Are Smart Meters Being Used Smartly?

A Case Study of Residential Electricity Customers in Vermont

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Introduction

In the United States, around $8 billion has been spent on smart meter installation, with federal funds supplying $3.4 billion of this (U.S. Department of Energy, 2016). Over 50 million smart meters have been installed, and around 43% of homes now have smart meters (The Edison Foundation, 2014). While traditional analog electric meters are capable of only recording the total amount of electricity a customer consumes, digital smart meters allow for two-way communication between utility companies and households and for electricity consumption to be measured hourly or even more frequently (U.S. Energy Information Administration, 2015). Smart meters have the potential to save utility companies money by reducing congestion in transmission lines, limiting the severity of blackouts (Cook et al., 2012), and lowering labor costs associated with meter readers (Smith, 2009). Customers may use the real-time or nearly-real-time pricing information from smart meters to shift electricity consumption away from peak demand to times when it is less costly (Groothuis & Mohr, 2014; Cook et al., 2012). Smart meters may also yield environmental benefits, as they enable utility companies and customers to use electricity more efficiently, thus reducing carbon dioxide emissions (Cook et al., 2012).

Despite the significant investments made in smart meters and the many benefits they could provide, not much is known about how effectively customers are using smart meter information. This study seeks to better understand how smart meters are utilized by electricity customers, using primary data from two statewide surveys conducted in Vermont in 2015 and 2016. Smart meters in Vermont are not typically linked to in-home displays, so customers could access nearly-real-time pricing information, as opposed to real-time pricing information, from them (Fredman, personal communication, April 22, 2016). Vermont provides an excellent case for studying the utilization of smart meters, as around $137 million has been spent to install 305,464

smart meters in the state (U.S. Department of Energy, n.d.), approximately 92% of electricity meters in Vermont are now smart meters, and less than 5% of electricity customers have opted out of having a smart meter installed (Goldman, personal communication, February 9, 2016). Specifically, primary data collected from the statewide surveys are used to assess both the effects of smart meters on electricity use and consumer concerns about smart meters' potential implications for health and privacy. In light of the huge public investment in smart meters and limited information on how consumers have used this technology, the results from this paper are expected to be helpful for Extension educators who are working on energy-related issues in their communities.

Data Collection

Data used in this study were collected by the Center for Rural Studies at the University of Vermont as part of the 2015 and 2016 Vermonter Polls. For the 2015 survey, 2,354 households were contacted by telephone, and 619 people completed the survey, a response rate of 26.3%. In 2016, 2,547 households were contacted by telephone, and 644 people completed the survey, a response rate of 25%. The 2015 survey has a margin of error of plus or minus 4%, and the 2016 survey has a margin of error of plus or minus 3.9%, and both surveys have confidence intervals of 95%. Included in these surveys were four questions on smart meters that assessed the following: (1) whether respondents think they have a smart meter, (2) whether having a smart meter has reduced their electricity use, (3) whether respondents are concerned about any potential health impacts due to smart meters, and (4) whether respondents are concerned about any potential impacts on privacy due to smart meters. In addition to these four questions, the 2016 survey also included a question on whether customers would like to receive additional

information on smart meters in one or more of the following areas: how they operate, how they can reduce electricity consumption, power outages, and the price of electricity, and their impacts on the environment, health, and privacy. The data for these five questions and other demographic variables were analyzed through descriptive analysis and Chi-square tests.

Analysis and Results

The survey data were coded and analyzed in SPSS (Statistical Package for Social Sciences), and the results are presented in five subsections: (1) summary statistics and differences between respondents who reported having smart meters and the respondents who did not, (2) respondents' lack of awareness about installed smart meters, (3) impacts of smart meter installation on electricity consumption, (4) respondent concerns about smart meters' potential impacts on health and privacy, and (5) respondents' interest in receiving additional information on smart meters.

Summary Statistics and Differences Between Groups

Table 1 reports the summary statistics for the year 2015 for the whole sample and by two groups: those who reported having a smart meter (Group A) and those who did not (Group B). Summary statistics for 2016 data that compare these same groups, while not reported here in table form, will be discussed in relation to the summary statistics for 2015 data. The only demographic variable that cannot be compared between the two years is that of housing type, as that variable was not included in the 2016 survey.

Table 1.

Summary Statistics (%) by Respondent Groups

	Whole sample (n = 617)	Group A: Respondents who reported having a smart meter	Group B: Respondents who did not report having a smart meter	Chi-square (x^2)

		(n = 276)	(n = 339)	
Gender				$x^2 = 10.39$***
Female	49.7	42.5	55.8	
Male	50.3	57.5	44.2	
Education				$x^2 = 6.95$
No diploma	1.8	2.6	1.2	
HS graduate or GED	20.2	17.4	22.4	
Some college	15.0	14.8	15.2	
Associate/technical degree	11.2	13.7	8.8	
Bachelor's degree	25.0	23.7	26.2	
Graduate/professional	26.8	27.8	26.2	
Income				$x^2 = 3.34$
Less than $25,000	13.0	11.8	14.2	
$25,000–$49,999	25.0	22.4	27.3	
$50,000–$74,999	20.2	21.9	18.5	
$75,000–$99,999	16.7	18.6	15.3	
$100,000 and over	25.1	25.3	24.7	
Housing Type				$x^2 = 6.87$**
Single-family dwelling	73.9	78.4	70.0	
Unit in multi-family dwelling	19.8	15.3	23.8	
Other	6.3	6.3	6.2	
Area Classification				$x^2 = 0.61$
Rural	58.6	56.8	59.7	
Suburban	23.9	25.4	22.8	
Urban	17.5	17.8	17.5	
Age Group				$x^2 = 5.97$
18–30	6.7	4.1	8.7	
31–40	9.6	9.0	10.2	
41–50	13.8	15.4	12.4	
51–60	21.1	22.1	20.4	
61 and over	48.8	49.4	48.3	
Concern about health impacts				$x^2 = 49.31$***
Not concerned at all	43.8	53.6	35.6	
Not concerned	21.8	26.4	18.1	
Concerned	5.3	4.7	5.7	
Very concerned	3.9	2.2	5.4	
Not sure	25.2	13.1	35.2	
Concern about privacy impacts				$x^2 = 47.02$***
Not concerned at all	39.5	45.6	34.4	
Not concerned	21.7	26.1	18.3	
Concerned	12.9	14.9	11.4	
Very concerned	5.9	5.4	6.0	
Not sure	20.0	8.0	29.9	

** The difference between the two groups is significant at the 0.95 significance level.

*** The difference between the two groups is significant at the 0.99 significance level.

The summary statistics reported in Table 1 and the results of Chi-square tests for determining whether the difference between Group A and Group B is significant suggest the following four findings: First, those who reported having a smart meter were more likely to be male than female. This result suggests that Vermont males are more likely to report that they have a smart meter than Vermont females.

Second, those who reported having a smart meter were more likely to live in a single-family dwelling than those who did not report having a smart meter. A potential driver of this relationship is that those who live in single-family dwellings may be more likely to own than rent and therefore live in one place for longer periods of time than those living in apartments or condos. Home ownership and longer duration of occupancy may lead to greater awareness of meter type. The overall rate of homeownership in Vermont for Q4 2015 was 71.3% (U.S. Census, 2016).

Third, those who did not report having a smart meter (Group B) were more likely to be concerned or uncertain about the meters' potential health effects than those who reported having a smart meter (Group A). In Group B, only 53.7% of respondents were either "not concerned at all" or "not concerned" about potential health impacts, compared to 80.0% of respondents in Group A. Similarly, respondents in Group B were more than twice as likely as those in Group A to report that they were "not sure" whether they were concerned about possible health impacts of smart meters.

Fourth, those who reported having a smart meter were less concerned about smart meters' impact on their privacy than those who did not report having a smart meter. In Group A, 71.7% reported either "no concern at all" or "no concern" about smart meters' potential impact on their privacy, as compared to 52.7% of Group B. Group B was much more uncertain about privacy concerns, with 29.9% reporting being "not sure," compared to only 8.0% of Group A respondents. Those who reported having a smart meter were more likely to be unconcerned and less likely to have uncertainty about smart meters' potential impact on privacy than those who did not report having a smart meter. The percentage of people who opt out of smart meter installation in Vermont is relatively low, at 3% to 5% (Goldman, personal communication, February 9, 2016), but concerns that smart meters will adversely affect health and privacy represent two possible reasons for opting out.

In 2016, the results were similar to those found in 2015. Those who reported having a smart meter (Group A) were more likely to be male than female. Those who did not report having a smart meter (Group B) were more likely to have concerns about the potential impact of smart meters on their health and privacy. Group B was also more likely than Group A to report that they were "not sure" whether they were concerned about the potential impact of smart meters on their health and privacy. As was the case in 2015, a higher percentage of respondents in both groups reported having concerns about privacy impacts due to smart meters as compared to those who reported having concerns about health impacts due to smart meters. Two additional demographic variables were found to be statistically significant in 2016 as compared to 2015, those of age and income in categories. Those who were under 40 were more likely not to report having a smart meter, whereas those who were over 40 were more likely to report having a smart

meter. This result suggests that those who report having a smart meter tend to be older than those who do not report having a smart meter. With income, those in Group B were more likely to make under $25,000 and $75,000-$99,999. Those in Group A were more likely to make $25,000-$74,999 and $100,000 or more. The relationship between income and whether one reports having a smart meter is not clear, and future research could investigate this relationship further.

Lack of Awareness about Installed Smart Meters

Many Vermont residents have a smart meter installed but do not know it. Although about 92% of Vermont's electricity meters are smart meters (Goldman, personal communication, February 9, 2016), only 45% of survey respondents in 2015 and 45.4% in 2016 reported having a smart meter. That means that close to half of Vermont's electricity customers are unaware that they have a smart meter. However, obviously, to maximize the benefits from smart meters, electricity customers must first be aware that they have them. Many of the benefits of smart meters depend on electricity customers changing their electricity consumption in response to the nearly-real-time pricing information that smart meters provide, which would be very difficult to do if customers are unaware that they have a smart meter. One possible exception to this would be if customers are nonetheless accessing the nearly-real-time pricing information that smart meters provide, but are not changing their electricity consumption in response to this information.

Impacts of Smart Meter Utilization on Electricity Consumption

Having a smart meter has not reduced the electricity consumption of many Vermont residents. In 2015, among respondents who knew that they had a smart meter, only 2.2% reported that having

a smart meter significantly reduced their electricity use, and 9.6% reported that having a smart meter reduced their electricity use a little bit. 63.7% of respondents reported that the smart meter did not change their electricity use, and 24.5% of respondents were unsure whether the smart meter affected their electricity use. In 2016, among respondents who knew that they had a smart meter, only 3.6% reported that having a smart meter significantly reduced their electricity use, and 14.1% reported that having a smart meter reduced their electricity use a little bit. 67.3% of respondents reported that the smart meter did not change their electricity use, and 15.1% of respondents were unsure whether the smart meter affected their electricity use. In 2016, as compared to 2015, an additional 5.9% of respondents reported that the smart meter had reduced their electricity use, but an additional 3.6% of respondents also reported that the smart meter had not changed their electricity use. One reason why a decrease in electricity consumption among those who are aware they have a smart meter is not more widespread may be because these individuals are not accessing the information that smart meters provide (Honebein, 2010; Smith, 2009). Ensuring that the information provided by smart meters is easily accessible—e.g., via in-home displays, the electricity bill, and online tools and apps—can help to promote a greater change in consumers' electricity consumption (Gram, 2014; Honebein, 2010; Smith, 2009). However, rather than decreasing total consumption, smart meters may provide more of an incentive to shift the time of day when electricity is used (Groothuis & Mohr, 2014; Cook et al., 2012). Future research could investigate whether people who are aware they have a smart meter are easily able to access the information that it provides and have reduced or shifted their electricity consumption as a result.

Concerns about Smart Meters' Potential Impacts on Health and Privacy

As Figures 1 and 2 show, while some Vermont residents were concerned about the potential impact of smart meters on their health and privacy, a majority of them were not. Previous research by Hess (2014) has shown that, nationally, some of the most outspoken opposition to smart meters arises from health and/or privacy concerns. In Vermont, respondents were more likely to be concerned about the potential impact of smart meters on their privacy than on their health. In 2015, respondents were a little over two times more likely to report being concerned about the potential impact of smart meters on their privacy (18.8%) than health (9.2%). In 2016, this difference had lessened, but respondents were still more likely to report being concerned about the potential impact of smart meters on their privacy (12.3%) than health (7.5%). However, from 2015 to 2016, respondents also became more uncertain about whether they were concerned about the potential impact of smart meters on their health. In 2015, 25.1% of respondents reported that they were "not sure" whether they were concerned about the potential impact of smart meters on their health, which had risen to 40.5% in 2016. Even though some respondents were concerned about the potential impacts of smart meters on their health and privacy, a majority of respondents in each year reported that they were not concerned about these potential impacts.

Figure 1.

Concerns About the Potential Impact of Smart Meters on Health in 2015 (n= 609) and 2016 (n=643)

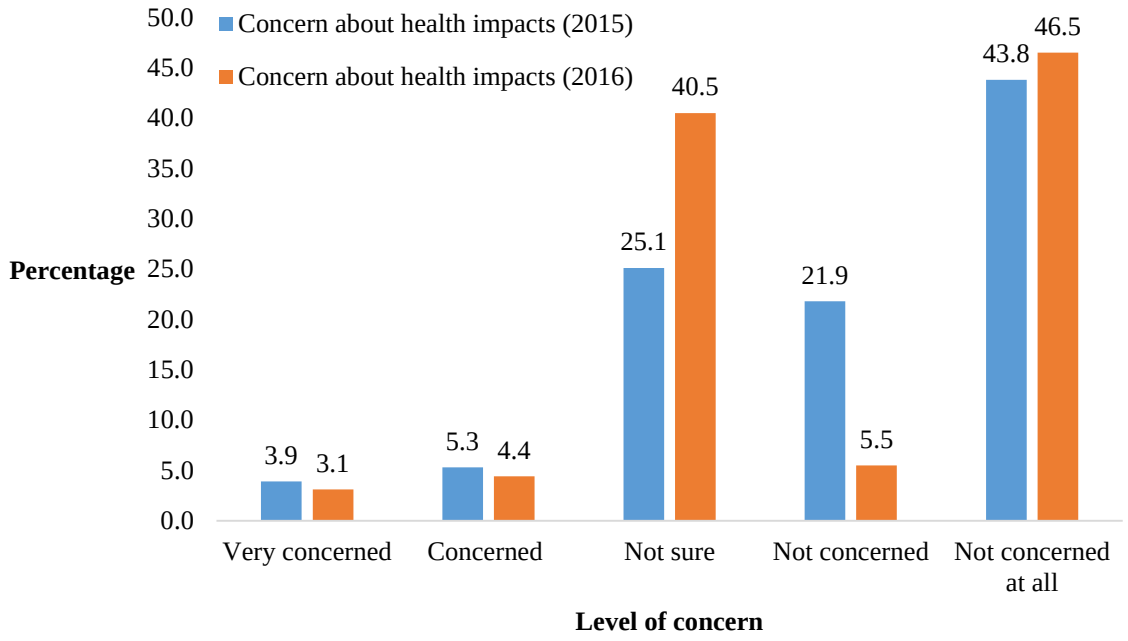
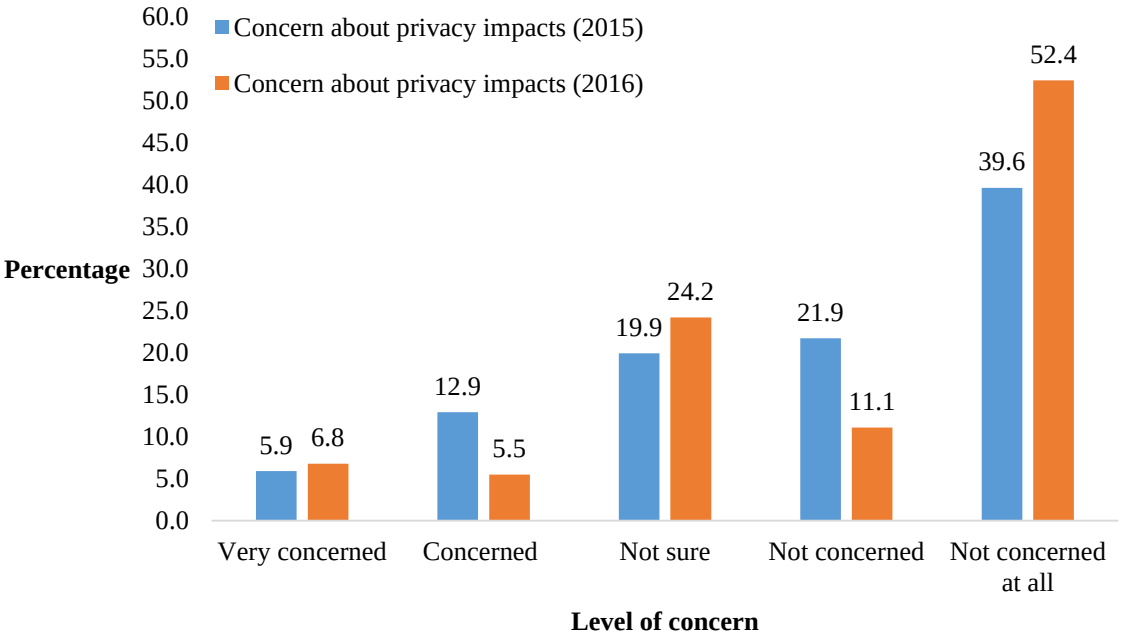


Figure 2.

Concerns About the Potential Impact of Smart Meters on Privacy in 2015 (n= 612) and 2016 (n=641)

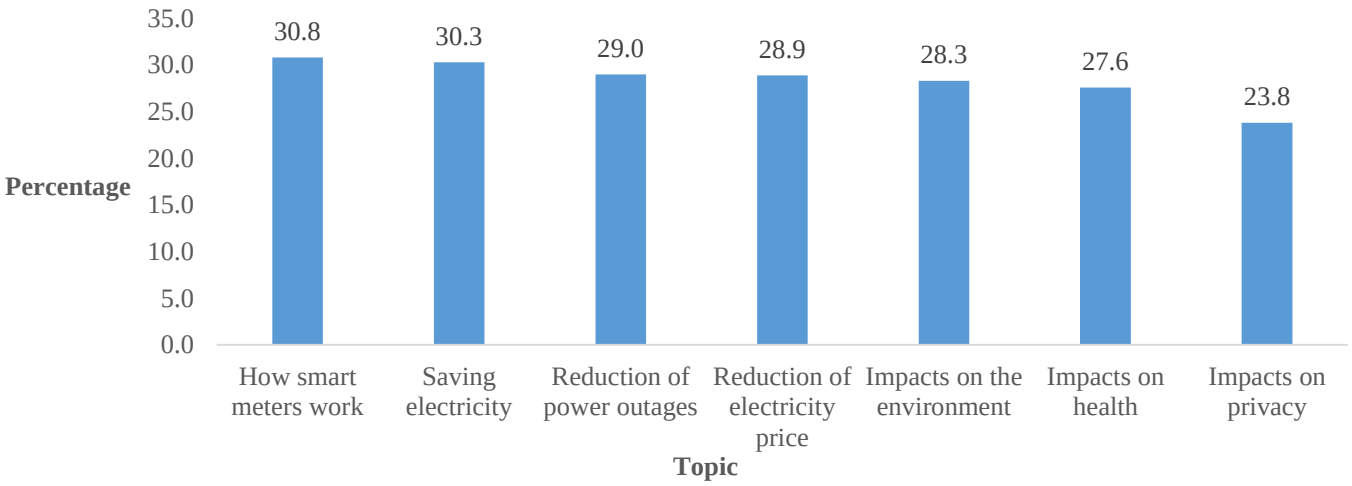


Interest in Additional Education on Smart Meters

Figure 3 shows the interest that 2016 survey respondents had in receiving different kinds of information on smart meters. The highest percentage of respondents (30.8%) wanted information on how smart meters work, whereas the lowest percentage of respondents (23.8%) wanted information on smart meters' potential impact on privacy. That no more than 30.8% of respondents wanted any one kind of information on smart meters may indicate a general lack of interest in or knowledge of smart meters. Increased education on smart meters and the benefits they can provide may help to pique customers' interest in smart meters.

Figure 3.

Additional Information Wanted on Smart Meters by Topic (n=644)



Discussion and Implications for Extension

The results of this study indicate a need for improved education on smart meters to bolster the benefits they can provide to utilities and electricity customers. As this research shows, many electricity customers may not be aware that they have a smart meter. Further, those who are aware that they have a smart meter might not be accessing the information it provides. Education on smart meters should first raise electricity customers' awareness of the presence of smart meters. Next it is necessary to educate customers on how to access and use the information that

smart meters can provide. However, education alone may not be effective if customers do not trust the source of information, which, in the case of smart meters, would tend to be utility companies. Effective education, in this regard, is not just about disseminating information but also about building trust (Lineweber, 2011; Wynne, 2006).

As other researchers have noted, Extension is often seen as an unbiased disseminator of information and thus is regarded as a trustworthy source (Romich, 2015; Laquatra, Pierce, & Helmholdt, 2009). Currently, Vermont's Extension agency is not doing any work in regard to smart meters (University of Vermont Extension, 2016). A partnership between Vermont's Extension educators and utility companies could facilitate dissemination of information regarding smart meters, including how to identify whether one has a smart meter and how to access the information it can provide. Extension educators may find benefit in tailoring this work according to demographics. For example, the data indicates that those living in units in multi-family dwellings are less likely to know that they have a smart meter. Educational efforts focused on those living in units in multi-family dwellings would be an effective way to increase awareness of smart meters. Additionally, Vermont residents are more concerned about privacy impacts of smart meters than they are health impacts. If Extension can learn what consumers' concerns are about smart meters, they can provide educational materials that will help address these concerns.

Although some work has been done in Vermont to educate electricity customers about smart meters (Gram, 2014), it is unclear how widespread and effective these efforts have been. In addition to Extension playing a more involved role in smart meter education, more research is

needed to better understand what baseline information, if any, electricity customers have on smart meters, where they obtained such information, what additional information, if any, they would like to obtain on smart meters and in which format(s), how information in different formats, such as in-home displays, affects electricity customers' electricity consumption, and what barriers they face in regards to changing their electricity consumption. Studies that evaluate how different educational campaigns and programs affect electricity customers' behavior will help Extension determine what kinds of education to focus on in the future.

Conclusions and Recommendations

Smart meters as a new technology have the capacity for many benefits, including reduced CO_2 emissions and cost savings for electricity customers and utility companies. While some benefits have been realized from smart meter installation, such as decreased labor costs for utility companies and decreased severity of power outages, other benefits, such as reduced electricity use and reduced cost for electricity customers, may not have been fully realized. Many of these benefits will depend on electricity customers changing their behavior in response to the real-time, or nearly-real-time, pricing information that smart meters provide. If electricity customers are not aware that they have a smart meter, are not accessing the information that smart meters provide, and are not changing their behaviors in response to the information that smart meters provide, the benefits realized from this advanced technology are likely to remain limited.

As the results from this study show, smart meter technology in Vermont appears to be underutilized. Many residential electricity customers are apparently unaware that they have smart meters, and many of those customers who do have smart meters have not changed their

electricity consumption as a result. Additionally, some residents report being concerned about smart meters' effects on their health or privacy.

Since it is often regarded as an impartial and trusted source of information, Extension can play an influential role in disseminating information on smart meters. Extension can work with utility companies to build trust in smart meter technology and to spread knowledge of how to maximize the technology's benefits. Additional research on smart meters will help to improve the efficacy of Extension's education in regard to smart meters. The underutilization of smart meters means that many more benefits are available to be obtained from them, and Extension, especially when combined with additional research on smart meters, can play an important role in helping these benefits to be realized.

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Abstract

Approximately 92% of electricity meters in Vermont, and more than 40% across the United States, have been replaced with smart meters because of their potential for improving grid efficiency and reducing electricity costs, but there is little information regarding efficiency of utilization by electricity customers. In this study, based on data from statewide surveys in Vermont, only 45% of respondents reported having a smart meter and, of those, only 12% indicated that having a smart meter had reduced their electricity use. Findings suggest that consumer education through Extension and other programs is needed for improving the efficacy of smart meters.

Keywords: smart meter**,** smart grid, customer education, electricity customer, Vermont