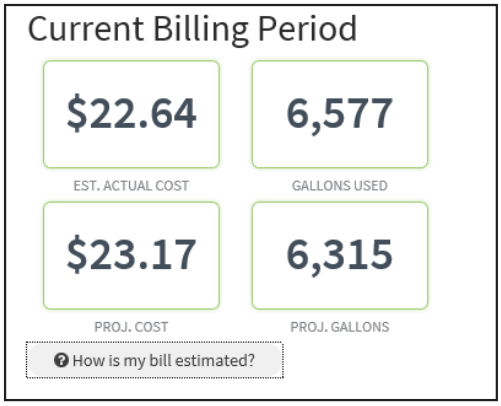

Figure G: Relative and comparative consumption prompt.

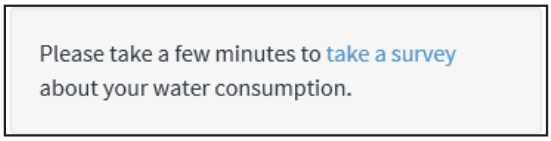

Figure H. Survey prompt.