THE STATE OF THE UTILITY BILL

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EXECUTIVE SUMMARY

The utility bill is the most common way for utilities to provide information about energy use to their customers, but it is often overlooked both as a way to give customers better control over their energy use and to support utilities' goals for more actively engaging customers, especially as a part of a smart grid strategy. Even as smart meters and smart phone apps proliferate, the paper bill, because it is already going to the vast majority of customers, has the potential to become a cost-effective feedback device with a broad reach.

This report provides a preliminary take on the potential for enhancing the utility bill to provide better indirect feedback to utility customers. Our goals are to present new research on the elements appearing on a sample of current bills, to outline some of the history of bill development, and, based on a review of the literature, to characterize how these bill elements align with previous research on bill information design.

In an effort to capture the current bill landscape, we analyzed one hundred utility bills (see Figure ES-1), finding that the average customer is being provided with basic accounting information such as the current usage and the total amount due, supplemented by specific rate information to allow the customer, in theory, to make the connection between usage and the amount due.

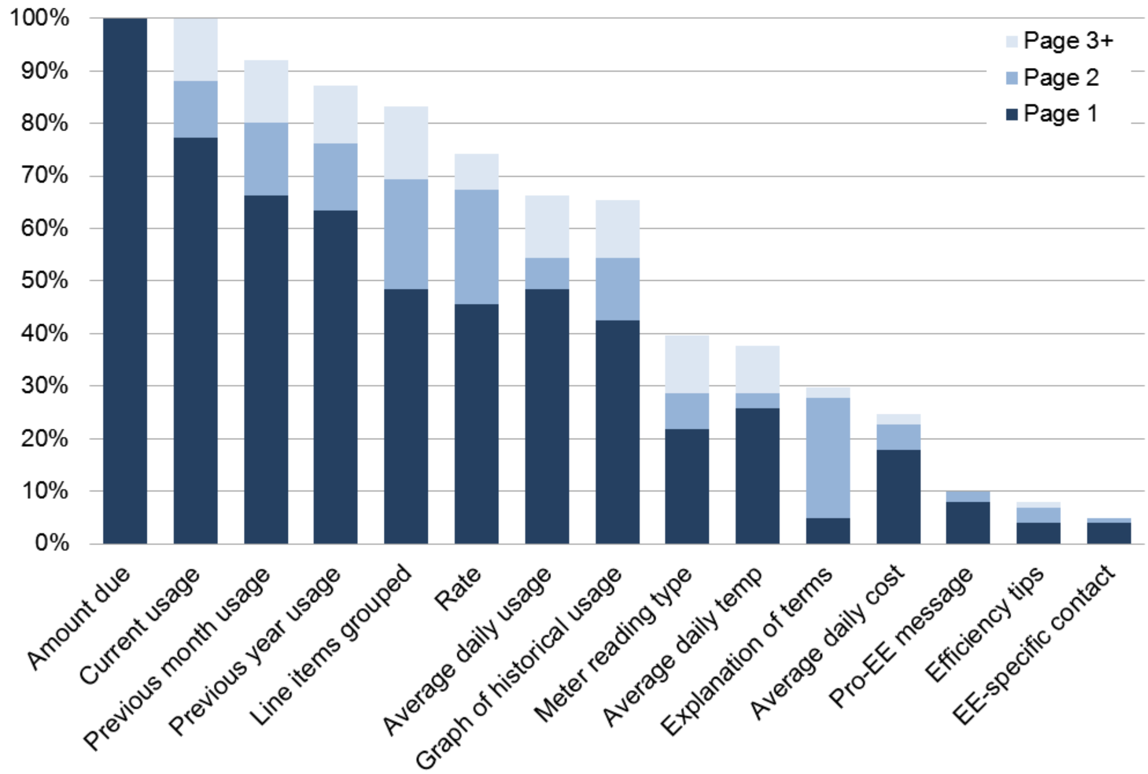
The average customer is also getting some comparative feedback on energy usage in the form of, most often, the previous month's usage. Most bills supplement this with the previous year's usage, the customer's average daily usage, and a graph that typically includes thirteen months of usage data. Comparative feedback is a necessary but not sufficient condition for understanding the impact of any behavioral or technological changes meant to reduce energy use, and the fact that such metrics are included on more than 60% of bills is somewhat promising. The question remains, however, whether customers actually grasp such metrics and are using them to better control energy use.

What is missing from the average bill, and, in fact, almost 90% of bills, are those innovative elements—such as pro-efficiency messaging, energy efficiency-specific tips and contacts, and peer comparisons—that may motivate consumers to take energy-saving actions. At the very least, the inclusion of these types of elements could make bills into a critical "touchpoint" as utilities seek to engage customers in their smart grid plans.

We propose that a "good" bill provide both accounting information and historical feedback on actual consumption. Average daily cost, temperature, and degree day information all provide other contexts against which to measure energy-saving actions, and were easily integrated into the design of bills that included them. This is information that utilities already collect, or that can be cheaply acquired, and should therefore be provided to all customers on every bill.

Because feedback is a necessary but not sufficient condition for motivating customers to take energy-saving actions, we propose that a good bill also include other innovative informational elements that enable customers to take action, such as pro-efficiency messaging, personalized tips, energy efficiency-specific contact information, and peer comparisons. These elements seem especially amenable to being wrapped into utilities' smart grid-related outreach plans, but this requires re-envisioning the bill as a crucial customer touchpoint. Integrating the bill into utility-wide strategic efforts and testing targeted bill designs that include these elements is a potentially productive avenue for understanding how to better engage customers in efficiency and smart grid programs.

Figure ES-1: Percentage of Bills Displaying Each Design Element, by Page (n=101)



Source: ACEEE analysis of a sample of utility bills

Now-defunct programs sought to scale up the use of some of these innovative elements, but this did not result in the widespread adoption of such metrics. This suggests that utilities are unlikely to undertake these changes unless they are required and/or are able to recover their costs through the rate structure. Changes to the utility business model, such as through the introduction of decoupling and shareholder incentives, could play a role in overcoming these disincentives to invest in bill changes that promote energy savings.

Based on research showing that overly specific rate information reduces bill comprehension, we also propose that a good bill either eliminate this information entirely, or—as some bills in our sample have done—move this information to page 2 or later in the bill. Utility commissions continuing to require rate specifics could allow that they be easily accessible on a utility's Web site for interested customers or those needing help calculating their bills.

In summary, we have found that the average customer bill does not provide the level of feedback and connection to program resources that it reasonably might. Even as utilities expect more customers to move online to find information about their energy use, there is a role for an improved paper bill to be a cost-effective means of capturing energy savings and customer good will.

INTRODUCTION

The utility bill is the most common way for utilities to provide information about energy use to their customers, but it is often overlooked both as a way to give customers better control over that energy use and to support utilities' goals of more actively engaging customers, especially as a part of a smart grid strategy. Even as smart meters and smart phone apps proliferate, the paper bill, because it is already going to the vast majority of customers, has the potential to become a cost-effective feedback device with a broad reach.

There is a large literature on using different types of feedback to save energy in the home, although much of it is decades old and includes studies conducted outside the United States. A recent meta-review of residential feedback programs conducted over the past 15 years found that consumers could cut their household electricity use by up to 100 billion kilowatt-hours (kWh) and save almost $35 billion over the next 20 years by aggressively adopting a range of feedback tools that empower and motivate them to take control of their energy use (Ehrhardt-Martinez et al. 2010). The programs and pilot projects analyzed in the meta-review fell into two broad categories according to whether they utilized indirect (post-consumption) or direct (real-time) feedback, and were further broken down into five feedback types: enhanced billing, estimated, daily/weekly, real-time, and real-time plus. Studies of these programs and pilot projects reported average household electricity savings ranging from 4–12% (2–11% in the United States), with enhanced billing yielding the lowest average savings and real-time plus feedback the highest. While enhanced billing has now been extensively studied, the results from other forms of feedback should be regarded as tentative until more high-quality evaluation studies with large samples can be conducted in the U.S to better understand and quantify both short-term impacts and long-term persistence of savings.

This report provides a preliminary take on the potential for enhancing the paper utility bill to provide better indirect feedback to utility customers. Our goals are to present new research on the elements appearing on a sample of current bills, to outline some of the history of bill development, and, based on a review of the literature, to characterize how these bill elements align with previous research on bill information design.

More specifically, we set out to answer several questions: What makes for a "good" utility bill? Why is the bill the way it is today? What elements are useful and effective, and how common are these elements on the bill? What are the opportunities for improving the bill? What further research needs to be done?

The report has six sections. We begin by presenting our analysis of a sample of residential bills, identifying common (and not so common) elements. This leads to a discussion of the factors that have made the bill what it is today, based upon conversations with experts and the results of a survey of utilities. This leads us into our literature review of past work on residential bill design. The report closes with a set of preliminary recommendations for potentially cost-effective improvements to bills and how the bill might be leveraged as part of a utility's smart grid strategy.

SNAPSHOT OF THE UTILITY BILL

In order to understand the "state of the utility bill," it seems reasonable to start with an assessment of what is actually *on bills now*. This section discusses the results of our analysis of a sample of approximately 100 utility bills, collected directly from utilities and through an online search. Our sample contains bills from investor-owned utilities (n=66), rural cooperatives (n=10), and public power utilities (n=25). The bills are from utilities operating in every region of the United States (including Hawaii and Guam, and excluding Alaska) and from one utility in British Columbia, Canada.

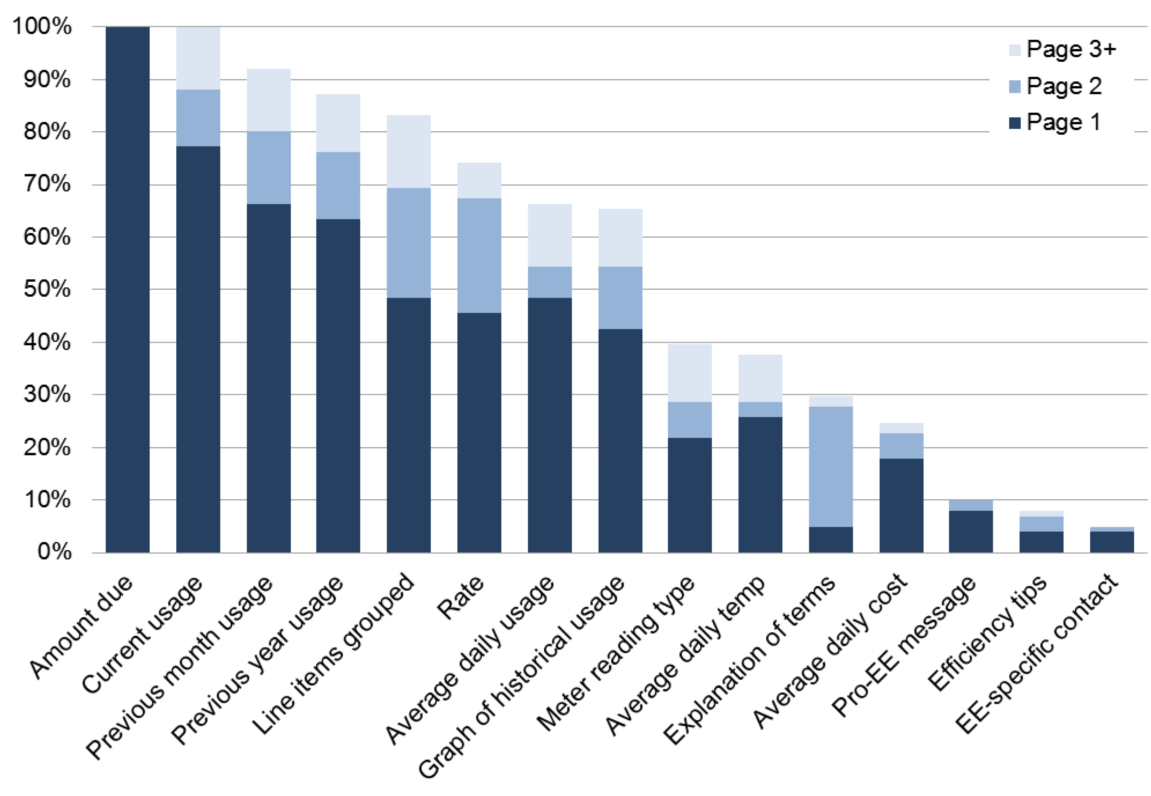
Our original request for paper bills from utility members of the Consortium for Energy Efficiency (CEE), the National Rural Electric Cooperative Association (NRECA), and the Institute for Electric Efficiency (IEE) yielded only a small number of bills. We supplemented those with an online search, the starting point for which was based on resources from the Edison Electric Institute (EEI 2010) and the American

Public Power Association (APPA 2009). The search for bills included a review of approximately 150–175 utility Web sites, approximately only half of which had a sample bill readily accessible. Some utility Web sites provided guidance on understanding bills but without including a full example; the bills in our sample are only those that we received in hard copy or that are provided in full on the utility's Web site.

Our analysis focuses on identifying the relative frequency on the bill of 17 elements, the bulk of which we identified through a review of the literature (see below) and a few additional ones that we included because they appear on many bills. Some explanation of each element is provided in the discussion below; see the full list of elements and their explanations in Appendix A. It is worth noting that this section provides a snapshot of what is on the average customer's paper bill. The question of whether these elements provide useful and actionable information to the customer in managing energy use is addressed in the literature review.

Figure 1 summarizes our analysis, showing the percentage of all bills that include each element, broken down into the percentage appearing on page 1, page 2, or page 3 or later. The elements are presented in order of most to least common overall. We can split the results in Figure 1 into three groups: "standard practice" elements (those that appear on approximately 70–100% of bills), "common" elements (those that appear on approximately 30–70% of bills), and "innovative" elements (those that appear on fewer than 30% of bills). The decision to split the results into these three categories and to give them these particular names does not reflect a judgment about their impact on energy savings. Rather, it is an attempt to succinctly indicate how common or uncommon they are in our bill sample.

Figure 1: Percentage of Bills Displaying Each Design Element, by Page (n=101)



Source: ACEEE analysis of a sample of utility bills

Standard Practice Elements

Six elements appear on 70–100% of the bills in our sample, making them de facto standard billing practice in the industry: the dollar *amount due*; *current usage* in kilowatt-hours or therms; a comparison to usage in the same month the *previous year*; the *previous month's usage*; *grouped line items*; and details of the *rate*. These elements serve both an accounting and a feedback function.

Reflecting the bill's historical role as a revenue collection device, it is not surprising that the total *amount due* and *current usage* appear on 100% of the bills in our sample, nor that they typically appear on the first page. Regulatory requirements and the efforts of customer advocacy groups likely resulted in the inclusion of additional elements such as the *rate* and *line items* to allow customers to calculate their bills accurately, although it is somewhat surprising that the details of the rate do not appear on a higher percentage of bills.

The presence of two comparative usage metrics (*previous year usage*, *previous month usage*) as standard practice indicates that the average customer is already receiving some comparative feedback, a necessary condition for understanding the impact of energy-saving actions and technology investments he might have made. As we note in our literature review, historical comparisons allow customers to identify the effects of seasonal weather patterns on changes in energy use. These two elements typically appear on the first page of the bill, although they often appear again in other forms on later pages.

Common Elements

Next most common are those elements that appear on approximately 30–70% of bills, what we might simply call "common" elements. These include average *daily usage* over the month; at least one *graph of historical usage*; *meter reading type*; *average daily temperature*; and an *explanation of terms* on the bill. Like standard practice elements, common elements also present customers with both feedback and explanation.

Average daily usage and a *graph of historical usage* appear on 65% of bills. Data on a*verage daily usage* may help to tie energy use to daily habits. Graphical presentation of historical usage information provides a useful alternative means of providing comparative feedback. Of the bills that include a graph or a table of historical usage, the number of months displayed ranges from two to twenty-four, with thirteen months the most common (on 87% of bills showing comparative usage history). Thirteen months (the current month plus a rolling twelve-month history) allows a comparison to not only adjacent months, but allows the customer to see seasonal changes in energy use and compare the current month's usage to the same month one year earlier.

Meter reading type refers to an explicit statement about the type of meter reading on which the usage displayed on the bill is based. While results from our survey suggest that the vast majority of consumers are receiving bills based on actual meter readings, less than half of bills are communicating this to customers.

Average daily temperature is also included on less than half of bills, and often appears in a chart with similar comparative metrics on the first page. Its inclusion on bills provides a reliable means of accounting for changes in weather (in addition to the previous year's usage), allowing consumers to better pinpoint behavioral or technological changes that account for differential energy use. Some bills also provided information on heating and cooling degree days, a measure of the demand for heating or cooling in a particular geographic location.

The *explanation of terms*—including explanations of the rate, line items, and usage metrics—appears on 30% of bills, meaning that only one-third of bills with rate specifications and categorized line items provide any explanation of what those terms mean.

Innovative Elements

Lastly, elements appearing on less than of 30% of bills we have called "innovative elements," following Rogers (1995), who noted that the diffusion of innovations reaches a critical mass at approximately 25% adoption. These four elements are "innovative" in the sense that they have not yet been widely adopted by utilities and present new kinds of information that may help to motivate customers to take energy-saving actions. This term was also used in the "Innovative Billing" program work (see below) to describe similar elements.

Innovative elements include providing an *average daily cost*; a *pro-energy efficiency message*; an *energy efficiency-specific contact*; and *efficiency tips*. These elements represent what we have called, in the literature review, the motivational design principle. Providing regular, accurate, understandable information about energy use is necessary but not sufficient to drive significant energy savings. People also need motivation and clear direction about steps they can take.

Average daily cost, like average daily usage, allows a rough comparison of the cost of energy use to other daily activities and budgets.

Omitted Elements

The final elements that we looked for on our sample bills were the use of *peer comparison* and *alternative metrics* in addition to the traditional kilowatt-hour and therm.

Not surprisingly, perhaps, neither appears on any of the bills in our sample. Peer usage comparison information is part of the services provided by third-party software companies such as Opower, Efficiency2.0, and Tendril. Opower, in particular, provides customers of utilities that purchase its services with regular home energy reports (on paper) as a supplement to their regular utility bill. These reports contain comparisons to residential peer group energy usage as well as targeted tips to save energy. Currently, only a small portion of utilities are piloting these services, and none of them has integrated peer comparisons into their normal utility bill.

Alternatives to the traditional metrics might include things such as carbon dioxide emissions from household energy use. The inclusion of such metrics has received limited consumer testing (AECOM 2011) and has yet to appear on bills in the United States. This may be because of regulatory restrictions on the mixing of estimated and verifiable information on the same bill, or because utilities lack an incentive to include on the bill alternative metrics that are not required by regulators.

Summary of Bill Analysis

Our review of one hundred utility bills found that the average customer is being provided, first, with basic accounting information such as their current usage and the total amount due, supplemented by specific rate information to allow them, in theory, to make the connection between usage and the amount due. Grouping line items on the bill may help control the proliferation of line items due to specifying the rate, but there is evidence that too much detail on the bill confuses rather than clarifies (Payne 2006).

The average customer is also getting some comparative feedback on their energy usage in the form of, most often, the previous month's usage. Most bills supplement this with the previous year's usage, the customer's average daily usage, and a graph that typically includes 13 months of usage data. Historical feedback is a necessary but not sufficient condition for understanding the impact of any behavioral or technological changes meant to reduce energy use, and the fact that such metrics are included on more than 60% of bills is promising. The question remains, however, whether customers actually grasp such metrics and are using them to better control their energy use.

What is missing from the average bill, and, in fact, almost 90% of bills, are those innovative elements—such as pro-efficiency messaging, energy efficiency-specific tips and contacts, and peer comparisons—that may motivate consumers to take energy-saving actions. At the very least, the inclusion of these types of elements could make bills into a critical customer "touchpoint" as utilities seek to engage customers in their smart grid plans. Evidence from recent smart grid pilots shows that utilities that have made the effort to cultivate customer goodwill prior to their programs have faced the fewest issues (SGCC 2011). Bills that incorporate innovative elements that not only inform customers about efficiency and smart grid pilots and programs, but also provide resources to help them enroll in programs, could serve as a critical piece of the customer engagement puzzle.

Now that we have an understanding of the current state of the bill, we next look at what has made the bill what it is today.

BILL PAST, BILL FUTURE

Several factors have historically determined the content of bills, most notably regulatory requirements and utility billing systems. In this section we discuss these factors, based on conversations with experts and a survey (n=241)[1] of utilities; we also identify some barriers to successfully redesigning bills.

The vast majority of households receive information about their energy use mainly through a paper bill, although other forms of feedback were reported in our survey. Survey respondents said that, on average, 95% of their customers or members receive information about their energy use through a paper bill, 11% by e-mail, 22% online, 11% through an in-home display, and 2% by pre-paid meter.[2] On average, the majority (89%) of bills are based on actual meter readings, although a small number are either from self-reads of the meter (6%) or are estimated (2%).[3] In addition, customers typically get feedback about their energy use on a monthly basis (82%), although a very small percentage of customers have access to information both less and more frequently.

Several utility industry experts emphasized that the form and content of the typical bill is the result of accumulated decisions made over the course of many years, rather than the product of a holistic, forward-looking process either by the individual utilities or by commissions (although results from our survey suggest that bill redesigns based on consumer research do happen). These legacy decisions include regulatory requirements that attempt to provide transparency on rate structure and line item charges to ratepayers so that they can, ideally, calculate their own bills. Typically included in the list of lines items are federal, state, and local taxes; facilities charges; public benefits charges; and costs associated with new generation and transmission.

Several experts mentioned, however, that the proliferation of line items in recent years has probably contributed little to ratepayers' understanding of their bills, and may actually have had the opposite effect. Utilities may be even be adding to the confusion. As our survey shows, amongst the 44% of respondents who said that their utilities had made bill changes in the past five years, one of the most common changes was to increase the number of line items.

Regulatory rules place further restrictions on bill content by not allowing for the mixing of estimated and verified information on one bill. The inclusion of typical metrics such as kilowatt-hours, therms, and dollars owed is permissible, whereas estimates of disaggregation by end-use may not be. It is unclear how widespread is this restriction on estimated information and whether it also applies to alternative metrics such as carbon emissions, which we found reported on none of the bills in our sample.

[1] The survey was sent to utilities through two member associations, the Consortium for Energy Efficiency (CEE) and the National Rural Electric Cooperative Association (NRECA). NRECA sent the survey to 761 of their members and received 233 responses, a response rate of 31%. From the 108 investor-owned utility members of CEE, we received eight responses, a response rate of 7.4%. The full survey instruments can be found in Appendix B.

[2] Because the same household can receive energy use information through multiple channels, these percentages need not add to 100%.

[3] Self-reads are actual monthly meter readings performed by the customer and reported to the utility. An estimated bill is based not on an actual monthly meter reading but on an estimate of the household's consumption, usually an average of past readings. For both self-reads and estimated bills, the next time the meter is actually read, the utility may "true up" the bill to reflect actual usage, with the customer paying any difference or receiving a credit on the next bill.

Utilities' legacy billing systems also have an influence on bill content by effectively freezing bills in time, making them difficult to redesign. Roberts (2004, 27–28) notes in his study of consumer preferences on feedback: "Suppliers have a wide range of issues associated with 'legacy' billing systems inherited from several different companies…[and that] adapting systems to meet feedback needs could be a major undertaking."

An oft-cited reason for maintaining the status quo on billing is that the high cost of making changes to legacy billing systems, although one expert noted that system overhauls are not necessarily as prohibitively expensive as is sometimes suggested. Estimates for capital costs gathered during the research for the U.S. Environmental Protection Agency's (EPA) ENERGY STAR Billing program ranged from approximately $10,000 to $100,000, with ongoing annual costs essentially zero (Lord et al. 1996). Another interviewee stated that these billing systems are, in fact, overhauled occasionally, but insufficient engagement between utilities and other stakeholders may limit the type and number of changes that are made to bills at these times. Changes to the billing system will likely already take place as utilities proceed with their smart grid plans, so the marginal cost of incorporating additional changes to provide customers with more informative bills is likely negligible.

In addition to regulatory requirements for what must appear on bills and legacy billings systems, other factors create barriers to easily changing bill format and content. These include organizational dynamics such as the limited communication between, and sometimes divergent goals of, a utility's various departments. Kempton and Layne (1994, 858) note:

> Current bill formats result from negotiation among internal utility departments (customer service, data processing, etc.), with some constraints set by public regulators in conjunction with consumer advocates and other stakeholders in public regulation. When bill design has been considered at all, readability and use evaluations have been based on reduction of complaints and maintaining the ability to compute billed total from legally approved rates.

The bill pulls information from, and impacts the operations of, multiple departments within a utility. The customer service department wants to minimize calls from customers concerned about unusually high bills, the accounting department wants to get paid, the legal department wants to meet regulatory requirements and avoid triggering a utility commission hearing, and the IT department has to deal with collecting, analyzing, and disseminating the information that appears on bills within the bounds of existing systems. Therefore, changes to bills can require significant buy-in from stakeholders across the organization (Payne 2011). However, there is some evidence that more informative, understandable, and engaging bills—complementing online offerings—can reduce customer service calls and help customers' manage their energy better (Michaels 2008), so overcoming institutional barriers to bill changes can have benefits for both utilities and customers.

It was suggested by one industry expert that another issue preventing change is the self-fulfilling prophecy on the part of utilities that customers do not look at bills and that, therefore, there is no incentive for the utility to improve their design or content. However, evidence from Kempton and Layne's (1994) ethnographic study suggests that customers do indeed look at their bills and try to extract as much information as possible beyond the total amount due. Specifically, customers use bills to identify unusual consumption and to evaluate previous behaviors taken to control that consumption.

Moreover, as our survey shows, customers use multiple channels simultaneously to get information about their energy use. This may be because, as evidence about residential customers suggests, there is significant and growing demand for access to meaningful information (Michaels 2008). Although the average customer may spend little time looking at an individual bill or their utility's Web site, access to several sources may add up. A recent study on excellence in customer engagement suggests that utilities begin to look beyond their industry to consumer electronics and telecom companies for ideas about engaging customers through multiple channels (SGCC 2011). We would like to suggest that, since the bill is a resource that *already* goes to *every* customer, it should be leveraged more heavily in utilities' overall strategies.

Our interviews with experts turned up two other potential barriers to making changes to the bill: customer turnover and resistance to normative comparison. Customer turnover creates an obvious barrier to providing historical comparisons in the form of 12 months of energy usage for those who have recently moved into a new home. In addition, while normative comparisons have shown to produce energy savings, privacy concerns and consumers' skepticism about peer group validity may create barriers to the inclusion of such comparisons on the bill.

Looking forward, we asked utilities whether they had recently conducted research on the bill and, if so, what types of research they had done. As noted above, 44% of survey respondents said that their utility had made a change to the bill within the last five years, and that a common change was to increase the number of line items. Happily, increasing the amount of feedback given to customers about their energy usage was also common. Strangely, though, only about 24% of respondents indicated that their utility had conducted consumer research on energy bills in the last five years. This raises the question about what formed the basis for these changes.

Of those respondents who had conducted research, many indicated an interest in connecting bill design and information provision issues to customer segmentation and engagement. One respondent indicated that they had recently conducted focus groups and online research to determine customers' needs related to bill design and information provision; this process formed the basis for recent changes to their bill design and layout. Smaller-scale research by other respondents is ongoing or has been recently completed, although the degree to which this research has informed bill design is unclear from the survey responses.

While the paper bill is still dominant, 83% of survey respondents indicated that they expect customers to increasingly access energy use information electronically and that, in some cases, they are actively promoting paperless billing to their customers. This includes setting targets for the percentage of their customers receiving energy use information electronically, whether through online portals, mobile devices, or in-home displays. The push towards electronic/paperless billing is unmistakable, but it does not undermine the position of the paper bill as either a feedback device or as a way for utilities to engage customers in efficiency programs or efforts like the smart grid. The principles of information design that make a good paper bill likely also make a good Web site. The bill can help to drive customers to online portals with more information and analytical resources, but our review of one hundred bills found that few, if any, utilities are referencing specific online resources for energy efficiency on the main portion (not inserts) of the bill.

Finally, to address the issue of feedback frequency, our survey asked utilities about how frequently they measure energy use, and how frequently it is updated and made available to customers. Thirty-six percent of respondents measure residential energy use daily, 28% measure it hourly or more frequently, 21% measure it monthly, and 4% measure it continuously. There tends to be a lag, however, between when the data is measured and when it is updated and made available to customers. Fifty-eight percent of respondents update residential customer energy use only monthly, followed by daily (21%), continuously (3%), hourly (3%), or every eight hours (1%). As we can see, the provision of feedback more frequently than monthly is still not widespread, but the pace of advanced metering rollouts suggests that this situation may change over the next decade.[4]

In summary, the paper bill has rarely been handled in a strategic way by either utilities or regulators. Starting out as purely an accounting document, the bill has arguably suffered from an overly legalistic approach to providing customers with information about their energy use. A notable barrier to making changes to the bill is institutional: different stakeholders within the utility influence the type of information that is on the bill, and so making non-mandatory changes likely requires significant buy-in from a large number of people. That said, there is an opportunity for utilities to use the roll-out of their smart grid plans to integrate the bill into their larger customer engagement strategy and to make changes to their systems

[4] According to the Federal Energy Regulatory Commission (FERC 2011), the estimated penetration of residential advanced meters in the United States reached 8.7% by 2010, nearly double the level found in 2008. This translates to a 40% annual rate of growth in smart grid penetration.

that will likely be required to handle a larger volume of energy use data. As the following section outlines, research suggests that the bill need not remain merely an accounting tool, but can serve to inform, engage, and motivate customers to reduce their energy use.

LITERATURE REVIEW

In this section, we seek to establish an operable definition of a "good" residential electric bill, based on a review of the literature over the past 30 years on energy use feedback. To summarize briefly, the literature reveals that multiple stakeholders have a vested interest in utility bill design, including utilities, regulators, customers, and energy efficiency policy advocates. These stakeholders have slightly different but overlapping objectives, including ensuring that bills are paid, that customers can understand how charges are calculated, that information can be used to manage energy use and costs, and that the bill promotes reductions in energy consumption. Three core design principles can be used to achieve these goals: feedback, explanations, and motivational elements.

Bill Purpose

In order to identify and promote well-designed utility bills, it must first be clear what the bill is intended to achieve and for whom. Historically, the electric bill has been used primarily as a collection mechanism for utilities. Because the bill was intended to be comprehensible, its design focused on providing transparent accounting of charges to justify the total dollar amount. But increasingly, customers are using other information on the bill, including total consumption and comparative information, to manage their energy use. The utility bill therefore also needs to be actionable and to provide information that allows customers to manage their costs and consumption. This reflects a broader change in the relationship between utilities and customers, in which utilities are providing new kinds of services and interacting with their customers in new ways. The bill may also be useful in improving utility-customer relations and promoting uptake into other utility services such as energy efficiency, demand response, and time-of-use pricing programs. Therefore, the literature suggests that good utility bills are *easily understandable, enable energy management,* and *enhance utility-customer relations*.

Ease of Understanding

Traditionally, the utility bill has been used exclusively as an accounting and payment mechanism. As regulated monopolies, utilities are required to provide customers with an itemized calculation of the charges incurred for electric generation and transmission, along with any taxes and fees. The bill is designed so that any customer can re-calculate their bill starting with the total kilowatt-hour consumption and base rate. While intended to provide clear and comprehensible information, this legalistic approach often results in a proliferation of line items showing one-time costs, taxes and fees, and other add-ons and adjustments.

The presence of irrelevant and overly detailed information—what we might call "billing noise"—can obscure or de-emphasize what is useful. A study on billing in Sweden surveyed 1,050 households in three utility territories and came to similar conclusions. Fully 57% of respondents said their bill was "hard" or "very hard" to understand. Respondents "experience expressions or concepts as being too complicated. They also feel that there is too much or too detailed information and sometimes the information is not specified clearly enough" (Sernhed et al. 2003, 1148).

When information does not make sense to customers, it may be ignored, and essentially lost. Payne (2006) found in his ethnographic study of bill comprehension in a small business setting that representing rate tariffs too precisely—to six or more decimal places—led many of the people he interviewed to disregard the information presented, and even raised suspicions among some of them that the utility was trying to hide additional changes in the long string of costs. Not surprisingly, the focus on providing an exhaustive list of itemized charges left many of his informants overwhelmed, not better informed. Therefore, both the number of line items and the precision of the individual lines had a (negative) impact on comprehension, and contributed to a sense of defeatism amongst customers that they could actually do anything to reduce their energy use.

A comprehensible utility bill should make it easy for consumers to receive and process core information, while still providing the details required by regulators. This can be addressed through what information is given and how it is organized and presented. For example, the news industry has designed its products to optimize consumer processing by starting with the most important information and adding successively greater detail, repeating key points, and enabling the reader to skip and skim parts they are less interested in (Kempton & Layne 1994). The same principles apply to the bill.

Enabling Energy Management

There is evidence that utility bills are being used by customers to do more than simply verify the dollar amount owed. Kempton and Layne wrote: "The bill, managed by the utility primarily as a revenue generating mechanism, is for many customers heavily utilized to extract as much information as can be gained from it" (1994, 859). In their study, 41% of customers reported examining the kilowatt-hour usage, and 41% looked at the table or graph comparing consumption to last year. In fact, the most frequent reason customers looked at additional bill information was to try to understand unusual bills. This indicates that customers are using bill information to gain insight into their energy consumption and help manage costs. Michaels (2008) also noted the significant demand amongst residential customers for meaningful information about their energy use.

However, the current typical bill design does not provide adequate information for customers to analyze their own energy consumption. Currently, most people make energy management decisions using informal, dollar-based analysis. In their work on the folk quantification of energy, Kempton and Montgomery wrote that dollars are the most meaningful metric to customers because they are a common basis of comparison to other activities and costs. "Dollar measurements, though inexact, offer advantages in household management. Dollars apply broadly to housing, food, and other expenses; thus they allow comparisons across expenditure categories" (Kempton & Montgomery 1982, 820). As we saw in our review of bills, metrics such as average cost per day appear on only one in four bills.

A reliance on dollars as the basis of comparison, however, makes it much harder to evaluate true consumption levels and savings from conservation measures. Such comparisons obscure changes in rates, weather, technology, and behavior. Kempton and Montgomery wrote that a dollar-based "payback calculation fails to adjust for fuel price increases and undervalues financial savings" (1982, 822–23). This results in an overestimation of the payback period from energy efficiency measures and leads to a broader sense of the futility of trying to save energy because utility bills will increase regardless.

The challenges inherent in dollar-based analysis reveal a broader issue that customers' analytic efforts are curtailed by the form in which they receive price and consumption information on utility bills. For example, the effects of weather also preclude an easy comparison of historic information using either dollars or kilowatts. Kempton and Layne wrote: "The problem we see with traditional billing is that it leaves to the consumer the intermediate steps of collecting weather data, adjusting energy use for weather, and deciding whether the month is anomalously high or low" (1994, 865). Eighty percent of their survey respondents recognized that weather has an important effect on utility bills. However, respondents reported using informal methods to compare this year to last year, including the "feel" of the winter, the number of days of snow, length of time winter clothing was needed, how often the heater was on, or the number of days with record lows (1994, 862). Thus, using typical utility bills of the time, there was no way for customers to precisely evaluate changes in consumption using kilowatt-hours and dollars. The situation has only improved somewhat.

A better utility bill might process the raw data into a form that helps customers manage their energy consumption. Utilities should carry analysis further by adjusting for price and weather changes and identifying whether there has been a statistically significant change. Customers can then attribute causes to changes in external factors or to changes in behaviors in the household, and then adjust their actions accordingly (Kempton & Layne 1994).

Customers' desire for richer decision-making information is also reflected in the Swedish study discussed earlier. The survey asked respondents which new features they would be interested in having on their utility bills. Ninety percent were interested in an alert or warning if their consumption suddenly increased; 75% wanted a comparison to the same month of the previous year; 60% wanted energy conservation tips; and 50% wanted information about comparable households (Sernhed et al. 2003). These consumer preferences reveal the importance of comparative information that puts energy consumption in context. Price and weather normalization are really only intermediate steps that allow customers to compare current use to historic usage or that of a peer group, and thus identify whether their use is anomalously high.

Enhancing Customer Engagement

Finally, the utility bill has the potential to become an increasingly important customer engagement tool as utility business models evolve and as utilities begin to offer a greater range of services to their customers. Historically there has not been much need for interaction between utilities and their customers; utilities provide an essential commodity and customers are charged based on set rates. As a result, utility bills are the primary, and in many cases only, interaction that customers have with utilities.

> Usually there is not so much interaction and engagement in the relation between electricity suppliers and customers in general. The electricity bill is one of the few contact situations that occur, and the attitudes that the customers have towards it is reflected in their evaluation of the service and the relationship (Sernhed et al. 2003, 1147).

From this perspective, the utility bill is at the center of the *relationship* between customers and utilities. As such, the bill is not a *one-way* communication (utilities providing billing information to customers), but two-way (customers responding by paying bills, contacting the utility, and/or participating in utility offers). Customers' experiences with bills are emblematic of their relationship with the utility. For example, more than 20% of customers call their utility about their bill each year, and each customer calls an average of 2.5 times (Michaels 2008). It is in the utility's interest to reduce the number of these calls, and to deal with the "vocal minority" proactively.

In 1994, Kempton and Layne conducted surveys and interviews of 56 households in New Jersey about their utility bills, finding that:

> Both the utility's customer service department and the state regulators are driven by complaints, from a minority of customers, toward putting each separate charge on the bill so the billed amount can be computed to the exact cent. Our data suggest that the complaining minority has unduly focused utilities and regulators on tabulation to the exact cent, since only 4% of our sample reported even looking at the arithmetic on the bill (1994, 861).

Yet there is evidence that improved information design on the bill can improve customer bill comprehension, thereby reducing the number of customer service calls. A pilot conducted by the Wisconsin Public Service found that the inclusion of energy diagnostics and information about efficiency resources on the paper bill resulted in 90% fewer calls from pilot participants and seven times higher usage of the utility's Web site. In addition, 90% of participants found the bill more understandable and 60% found it helped them manage their energy use (Michaels 2008).

Utility experiences dealing with complaints from smart meter deployment also provide interesting lessons for dealing with general bill complaints. Several utilities have established trouble-handling capabilities to resolve customer complaints before smart meter deployments, and many have minimized the intensity of complaints from the vocal minority by adopting a customer-centric, personal approach. San Diego Gas & Electric, for example, trained its entire staff about smart meters and sent customer service representatives into the field to respond to emotional complaints both empathetically and factually. Overall, utilities that have made an effort to establish customer goodwill in advance of their smart meter programs have been most successful in avoiding issues (SGCC 2011).

Equally large-scale efforts related to energy efficiency might go a long way in promoting trust of utilities amongst customers. Research has found that while customers trust utilities to keep the power on, they find bills to be highly technical, complex, and abstruse (Kempton & Montgomery 1982). This reflects customers' overall sense of utilities as inaccessible, bureaucratic monopolies. Great Britain's Office of Gas and Electricity Markets (Ofgem), responsible for the regulation of the nation's electricity and gas markets, sponsored a series of focus groups to understand consumer preferences for different kinds of information on utility bills. One of the study's main findings was that a typical energy consumer has "little faith in their energy supplier and no sense of why they might promote energy saving" (Roberts 2004, 20). As evidenced through our own interviews and others' research, many customers have a deep distrust of utilities and are cynical about their motivations in promoting energy efficiency.

The author of the Ofgem study postulated: "the extensive cynicism about energy suppliers and their role in energy saving may be an important factor in how ready consumers are to seek energy saving advice and assistance from their suppliers" (Roberts 2004, 31). While the current situation is a challenge, it is also an opportunity to use the existing bill-based interaction to reposition utilities as trusted advisors for energy-related issues and decisions. This is especially the case with the introduction of time-differentiated pricing and increased supply choices for customers, both of which will likely add an additional layer of complexity to already confusing bills.

In addition, an improved and customer-oriented bill may be essential to retaining customers and, therefore, to utility success, especially in a deregulated environment (Lord et al. 1996; Wilhite et al. 1999). Researchers have investigated the possibilities for bills to be used as tools for improved customer relations:

> The separation of the current integrated utilities into component parts is likely to result in multiple power vendors competing for the same customers. Building customer loyalty, therefore, becomes important to maintain a competitive position in the market (Eide et al. 1996, 2).

They go on to say:

> In order for utilities to develop effective customer service programs, they need to learn more about their customers, how they use currently available information, and what additional information and services they want (Eide et al. 1996, 3).

Utilities' efforts to understand their customers are only just getting underway. The use of customer segmentation techniques in targeting programs, while widely used in other industries, is beginning to appear in utilities' communications strategies related to the smart grid. In particular, the Sacramento Municipal Utility District (SMUD) has used an attitudinal segmentation that groups customers into, amongst others, "young families," "money minded strivers," and "big toys, spenders." SMUD measures each segment's engagement with the program and monitors the use of different media by each segment (SGCC 2011). Such research could easily be adapted to provide different bills to different segments, assuming that any regulatory hurdles can be overcome.

A better designed utility bill may therefore have direct benefits to the utility by enhancing customer engagement**.** At the most basic level, a more easily understandable bill can result in less questions or complaints to customer service, because people understand why their total bill is what it is. While this was the original intention behind increasing the level of detail and number of line items on bills, the result has been a more complicated bill. A residential bill that presents key information, places it in context, and provides explanations and resources could also lead customers to feel they have a better relationship with or more trust of utilities. This improved relationship could potentially increase uptake into the utilities' energy efficiency programs or other service offerings.

Information Design

After revenue collection, the most important purpose of a successful utility bill is information feedback. Darby wrote that feedback is "a learning tool, allowing energy users to teach themselves through experimentation" (2006, 3). In order to be meaningful to consumers, energy consumption feedback should be provided frequently, include key consumption-related metrics, and be placed in context using historic baselines or peer comparisons. However, most consumers are not energy experts. Bills can help customers interpret and utilize energy data by organizing information to highlight key metrics, defining terminology, and using compelling graphics. Customers can then use the bill information, and their knowledge of household activities and events, to connect cause and effect. Finally, bills can help customers take the step from understanding to action by utilizing pro-efficiency messages, giving actionable tips, and providing contact information for efficiency incentives or technical assistance programs.

These principles generally align with the cycle of learning and action developed by Ofgem's Energy Demand Research Project: "This cycle has three inputs: feedback to consumers about energy consumption, advice… about how to make savings, and motivation… to implement that information" (Darby 2010, 2). Our paradigm articulates how the utility bill can support this broader cycle.

Feedback

Information is necessary to make good decisions and evaluate actions in many areas of life. But raw data is helpful only to the extent that it is translated into meaningful feedback connecting behavior and outcome. Regularly updated, accurate energy use data can serve as a mechanism that enables people to exert greater control over their consumption and see the impact of their actions.

> Information may increase knowledge, but does not necessarily affect behavior. Feedback is effective to the extent that it provides highly specific, relevant, actionable information, and a means for checking the effectiveness of actions (Darby 2010, 6).

Much of the research on influencing resource-using behavior is based on psychological theories of learning and reinforcement, which hold that information provided after an act is considerably more effective than prompts provided before an act, although the combination of these two strategies is generally most effective (Lutzenhiser 1993). Thus feedback entails providing both antecedent information, such as baseline data, advice and goal-setting, as well as consequent information, including comparisons to one's baseline, goals, and peers (Abrahamse et al. 2005). The residential utility bill is well suited to provide this kind of regular, comparative information after the fact.

The components of effective feedback have been well defined. In ACEEE's meta-review of residential feedback programs, the authors identified three characteristics of feedback that correlate with higher program effectiveness: "(i) the frequency of feedback, (ii) whether the feedback is direct or indirect, and (iii) whether or not the feedback provides a contextual framework by which the individual can evaluate his or her performance" (Ehrhardt-Martinez et al. 2010, 39). A joint study from the EPA and the University of Delaware on improving residential billing options proposed a similar definition: feedback should be given in a prompt time span; presented in specific, understandable, and significant units; and should relate to a comprehensible standard or comparison group (Lord et al. 1996).

In the 1970s and 1980s, energy efficiency policy advocates focused on ensuring customers were given accurate information regularly, including using actual rather than estimated meter readings and providing bills on a monthly rather than quarterly basis. A study in Norway showed that increasing billing frequency from quarterly to monthly, and providing actual rather than estimated consumption, led to electricity savings of 7.9% in the first year of the study and 10.4% in the second year. The authors found, based on interviews with study participants, that the results were due to people clearly seeing the relationship between their behavior, their energy use, and the bill (Wilhite & Ling 1992a).

Much progress has been made on these fronts in the United States. Today, all of the utilities in our bill sample provide monthly bills, and the vast majority of customers receive bills based on actual readings, while only about 2% of bills are based on estimates each month. This 2% of meters may be located in relatively inaccessible areas, or may be due to one-time weather events or other factors that limit access to the meter in areas that typically receive bills based on a reading. With the continued rollout of automated metering reading technologies as part of the smart grid infrastructure, the percentage of estimated bills will likely continue to drop over the next decade or so. In our sample of bills, most bills at least indicate the type of *meter reading*.

While the frequency of feedback provided by paper bills is unlikely to change, there is potential to improve the quality of the information and its contextual framework. While provided on most bills, *current usage* in kilowatt-hours or therms, the electric *rate,* and the *total amount due* are not always sufficient metrics for energy analysis. Bills can provide more specific and understandable information by computing a *daily average kilowatt-hour or cost* metric. This accounts for differences in the lengths of months and breaks consumption into a tangible cost that relates to daily routines. In order to account for the effects of weather, bills could either conduct weather normalization or provide *average temperature* data. Weather normalization may not be the best alternative as it requires advanced analyses on the part of the utility and the results would not directly correlate with historic bills. In contrast, average temperature data is a simple addition to bills and still provides a better benchmark than the lay methods of accounting for weather.

Although feedback provided on the regular monthly bill serves to strengthen the connection between energy consumption, cost, and behavior, other types of billing that are becoming popular tend to weaken that connection, effectively returning us to the era of estimated consumption. For example, we found in our review of bills that many utilities are heavily promoting "budget" (or "levelized") billing on their Web sites. In this type of billing scheme, the utility estimates the customer's total annual bill, divides it by 12 (months), and sets the customer up to pay that amount each month. Any difference at the end of the year is "trued up." In this way, energy is treated as a fixed cost for the customer, severing the connection between consumption and cost, and removing any incentive for the customer to pursue cost savings through energy-saving investments or behaviors.

The second key component of feedback is providing a meaningful context through comparing one's own *historical usage*. Research shows that residential energy consumers benefit from having a point of comparison from which to assess their own levels of energy consumption (Ehrhardt-Martinez et al. 2010; Payne 2006). In her work on historic feedback, Darby (2010) argued that feedback is central to the cycle of learning and action. Based on psychological and educational theory, she concluded that historic comparisons increase customers' sense of control by allowing experimentation and self-education.

Feedback enables customers to evaluate the effect of their attempts to use less energy, and evidence suggests that they want and are able to use this kind of information. Results from a study of consumer billing preferences found that people like "simple bar charts with historical data, direct, and personal" (Roberts 2004, 17), and that they are able to interpret and respond appropriately to historic data. An earlier Nordic study found that, after historical usage was added to their bills, participants reported reading the bill more often, found it easier to understand, and better grasped trends in consumption (Wilhite et al. 1999). A third study found that the most readily recalled information from bills was the comparison to the same period last year (Eide et al. 1996).

More importantly, results of pilot studies have shown that adding basic historical comparisons to the bill resulted in customers saving energy. In the Nordic study cited above, participants had average savings of 10%, which persisted over the three years of the study (Wilhite & Ling 1995). A recent large-scale, coordinated pilot involving 60,000 utility customers in the UK found that average savings from adding historical usage information to the bill ranged up to 5% (AECOM 2011).

Energy usage could also be provided by in other units than it is now. While there are references to the difficulties that customers have in understanding the traditional metrics used on bills and comparing them to other energy-using activities (Kempton & Montgomery 1982), we found no literature that goes beyond recognition of the abstruseness of kilowatt-hours and therms to propose *alternative metrics* that can provide different types of feedback.

Parallel examples do exist, however. The recent redesign of the U.S. fuel economy label provides some insights into the rationale for adding new metrics to an information source with which consumers are already familiar. Under the Energy Independence and Security Act of 2007, Congress mandated that the

National Highway Traffic Safety Administration (NHTSA) develop a label program for new automobiles based on its performance regarding fuel economy and greenhouse gas and other emissions over the useful life of the automobile (EPA & NHTSA 2011).

The rationale for adding new metrics and redesigning the label was two-fold. First, the development of a more technologically diverse vehicle market that includes non-liquid fuel powered vehicles requires different label content to inform consumers about the capabilities of these new technologies. Second, the agencies involved in the label redesign believed that the new requirements would improve the content and presentation of information to promote informed decisions among consumers (EPA & NHTSA 2011). These conditions are analogous to the growth in the renewable energy sector and the continued push towards integration of these new resources into the electricity grid, which, in combination with state-level renewable resource standards, is starting to have an impact on utility fuel mix. A utility bill that includes an alternative to the kilowatt-hour, such as greenhouse gas and other emission metrics based on the fuel mix, provides information that informs consumers about the advantages and disadvantages of different electricity-generating fuels and technologies.

In addition to the traditional fuel economy metric of miles per gallon (MPG) that has appeared on the vehicle fuel economy label since the 1970s, several alternative metrics were considered in the label redesign. A new metric of miles per gallon equivalent (MPGe) represents the energy use of non-liquid fuel vehicles in the gallons of gas that have the equivalent energy content, allowing for easy comparison across technologies (EPA & NHTSA 2011). The kilowatt-hour plays this role on the electricity bill by allowing utilities to report one metric for usage no matter the fuel used to generate the electricity. While cross-comparison is useful, metrics such as MPGe and kilowatt-hour gloss over the differences in conversion efficiency of various technologies and their associated impacts on the economy, national security, and the environment.

Other metrics added to the redesigned fuel economy label include both an absolute and a relative measure of greenhouse gas and other vehicle emissions. Absolute greenhouse gas emissions for a particular vehicle are displayed on the label in grams of carbon dioxide per mile driven, while a relative score from 1 to 10 combining greenhouse gas and fuel economy appears along a slider bar, a type of comparative metric. A separate slider bar is used to display the vehicle's smog rating (EPA & NHTSA 2011). The absolute measure of greenhouse gas emissions could easily be adapted to the utility bill, for example, as pounds of carbon dioxide per kilowatt-hour, the calculation of which would be based on the utility's fuel mix, capacity factor, and system efficiencies.

Beyond the analogous situation of the fuel economy label, in order to help customers better understand the magnitude and environmental impact of electric consumption, bills could provide a range of alternative metrics and equivalencies that people can relate to, such as car trips, air miles, calories needed to run a mile, the embodied energy of a hamburger, hours of TV or computer use, etc. Alternative metrics can be used to measure either total consumption or consumption reduction, and help people feel that the impacts of their energy-saving actions are not just a "drop in the bucket." Efficiency programs might present a variety of metrics on performance and savings that resonate with different customer segments, based on market research by utilities.

Explanation and Presentation

Utility bills can help customers interpret energy data in a way that can be directly connected to causes within the household. In fact, many customers are already trying to use their bills to understand their consumption. Research suggests that a large portion of customers use their utility bills to understand consumption, detect changes in consumption patterns, and evaluate the impact of actions they have taken to save energy (Kempton & Montgomery 1982). As we have noted, however, bills have not been designed with the explicit goal of enabling customer interpretation and energy management. One study found that rates have been of most concern to regulators and consumer advocates, rather than a consideration of how consumption information reaches the utility customer (Kempton & Layne 1994). The authors argue that while customers are not well suited to conduct detailed energy analysis, they are in the best position to interpret the results based on first-hand knowledge of household events. Bills should therefore feature the core metrics that relate directly to consumption.

Along these lines, a good utility bill should not only address what information is presented, but how it is presented. Roberts (2004) argued that the manner of presentation is a core consideration that has been much overlooked in research on utility bills. Likewise, in describing the purpose of the now defunct ENERGY STAR Billing program, the authors wrote, “The challenge to researchers and utilities is to accurately convey consumption data to the average customer in a comprehensible manner” (Lord et al. 1996, 6). Ultimately, bill design should enable energy management by helping customers understand the extent to which variation in bill totals are a result of changes in actual consumption or of other factors such as weather, changing rates, and surcharges.

At the most basic level, bills that *group line items* and provide an *explanation of terms* may be easier to understand. There is a range of charges on most bills, reflecting supply and distribution costs, taxes and fees, and one-time charges. Some of these charges are variable depending on the amount of energy consumed, while other charges may be fixed. A proliferation of line items on bills makes it more difficult for customers to understand why the total is what it is. In the absence of changes to regulatory requirements, the proliferation of line items can be addressed by grouping them into appropriate categories.

Grouping line items takes advantage of the cognitive principle of “chunking,” facilitating short-term memory and understanding. In his seminal paper on information processing, Miller (1956) found that there are limits to the amount of information that humans can receive, process, and remember. He found that the number of “bits” of information that a person can process—whether faces, numbers, words, or musical tones—is limited to seven, plus or minus two.[5] This bottleneck can be broken, however, by “chunking” the information, or grouping it hierarchically.

On some utility bills in our sample, category totals are presented in a summary format, with detailed line items either listed below subtotals or broken out on subsequent pages of the bill. Organizing information in such a more easily digestible manner can meet regulatory requirements to show all component parts, while also highlighting the most important information for customers. Along the same lines, many customers may not be familiar with technical terminology on bills such as the difference between supply and distribution charges, or the purpose of bill riders, meter multipliers, charges for merchant or billing services, specific taxes, etc. Few bills provide definitions of these terms, or even a short narrative explaining how to use the detailed information to calculate the total. Both of these design elements allow customers to choose the level of detail or explanation that is useful to them.

As discussed earlier, historical comparisons provide a meaningful context for consumption data. However, special attention must be paid to the design of *graphs of comparative data*. In a survey and series of interviews about how customers understand and use graphics of comparative energy consumption, Egan et al. (1996) found that at least half of participants had problems comprehending the graphs. This may be because interpretation of graphical information is a learned skill, as Tufte (1983) implied in his study of the principles of statistical graphics. Egan et al. wrote: “There are tradeoffs between customer comprehension of graphics and the accuracy with which the display presents the underlying data” (1996, 5).

It is not just complex graphics that create comprehension problems. In his study of energy consumption behavior in the commercial sector, Payne (2006) found that meter reading data (showing consumption) was often misinterpreted when presented in a simple row format on the bill, especially when the row also contained accurate but extraneous data such as the date of the meter reading and the meter number. As we found in our bill analysis, this type of presentation is still very common. Thus, it is not just the *type* of information presented that is important, but also *how* it is presented in relation to other information on the bill. Simple changes, such as rearranging the meter readings into a standard vertical subtraction problem, might improve comprehension.

[5] Subsequent research has shown that seven is probably high (Farrington 2011), but the principle remains the same.

The tension between comprehensibility and accuracy also emerged in research conducted for the ENERGY STAR Billing and "Innovative Billing" programs on potential formats for *peer comparison* graphs. The authors of the study found that the typical distribution of utility customers is skewed to the right, potentially misrepresenting results when comparison groups are displayed on bar graphs. In single horizontal bar graphs showing a range of customer consumption, a few high outliers can make average customers look like they have comparatively low use. The researchers concluded that a distribution graph is preferred to minimize potential to mislead. The team further recommended removing outliers from the graph and using approximately 30 small icons of houses to represent the distribution rather than drawing a bar graph (Iyer et al. 2005). The complexities of developing effective peer group comparisons underscore the importance of utilizing an iterative design process and pilot testing for readability and comprehension with customers.

With new technologies, utilities can provide even better analysis of energy data for customers, including weather normalization of historic data, estimated disaggregation by end use, and flags or warnings when consumption is abnormal. Darby, Ehrhardt-Martinez, and others agree that disaggregated feedback, showing the relative energy consumption of different end uses, would be ideal. That said, there is the possibility that knowing more about the energy consumption of specific end uses in the home will encourage some people to increase their use of a particular appliance, especially if it consumes less energy than they previously thought.

Motivational Elements

Providing regular, accurate, and clearly presented energy consumption information is necessary but not sufficient to facilitate household energy management (Darby 2010). It is hard for the typical consumer to connect actions and routines in their home to the resulting bill, because energy use is an invisible means to other ends, a consequence of everyday actions (Egan 2001). People cook dinner and run the dishwasher, wash and dry clothes, take showers, watch TV and use their computers, and do not see or experience the volume of energy used. Most people do not know how much energy their home consumes on a daily or monthly basis, how the building systems work, or the amount of energy used by different appliances. In their research on consumers' energy analyses, Kempton and Layne (1994) found that respondents sometimes incorrectly identified small end uses as primary causes of observed differences (i.e., cooking Thanksgiving dinner, Christmas lights). In other words, there is a high level of energy illiteracy. Other studies have found that energy illiteracy differs according to the type of service provided—space heating is more invisible than electricity—and that, if poorly designed, the typical utility bill may reinforce it (Wilhite & Ling 1992b).

As a result, people feel that they cannot control their energy consumption and so may lack the motivation to try. This point was echoed by Payne (2006) in his study of the commercial sector. The electric bill is seen as just another bill to be paid, along with rent, Internet, and cable. Energy invisibility and illiteracy, "extends not just to energy use itself but to the workings of many efficiency measures" (Egan 2001, 2). Just as people do not know the relative energy intensity of different actions, they also do not know the savings potential from different conservation measures. Even if a person were motivated to reduce consumption primarily for economic reasons, it can be complicated and time-consuming to evaluate one's energy consumption and identify the most beneficial actions.

Assumptions about the primacy of economic factors in motivating the installation of energy efficiency measures or changes to behavior have, however, been repeatedly called into question (Lutzenhiser 1993; Wilhite 1994; Wilhite & Shove 1998). Interaction with one's home and appliances relates not only to price signals but also to routines, comfort, ambiance, and lifestyle (Wilhite 1992b); implementing energy efficiency measures and behaviors may be perceived to negatively impact these factors (Lutzenhiser 1993).

The importance of understanding the impact of social dynamics on energy use is evident in a recent study reporting on follow-up interviews conducted with participants in Britain's Visible Energy Trial. The trial involved the installation of in-home displays in 275 households to provide real-time feedback on energy use. Through the interviews, the author found that feedback information from energy monitors dramatically increased participants' level of awareness about energy consumption and encouraged them to take energy-saving behaviors such as switching off appliances when not using them. While raising awareness about participants' "normal" energy use, the feedback also served to cement that level of use in participants' minds, and they reported consistently avoiding taking action to reduce energy use below the level they now considered normal. Thus, one unfortunate consequence of providing customers with historical feedback on their *own* energy use is that doing so can establish expectations about what is a "normal"—as opposed to a "wasteful" or "unnecessary"—level of consumption (Hargreaves et al. 2011).

The same dynamic exists in the commercial sector. While historical energy consumption comparisons seem to solidify both homeowners' and business owners' sense of the appropriate level of energy use, one study hypothesized that "the primary value of comparative consumption information is the way it makes visible the potential for energy consumption reduction by demonstrating that people are already doing it" (Payne 2006, 127).

This suggests a role not only for historical information about one's energy use, but also for comparisons with peers, perhaps through the mechanism of social norms. The effectiveness of social norms in motivating behavior was demonstrated in a widely cited study on the impact of messaging on conservation behaviors, including recycling in parks and towel reuse in hotels. The researchers:

> …consistently found: a) that normative beliefs are correlated with behavior, and b) that normative messages can cause a change in behavior…. Participants rate normative messages as the least effective and believe that they are not influenced by their perceptions of others. But our data show otherwise (Cialdini & Schultz 2004, 6).

Cialdini and Schultz found that regardless of whether people say they are influenced by perceptions of others, they model their actions based on what they think others are doing, or what they think others would approve of. That is, as long as they believe that the comparisons are valid.

Responses to peer comparison are mixed. A survey conducted in conjunction with the University of Delaware on how utility customers interpret and use graphics of energy use found that "over 70% of the respondents said they would take energy conservation actions if they received an Innovative Billing graph showing them to be on the high-consumption end (80th percentile) of their comparison group" (Egan et al. 1996). Other studies have shown that customers are willing to pay a small amount to receive comparative usage information (Kempton & Layne 1994; Egan et al. 1996).

In contrast, Roberts' (2004) study on billing preferences revealed significant skepticism among customers that average homes are 'like theirs.' In focus groups, many customers made statements to the effect that every house is different, or nothing ever matches the average. Likewise, in a study in the commercial sector, small and medium business decision-makers, in particular, were "adamant" that making appropriate comparisons would be very difficult, and that any comparisons that were made would be essentially "meaningless" (Payne 2006, 104). Part of this resistance may be that so few home or business owners have experience with this type of information on the bill.

A program called "Innovative Billing," a follow-up to the EPA's ENERGY STAR Billing program mentioned above, sought to encourage the large-scale addition of peer group comparisons to bills by providing utilities with empirical guidelines for selecting the most appropriate peer comparison groups. After looking at a number of potential factors upon which to base comparison, the researchers found that the highest quality comparison groups result from using a combination of house data (housing type, heating fuel, and floor area), but that some of this data is often not cheaply available to utilities. Therefore, they recommended as a reasonable alternative comparison groups based on street name, which has the added advantage of being easily explainable to, and more easily accepted by, customers (Iyer et al. 2005).

By using people's own neighborhoods as comparison groups, utilities can address customers' skepticism that the households in comparison groups are 'like them.' Moreover, neighborhood-based comparisons tap into a desire to be as good as or better than one's neighbors, and may be able to build on conversations regarding energy consumption that are already taking place among neighbors (Kempton & Layne 1994; Payne 2006).

Evidence for actual energy savings from the use of peer comparisons is small, but growing. Software company Opower has been successful in combining peer comparisons and targeted energy-saving tips on a report sent to residential utility customers as an addendum to the regular monthly bill. Independent evaluations of utility pilots have shown that the reports yield an approximate average electricity savings of 2% (Allcott 2009; Summit Blue 2009; ODC 2011). Moreover, there is some emerging evidence for the persistence of savings from this type of report, particularly for high consumption households receiving monthly feedback (Provencher 2011).

Through bills, utilities also have the opportunity to serve as trusted messengers to their consumers. Roberts (2004, 5) found that "…[f]ocus group participants showed interest in improved messages on their bills about energy saving and about the energy saving obligations of their suppliers." This highlights the importance of how the message is presented. In his work on the psychological aspects of energy conservation, Stern (1992, 1228) write: "What matters is not so much the amount of information contained in a label, advertisement or other message but getting the audience to pay attention and take the message seriously." Customers are interested in energy saving information, but it must be presented in a compelling manner.

The framing of *pro-efficiency messages* on the bill can be crucial to their effectiveness. As mentioned earlier, social norms can be a very powerful tool for catalyzing action. In their work on environmental conservation behaviors, Cialdini and Schultz (2004) found that while people may identify environmental protection, social responsibility, or saving money as their reason for conserving energy, normative beliefs actually exert a strong influence over action. Therefore efficiency messages will be more effective when framed in terms of what one's peers are doing. The best messages can utilize multiple motivation techniques, such as "join your neighbors in protecting the environment."

Equally important as providing motivation is giving specific, *actionable tips* about things people can do to reduce consumption. A short list of recommended actions can provide the basic information for consumers to make selections and trade-offs among the most common efficiency behaviors. Actionable tips often focus on "quick wins" like changing thermometer settings, weather stripping, and turning off energy-intensive appliances such as TVs and computers when they are not in use. We found in our bill sample that actionable tips are almost non-existent on the typical bill. We speculate this is because utilities are not able to get "credit" for any resulting consumption reductions without formal, approved information feedback and behavior change programs.

In lieu of (or in addition to) a regulator-approved behavior program, bills can channel people to existing efficiency programs. Bills could connect customers to resources that provide technical assistance or financial incentives. In their research for the ENERGY STAR Billing program, Lord et al. (1996) reviewed several pilots that combined energy analysis information and contacts for efficiency programs. A National Fuel Gas program had promoted an audit program through newspaper, bill stuffers, and radio ads with minimal success. But when they sent out annual energy reports with relative consumption info and info on an audit program, they received so many requests that there was a year's backlog. Similarly, a Madison Gas and Electric annual energy report with efficiency program contact information resulted in audit requests from 15% of customers. Simply adding the contact information for efficiency programs onto bills has the potential to substantially increase program participation as customers seek ways to manage their consumption.

Conclusions & Recommendations

The utility bill was originally intended to serve exclusively as an accounting mechanism. Yet a focus on itemization of charges has ultimately worked against transparency, and resulted in bills that are overly legalistic, abstruse, and confusing. At the same time, customer representatives, policymakers, and energy efficiency advocates are increasingly interested in the role of the bill as a tool to support customers' energy analysis and consumption management, and a means of facilitating interaction between utilities and their customers. Therefore, the principles that guide utility bill information design need to be updated.

We have identified several opportunities to improve the utility bill, and to connect it to other utility efforts, especially related to the smart grid. Below we provide specific recommendations for changes to the bill and the regulatory environment that, the evidence suggests, could improve the link between energy consumption and energy cost for the residential customer, and potentially improve utility-customer relations. Utilities could choose to initiate these changes alone, or could take advantage of planned bill adjustments or billing system upgrades—especially in connection to smart grid improvements—as a window of opportunity for making additional improvements.

Evidence suggests that a "good" bill provides both accounting information and historical feedback on actual consumption. As our bill analysis shows, all bills currently provide a total amount due and current usage, and more than half provide historical consumption information such as the previous month's and year's usage, average daily usage, and a graph of historical usage. Average daily cost, temperature, and degree day information all provide other contexts against which to measure one's energy-saving actions, and were easily integrated into the design of bills that included them. This is information that utilities already collect, or that can be cheaply acquired, and should therefore be provided to all customers on every bill.

As we noted several times, however, feedback is necessary but not sufficient to motivate customers to take energy-saving actions. Peer group comparisons have been shown to lead to savings and to be acceptable to customers if comparison groups are designed and communicated correctly. Third-party-administered efficiency programs successfully implemented these elements on adjuncts to the regular bill, but large utilities may, in the future, choose to integrate these elements into their standard bills. Now-defunct programs such as ENERGY STAR Billing and Innovative Billing sought to scale up the use of comparative feedback, but, if our review of sample bills is any guide, did not result in the widespread adoption of such metrics. This suggests that utilities are unlikely to undertake this task unless they are required to and/or able to recover their costs through the rate structure.

Other innovative informational elements that enable customers to take action, such as pro-efficiency messaging, personalized tips, and energy efficiency-specific contact information, should also be more widely included on bills. These elements seem especially amenable to being wrapped into utilities' smart grid-related outreach plans, but this requires re-envisioning the bill as a crucial customer touchpoint. Utilities doing customer segmentation, especially by attitudinal differences, should seek to apply what they learn to their bills. Integrating the bill into utility-wide strategic efforts and testing targeted bill designs, based on customer segments, that include these three elements is a potentially productive avenue for understanding how to better engage customers in efficiency and smart grid programs.

The evidence also supports the removal of certain elements of the bill. Based on research showing that overly specific rate information reduces bill comprehension, we recommend that a good bill either eliminate this information entirely, or—as some bills in our sample have done—move this information to page 2 or later in the bill. Utility commissions continuing to require rate specifics could allow that they be easily accessible on a utility's Web site for interested customers or those needing help calculating their bills.

Larger changes to the regulatory and institutional environments could support the inclusion of better information on the bill. Regulators can realign the costs and benefits to utilities of making some of the more innovative changes. For example, utilities would be more likely to include pro-efficiency messages and efficiency tips on the bill if they were operating in a regulatory framework where revenue decoupling[6] had been adopted, so that reductions in customer energy use did not adversely affect their ability to

[6] Revenue decoupling is a pricing mechanism that severs the link between the amount of energy sold by a utility and the amount of revenue it is allowed to collect, eliminating both the utility's incentive to increase profits by increasing energy consumption and its disincentive to invest in energy efficiency programs that reduce energy consumption (RAP 2011).

recover authorized costs. Similarly, other types of financial incentives could encourage these types of billing system modifications.[7]

Eventually the entire bill design and approval process may need to change. This requires an intentional shift from a line item approach to a strategic, customer-focused perspective, and would likely entail a comprehensive bill redesign process with consumer testing and stakeholder participation. Such a wholesale bill redesign is likely costly to utilities, therefore either regulatory requirements or financial benefits are needed. Regulators requiring utilities to redesign their bills should provide adequate compensation and oversight to ensure good performance.

In summary, we have found that the average customer bill does not provide the level of feedback and connection to program resources that it reasonably might. Even as utilities expect more customers to move online to find information about their energy use, there is a role for an improved paper bill to be a cost-effective means of capturing energy savings and customer goodwill.

FURTHER RESEARCH

We close with a discussion of specific areas where additional research would be valuable.

First, and most basically, the question remains about how much information to include on the bill, and how best to juxtapose that information to increase customer comprehension and encourage energy-saving actions and investments. Considering the heterogeneity of utility customers, there is likely no final answer to this question, and approaching it will likely require the combined efforts of graphic designers, market researchers, social scientists, regulators, and customers themselves.

A place to start is perhaps with those utilities that have made recent changes to their bills. Follow-up might consist of a series of interviews with the responsible person in each utility to understand what changes were made and why they were made, and to gather any available evaluation on energy savings or other effects attributable to the changes.

Secondly, more research needs to be done on the impact of adding specific new elements—those we called "innovative elements"—to the bill. Such research might involve working with a specific utility and its associated commission to design a series of bills differing only on the included design elements that would be delivered to randomly selected groups of demographically similar customers. The advantage of doing this type of experiment is that it could provide commissions with data on bill design elements that deliver energy savings.

Thirdly, there is a need for more empirical evidence on the connection between bill redesign and decreases in customer service calls, increases in customer satisfaction, and increased uptake of energy efficiency programs. This evidence could be gathered through a series of online surveys of customers, cross-referenced with data on the prevalence of customer service calls and program uptake pre/post bill redesign.

Lastly, there seems to be little research into how the interaction between utilities and regulators affects the bill design process. What opportunities are there for regulators to guide bill design? Do utilities perceive that they benefit from a bill redesign? If not, what kinds of regulatory changes, other than our proposed adoption of decoupling, might facilitate and encourage improved bills?

[7] See *The Old Model Isn't Working: Creating the Energy Utility for the 21st Century* (York & Kushler 2011) for a discussion of changes to the utility business model that would encourage energy efficiency investments.

REFERENCES

Abrahamse, W., L. Steg, C. Vlek, & T. Rothengatter. 2005. "A Review of Intervention Studies Aimed at Household Energy Conservation." *Journal of Environmental Psychology*, 25: 273-291.

AECOM. 2011. *Energy Demand Research Project: Final Analysis*. Prepared for the UK Department of Energy and Climate Change. Hertfordshire, UK: AECOM House. http://www.ofgem.gov.uk/sustainability/edrp/Pages/EDRP.aspx.

Allcott, H. 2009. "Social Norms and Energy Conservation." Working Paper. Massachusetts Institute of Technology (November).

[APPA] American Public Power Association. 2009. *100 Largest Public Power Utilities, by Electric Customers Served: 2009.* Washington, D.C.: American Public Power Association. http://www.publicpower.org/files/PDFs/100LargestPublicPowerUtilitiesbyElectricCustomersServed2009.pdf.

Cialdini, R. & W. Schultz. 2004. *Understanding and Motivating Energy Conservation Via Social Norms.* Final Report Prepared for the William and Flora Hewlett Foundation. http://opower.com/uploads/library/file/2/understanding_and_motivating_energy_conservation_via_social_norms.pdf.

Darby, S. 2006. *The Effectiveness of Feedback on Energy Consumption: A Review for DEFRA of the Literature on Metering, Billing and Direct Displays*. Oxford, UK: University of Oxford Environmental Change Institute.

———. 2010. *Literature Review for the Energy Demand Research Project*. Oxford, UK: University of Oxford Environmental Change Institute.

[EEI] Edison Electric Institute. 2010. *EEI U.S. Member Company Service Territories: June 2010*. Washington, D.C.: Edison Electric Institute. http://www.eei.org/whoweare/ourmembers/USElectricCompanies/Documents/EEIMemCoTerrMap.pdf.

Egan, C. 2001. *The Application of Social Science to Energy Conservation: Realizations, Models, and Findings*. Report Number E002. Washington, D.C.: American Council for an Energy-Efficient Economy.

Egan, C., W. Kempton, A. Eide, D. Lord & C. Payne. 1996. "How Customers Interpret and Use Comparative Graphics of Their Energy Use." In *Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings, 8:39–45*. Washington, D.C.: American Council for an Energy-Efficient Economy.

Ehrhardt-Martinez, K., K. A. Donnelly, & J. A. "Skip" Laitner. 2010. *Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities*. Report Number E105. Washington, D.C.: American Council for an Energy-Efficient Economy.

Eide, A., D. Lord & W. Kempton. 1996. "Innovative Billing Options: A Tool for Improving Customer Relationships in a Restructured Utility Environment." In *Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings, 9:49-54*. Washington, D.C.: American Council for an Energy-Efficient Economy.

[EPA & NHTSA] Environmental Protection Agency & National Highway Traffic Safety Administration. 2011. *Revisions and Additions to Motor Vehicle Fuel Economy Label: Final Rule.* 76 (129): 39478-39587.

Farrington, J. 2011. "Seven Plus or Minus Two." *Performance Improvement Quarterly*, 23 (4), 113–116.

[FERC] Federal Energy Regulatory Commission. 2011. *2010 Assessment of Demand Response and Advanced Metering*. Washington, D.C.: Federal Energy Regulatory Commission. http://ferc.gov/legal/staff-reports/2010-dr-report.pdf.

Hargreaves, T., M. Nye & J. Burgess. 2011. "Keeping Energy Visible? Exploring How Householders Interact with Feedback from Smart Energy Monitors in the Longer-Term." Submitted to *Energy Policy,* September 2011.

Iyer, M., W. Kempton & C. Payne. 2005. "Comparison Groups on Energy Bills: Automated, Personalized Energy Information." *Energy and Buildings* 38: 988–996.

Kempton, W. & L. Layne. 1994. "The Consumer's Energy Analysis Environment." *Energy Policy* 22 (10): 857–866.

Kempton, W. & L. Montgomery. 1982. "Folk Quantification of Energy." *Energy* 7 (10): 817–827.

Lord, D., W. Kempton, S. Rashkin, A. Wilson, C. Egan, A. Eide, M. Iyer & C. Payne. 1996. "Energy Star Billing: Innovative Billing Options for the Residential Sector." In *Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings, 2:137–143*. Washington, D.C.: American Council for an Energy-Efficient Economy.

Lutzenhiser, L. 1993. "Social and Behavioral Aspects of Energy Use." *Annual Review of Energy and Environment 18: 247–289.*

Michaels, H. 2008. "Bringing the Vision to Life—Will Advances in Energy Communication Create a Significant Resource Strategy?" In *Proceedings of the ACEEE 2008 Summer Study on Energy Efficiency in Buildings*, 10:97–105. Washington, D.C.: American Council for an Energy-Efficient Economy.

Miller, G.A. 1956. "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information." *Psychological Review, 63 (2), 81–97.* http://www.musanim.com/miller1956/.

[ODC] Opinion Dynamics Corporation. 2011. *Massachusetts Cross-Cutting Behavioral Program Evaluation* Volume 1 Final. Prepared for the Massachusetts Energy Efficiency Advisory Council. Waltham, Mass: Opinion Dynamics Corporation. http://www.ma-eeac.org/docs/2011%20EM&V%20Studies/MACC%20Behavioral%20Report%20Volume%201%20Final.pdf.

Payne, C. T. 2006. "Energy Consumption Behavior in the Commercial Sector: An Ethnographic Analysis of Utility Bill Information and Customer Comprehension in the Workplace." Dissertation submitted to the Faculty of the University of Delaware, Summer 2006. http://eetd.lbl.gov/payne/publications/Energy%20Consumption%20Behavior%20in%20the%20Commercial%20Sector.pdf.

Payne, Christopher (Lawrence Berkeley National Laboratory). 2011. Personal communication. October 11.

Provencher, B. 2011. *Evaluation Report: OPOWER SMUD Pilot Year 2*. Report submitted to OPOWER. Chicago, Ill.: Navigant Consulting.

[RAP] Regulatory Assistance Project. 2011. *Revenue Regulation and Decoupling: A Guide to Theory and Application*. Montpelier, Vt.: Regulatory Assistance Project. www.raponline.org/document/download/id/902.

Roberts, S. 2004. *Consumer Preferences for Improving Energy Consumption Feedback*. Report to Ofgem. Bristol, UK: Center for Sustainable Energy.

Rogers, E.M. 1995. *Diffusion of Innovations*, *4th Edition*. New York, N.Y.: The Free Press.

Sernhed, K., J. Pyrko and J. Abaravicius. 2003. "Bill Me this Way!—Customer Preferences Regarding Electricity Bills in Sweden." In *Proceedings of 2003 ECEEE Summer* Study*, 6:1147–1150*.

[SGCC] Smart Grid Consumer Collaborative. 2011. *Excellence in Customer Engagement*. Prepared by Altman, Vilandrie & Company for the Smart Grid Consumer Collaborative. http://smartgridcc.org/best-practices-and-case-studies/excellence-in-consumer-engagement-release.

Stern, P. 1992. "What Psychology Knows about Energy Conservation." *American Psychologist*, 47 (10), 1224–1232.

Summit Blue. 2009. *Impact Evaluation of Opower SMUD Pilot Study*. *Update—September 24, 2009*. http://opower.com/uploads/library/file/13/summit_blue_june_2009.pdf.

Tufte, E.R. 1983. *The Visual Display of Quantitative Information.* Cheshire, Conn.: Graphics Press.

Wilhite, H. 1994. "Market Signals Fall Short as Policy Instruments to Encourage Energy Savings in the Home." In *Proceedings of the ACEEE 1994 Summer Study on Energy Efficiency in Buildings, 1:193–200.* Washington, D.C.: American Council for an Energy-Efficient Economy.

Wilhite, H. & R. Ling. 1992a. "The Effects of Better Billing Feedback on Electrical Consumption: A Preliminary Report." In *Proceedings of the ACEEE 1992 Summer Study on Energy Efficiency in Buildings, 10:173–175.* Washington, D.C.: American Council for an Energy-Efficient Economy.

———. 1992b. "The Person Behind the Meter: An Ethnographic Analysis of Residential Energy Consumption in Oslo, Norway." In *Proceedings of the ACEEE 1992 Summer Study on Energy Efficiency in Buildings, 10:177–186.* Washington, D.C.: American Council for an Energy-Efficient Economy.

———. 1995. "Measured Energy Savings from a More Informative Energy Bill." *Energy and Buildings,* 22, 145-155*.*

Wilhite, H. & E. Shove. 1998. "Understanding Energy Consumption: Beyond Technology and Economics." In *Proceedings of the ACEEE 1998 Summer Study on Energy Efficiency in Buildings, 8:321–332.* Washington, D.C.: American Council for an Energy-Efficient Economy.

Wilhite, H., A. Hoivik & J. Olson. 1999. "Advances in the Use of Consumption Feedback Information in Energy Billing: The Experiences of a Norwegian Energy Utility." In *Proceedings of 1999 ECEEE Summer* Study *3: 1147–1150.*

York, D. & M. Kushler. 2011. *The Old Model Isn't Working: Creating the Energy Utility for the 21st Century*. White Paper. Washington, D.C.: American Council for an Energy-Efficient Economy. http://aceee.org/white-paper/the-old-model-isnt-working.

APPENDIX A: DETAILS OF BILL ANALYSIS

This section details the 17 elements that we looked for in our analysis of sample bills, grouped into categories by type. Feedback elements are those that provide direct and contextual information about current usage and energy cost. Explanation elements provide information about the specifics of the rate and other specialized terms in the bill. Motivational elements provide information that potentially helps consumers to take energy-savings actions.

Table A-1 shows the frequency with which each variable appeared in our sample, sorted from most common to least common overall. It also provides the data for Figure 1 in the main body of the text.

Table A-1: Frequency of Bill Elements (n=101)

Bill Element	*Total # incl.*	*%*	*Page 1*	*%*	*Page 2*	*%*	*Page 3+*	*%*	*# Not incl.*	*%*
Amount due	101	100%	101	100%	0	0%	0	0%	0	0%
Current usage	101	100%	78	77%	11	11%	12	12%	0	0%
Prev. month usage	93	92%	67	66%	14	14%	12	12%	8	8%
Prev. yr. usage	88	87%	64	63%	13	13%	11	11%	13	13%
Line items grouped	84	83%	49	49%	21	21%	14	14%	17	17%
Rate	75	74%	46	46%	22	22%	7	7%	26	26%
Avg. daily usage	67	66%	49	49%	6	6%	12	12%	34	34%
Graph of historical usage	66	65%	43	43%	12	12%	11	11%	35	35%
Meter reading type	40	40%	22	22%	7	7%	11	11%	61	60%
Avg. daily temp	38	38%	26	26%	3	3%	9	9%	63	62%
Explanation of terms	30	30%	5	5%	23	23%	2	2%	71	70%
Avg. daily cost	25	25%	18	18%	5	5%	2	2%	76	75%
Pro-EE message	10	10%	8	8%	2	2%	0	0%	91	90%
Efficiency tips	8	8%	4	4%	3	3%	1	1%	93	92%
EE-specific contact	5	5%	4	4%	1	1%	0	0%	96	95%
Peer usage comparison	0	0%	0	0%	0	0%	0	0%	101	100%
Alternative metrics	0	0%	0	0%	0	0%	0	0%	101	100%

Feedback

- Amount due (US$): the amount due for the current month
- Average daily cost (US$/day): the average cost of usage (of electricity and/or gas) for the month
- Rate ($/kWh or $/therm): details of the rate structure, taxes and fees
- Current usage (kWh or therm): usage for the current month
- Average daily usage (kWh/day or therm/day): average daily usage for current month
- Previous year usage (kWh or therm): usage in same month of previous year
- Previous month usage (kWh or therm): usage in previous month in same year
- Graph of historical usage: historical usage in graphical format
- Average daily temperature (degrees F): average daily temperature for the current month
- Billing frequency:[8] how often the bill is provided.

[8] This element doesn't appear on our bills because all bills in the sample were monthly.

Explanation

- Line items grouped: whether bills are arranged in groups or chunks, without considering the number of chunks or the number of items in each chunk
- Explanation of terms: language detailing the meaning of terms on the bill, including line item charges, types of service, usage metrics, etc.
- Meter reading type: whether the bill indicated the type of meter reading that was done to determine usage
- Alternative metrics: alternatives to the traditional usage metrics of kilowatt-hour or therm, e.g., pounds of carbon dioxide per kilowatt-hour

Motivation

- Pro-EE message: an explicit statement in favor of energy efficiency
- EE-specific tips: specific actions that consumers can take to save energy, e.g., setting the thermostat higher by a few degrees in the summer
- EE-specific contact: a phone number or website providing more information about an energy efficiency program
- Peer usage comparison: information about the average usage in some relevant peer group, e.g., similar households

APPENDIX B: SURVEY INSTRUMENT

Two survey instruments provided the data for this report. The first was sent to members of the Consortium for Energy Efficiency (CEE), and a slightly altered version was sent to utility members of the National Rural Electric Cooperative Association (NRECA). The survey was altered slightly in consultation with NRECA staff to better meet the needs of their members.

CEE Member Survey

Instructions

Please answer the following questions as accurately as possible. If necessary, you may use more space than is given. Please also attach an anonymized copy of a current residential paper bill and return it with this survey.

1. Utility name ____________________ Location ___________________________

   Service provided ________________ (gas, electric) Type of utility ______________________ (IOU, muni, co-op)

   # of customers _____________________

2. What percentage of your residential ratepayers receives information about their energy use in the following formats (may total more than 100%):

Bill Format	**Percentage (%) of members/ratepayers**
Paper bill	
E-mail	
Online Website	
In-home display	
Other (please specify)	
Don't know	

3. Do you expect these percentages in question 2 to change over the next 5 years?
   - ☐ No
   - ☐ Yes. Please explain briefly:

4. What percentage of your residential ratepayers receive information about their energy use with the following frequency:

Bill Frequency	**Percentage (%) of members/ratepayers**
Daily or more frequently	
Weekly	
Monthly	
Less frequently	
Other (please specify)	
Don't know	

5. For each billing period, what percentage of your residential ratepayers receive:

Consumption Calculation	**Percentage (%) of members/ratepayers**
Estimated bills	
Bills based on a meter reading	
Other (please specify)	
Don't know	

6. To your knowledge, what was the last change that your utility made to its residential bill design or format? When was this change made? Why was it made?

7. Has your utility conducted research related to energy bills in the last 5 years?
   - ☐ No
   - ☐ Yes. Please explain briefly:

8. May we contact you for follow-up?
   - ☐ No
   - ☐ Yes. Please provide your contact information:

Please attach **an anonymized copy of a current residential paper bill** and return it with this survey.

NRECA Member Survey

1. What percentage of your residential members receives information about their energy use in the following formats (may total more than 100%):

Bill Format	Percentage (%) of members
Paper bill	
E-mail	
Online Website	
In-home display	
Pre-paid meter	
Other (please specify)	
Don't know	

2. Do you expect these percentages (in Question 1) to change over the next five years?
   - ☐ No
   - ☐ Yes. Please explain briefly:

3. What percentage of your residential members obtain energy use information for each of the following time increments:

Frequency	Percentage (%) of members
Daily or more frequently	
Weekly	
Monthly	
Less frequently	
Other (please specify)	
Don't know	

4. What is the shortest time interval over which residential consumer use data is measured? (check one) and please estimate the percentage of your residential members' meters read at this frequency:

___ Real time/continuous
___ Hourly or more frequently
___ 8-hour increments
___ Daily (24 hour period)
___ Weekly
___ Monthly
___ Less Frequently
___ Other (specify) ____
___ Don't know

4a. Please estimate the percentage of your residential members' meters read at this frequency: ___%

5. How frequently are electricity use data updated and made available for residential consumers? (check one)

___ Real time/continuous
___ Hourly or more frequently
___ 8-hour increments
___ Daily (24 hour period)
___ Weekly
___ Monthly
___ Less Frequently
___ Other (specify) ____
___ Don't know

6. About what percentage of your residential members access this information for each of the following time increments:

Frequency	Percentage (%) of members
Daily or more frequently	
Weekly	
Monthly	
Less frequently	
Other (please specify)	
Don't know	

7. What percentage of your residential members receive bills that are:

Usage Calculation	Percentage (%) of members
Estimated	
Based on a meter reading	
Based on self-read meter reading	
Levelized	
Pre-paid meter	
Other (please specify)	
Don't know	

8. To your knowledge, has your utility made a change to its residential bill design or format in the last five years? What changes were made, when were they made, and why?

9. In the last five years, has your utility conducted consumer research to get feedback on your energy bill?

   ☐ No
   ☐ Yes. Please explain briefly:

10. Which of the following features do you currently provide on your residential bill? *(check all that apply)*

    __ Electricity use in kilowatt-hours for current bill period
    __ Itemized list of additional charges
        IF YES: which of the following do you have?
        __ local taxes
        __ state taxes
        __ federal taxes
        __ facilities charge (to cover fixed costs/infrastructure)
        __ storm response recovery fees
        __ cost of construction of new generation and/or transmission facilities
        __ other (specify) ___________________________
    __ Historical electricity use information over past 12 months
    __ Current period electricity use compared to same period in previous year
    __ Electricity use comparison with other consumers with similar circumstances for the same billing period
    __ Graphic display of daily use over billing period
    __ Daily outside temperature highs and lows over billing period
    __ Energy saving tips
    __ Explanation of key terms (e.g., kilowatt-hour, therms, specific surcharges)
    __ Carbon footprint estimate based on consumer's use for current billing period
    __Other (specify) ____
    __ None of the above

    Is this information available for the individual consumer on the website? __ Yes __ No

    IF DON'T OFFER IN EITHER PLACE: How likely are you to offer this in the next 12 months? *(ask for each not checked in Q8)*

Definitely Will Probably Will May or May Probably Will Not Definitely Will Not