Electrifying Smart Consumers with Information

by

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1. INTRODUCTION

The electricity sector is being transformed in the United States (US) by policies to reduce greenhouse gas emissions, increase renewable energy and distributed generation, and improve energy efficiency. For example, as of January 2012, 30 states and the District of Columbia had in place an enforceable renewable portfolio standard and seven additional states had voluntary goals for renewable generation. These policies require or encourage electricity producers to generate a certain amount of electricity from renewable sources.¹ Federal financial incentives have also encouraged the development of renewable generation. Over the time period these policies have been in place, renewable generation has increased rapidly, especially from intermittent source such as wind and solar. In fact, from 2005 to 2010 wind and solar energy production in the US increased by an average of 39.7% per year and 17.1% per year respectively. This occurred during a period that saw overall electricity production grow at only 0.3% per year.²

Not only are sources of electricity supply becoming more intermittent, but they are also becoming more distributed. The capacity of distributed solar photovoltaic installations in the US is growing at a particularly rapid rate, nearly doubling between 2010 and 2011 from just over 600 Megawatts in 2010 to over 1,100 Megawatts in 2011.³

Since reliable operation of the electric grid requires that supply and demand remain in continuous balance, the new intermittent and distributed generation sources need to be balanced with flexibly operated power plants, such as single-cycle natural gas turbines, or with changes in demand.

Flexible demand is playing a growing contribution toward balancing supply and demand. For example, a survey by the Federal Energy Regulatory Commission found that total potential peak load reduction from demand response programs in the US increased by 79 percent between 2006 and 2010, reaching over 53,000 Megawatts.\textsuperscript{4} The study found that most of the growth was from commercial and industrial customers, with very limited growth from residential customers.\textsuperscript{5} It has been surmised that increasing the ability of demand to balance supply could substantially improve market efficiency, especially as supply becomes more unpredictable.

The flexibility of residential customer demand, however, has been hindered by customers’ lack of information about the relationship between consumption decisions and the quantity and cost of the electricity consumed. Consumption is typically measured monthly by utilities in the US, and provided to customers after-the-fact on a monthly bill. Aggregating 30 days of consumption into one data point and delivering that data point well after the consumption period is, needless to say, a blunt way to provide feedback to consumers. Furthermore, the diversity of electricity uses within a typical home makes it exceedingly difficult for a consumer to understand the causation between any given end use, the associated amount of electricity consumed, and the cost.

Filling in the information gap would require a customer to purchase electricity monitoring devices, spend time monitoring different household end uses, and calculate how different behaviors translate to energy and bill savings. All this amounts to very significant transaction costs that likely contribute to the limited amount of residential demand response today. The availability of new technologies, however, has the potential to dramatically lower transaction costs.

For residential consumers, the most significant new technologies are advanced meters that measure a household’s electricity usage on a continuous basis, and transmit hourly or sub-hourly increments of electricity consumption to the utility. According to one study, as of May 2012,\textsuperscript{4} Federal Energy Regulatory Commission, \textit{Assessment of Demand Response & Advanced Metering: Staff Report}, February 2011, p. 29.\textsuperscript{5} \textit{Ibid.}, pp. 30-31.
one-in-three US households, or approximately 36 million, had an advanced meter. The study projects advanced meter installations will grow to 65 million by the end of 2015.6

Additionally, low cost sensors, controls and communications are proliferating in household appliances. This phenomenon has become known as the “Internet of Things”, intended to describe an environment in which “things” communicate with and control other “things”, just as people interact on the Internet. In the electricity context, technology companies such as Tendril have developed “smart” devices that can be pre-programmed to manage electricity with minimal consumer interaction. Technology is rapidly evolving to the point where a consumer can simply tell his or her home energy management system to, for example, “reduce my bill by 10% while maintaining my comfort”, or program a home to automatically power down when the resident’s car leaves the house, and power back up when the car’s GPS sensor tells the home that the resident is approaching.

Studies have demonstrated that information can enable a residential consumer to not only make short term changes in electricity consumption, but also to identify no- or low-cost energy and money saving approaches that can be implemented on a permanent basis.

However, until recently, utilities have not provided consumers access to the data measured by advanced meters on a mass scale. In other words the transaction costs for the consumer have not been lowered, and opportunities to increase market efficiencies and better optimize consumer purchases are being lost.

The remainder of this paper draws upon the experiences of the author at a state utility regulatory agency developing regulations to require that utilities provide access to energy data and at a technology company that is focused on influencing the behavior of residential electricity consumers through personalized insights and “smart”, controllable devices. The paper starts by reviewing evidence that residential consumers respond to electricity usage information, discusses how utility disincentives are likely limiting consumer access to information, describes early efforts of regulators to require access to information, and highlights a new effort that is intended to lead to widespread access to information.

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2. EVIDENCE THAT CONSUMERS RESPOND TO INFORMATION

There is a growing body of evidence that consumers respond to information related to how and when they consume electricity. One group of examples is what has become know as “behavioral” energy efficiency programs, which have been offered by a number of utilities. Behavioral programs encompass efforts to influence consumer behavior on an ongoing basis, often through providing information, context, and analysis. A paper from the American Council for an Energy-Efficient Economy (ACEEE) provides several case studies of programs that have taken a behavioral approach.\(^7\)

One such example is the Residential Smart Energy Monitoring Pilot conducted by Cape Light Compact in Massachusetts with the technology company GroundedPower, which is now owned by Tendril. Through the program consumers obtained in-home energy monitoring systems. The monitoring systems measured whole-home electricity consumption and uploaded that information in real-time to a website. On the website consumers could view graphs, set goals, compare their electricity to other households and educate each other through an interactive message board.\(^8\) Because the information provided to consumers was in real-time, some participants were able to diagnose how much energy certain devices were using by turning devices on and off and observing how the whole-home measurement changed. In surveys, consumers expressed surprise at some of the things they learned.\(^9\) With this knowledge consumers were able to target energy saving efforts at specific end uses. For example, one participant described how they used to turn on a 60-inch plasma television first thing in the morning. Once the consumer realized how expensive operating the television was, he or she purchased a small energy efficient television for the kitchen and used that instead and claimed to have reduced the monthly utility bill by 25 to 30 dollars per month in the process.\(^10\) On average, participants in the program reduced their energy use by 9.3%.\(^11\)

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\(^8\) Ibid., p. 13.

\(^9\) Ibid., p. 16.

\(^10\) Ibid., p. 16.

A related set of evaluations has looked at programs that send letters to consumers that provide a social comparison of the recipient’s energy use to other households and provide targeted energy savings tips. An evaluation by Allcott finds that 17 such experiments resulted in average energy savings of 1.4% to 3.3%.\textsuperscript{12}

These examples demonstrate how behavioral approaches fueled by information can influence average electricity consumption. Other studies examine how information can enable consumers to behave more dynamically.

A recent paper by Jessoe and Rapson demonstrates one such example.\textsuperscript{13} The authors implemented a randomized controlled trial in which all treatment households were exposed to pricing events in which the price of electricity increased by 200 to 600 percent. Some households were also given in-home displays (IHDS) that provide real-time information on a household’s total electricity consumption and the electricity price.\textsuperscript{14} The paper found that households that experienced pricing events and did not have IHDS reduced their energy usage by between 0 and 7 percent during events while those households that had an IHD reduced usage by between 8 and 22 percent. The paper concludes that providing simple, real-time consumption information to residential consumers increases the price elasticity of demand three-fold.

While the study of how information can influence electricity consumption is still at an early stage, the results thus far suggest information can have a substantial impact on consumer behavior. It is worth noting that the studies described here have been controlled experiments driven by regulatory requirements. What is the prospect for a market-driven expansion of consumer technologies and services that make use of electricity information?

3. CHALLENGES FACING THE MARKETPLACE TODAY

While studies are demonstrating the impact information can have, the marketplace for technologies that would allow a residential consumer to monitor and manage electricity use has

\textsuperscript{14} The project studied involved the author’s company, Tendril.
been slow to develop. Why is this? In part due to continued barriers to consumers obtaining useful electricity usage information.

One way to obtain electricity usage information for a whole home is with an advanced utility meter that measures continuous or periodic electricity usage data.

As noted above, utilities have been replacing manually read, electro-mechanical meters with advanced meters at a rapid pace. Utilities are making this transition for a number of reasons: lowering meter reading costs by eliminating human meter readers; helping to detect outages, thus, speeding outage restoration; automating the process of initiating and terminating service as residents move in and out of a location.

To understand how advanced meters can provide consumers with electricity usage information, it is worth describing how advanced meters measure and transmit data.

In the US, advanced meters commonly include two radios. One higher-powered radio is used to transmit meter readings from the meter back to the utility back-office, and the other, lower-powered, radio is intended to transmit meter measurements and other information into a customer’s premises.

The transmission of data to the utility via the higher-powered radio is sometimes referred to as the “backhaul”. The backhaul transmission of data is generally not done on a continuous basis. Rather, the meter records measurements every 15 minutes or one-hour, stores the meter measurements for several hours or even a full day, then transmits the data to the utility in a batch. The batch transmissions are intended to make more efficient utilization of the backhaul communications network than would a continuous transmission. The result is that the data collected by the utility is not real-time data, but is delayed by up to 24 hours.

The data collected by the utility through the backhaul could be used to enable behavioral and analytical consumer services. To do so, the utility would need to provide these new services, or the utility would need to provide the data to consumers or to companies that offer behavioral or analytical services. (Under typical privacy frameworks, a customer would need to provide some form of authorization before a utility transmits the customer’s data to other companies.) The delayed, historical 15-minute or hourly data can be analyzed to provide insights that could
influence consumer behavior. However, the backhaul data is not suited to provide timely, interactive feedback to a consumer to help guide opportunities for dynamic changes in demand.

The second, lower-powered, radio is sometimes called the Home Area Network (HAN) radio. Unlike the backhaul radio, the HAN radio measures and transmits electricity use continuously. To access the data a consumer needs a device that can receive the HAN broadcast. The collected data can then be used directly by other in-home monitoring or management devices, or transmitted via the internet to internet-based services or internet-connected devices. HAN data is highly valuable as an input to provide consumers with real-time feedback that links consumption decisions to quantities consumed.

Seemingly, the rapid deployment of advanced meters would translate to the mass availability of electricity usage data for consumers. However, until recently, this has not been the case.

Data concerning a consumer’s electricity usage that is collected by a utility through its backhaul systems cannot typically be accessed by the consumer. Where the data is available it is typically only accessible on a utility website in a non-standard format. Similarly, a consumer has little or no ability to obtain the continuous data from an advanced meter’s HAN radio. In California, for example, the largest investor-owned utilities had installed 9.9 million meters as of May 2012.15 However, as recently as of the end of 2011, backhaul meter data could only be accessed in non-standard formats on utility websites and no customer could access real-time HAN data outside of some very small pilot projects.

Why is this? When the cost of the metering systems is “sunk”, what are the remaining barriers preventing a household from accessing its electricity data?

4. MISALIGNED INCENTIVES

This assessment of incentives is based on the author’s professional experience and observations working in the field of regulatory economics with a state regulatory agency that regulates the electric utilities.

Ultimately, access to electricity data from advanced meters is in the hands of the owners of the metering infrastructure—the electric utilities. The results of studies noted above suggest that there is potential value to be realized through the provision of information to customers, yet the utilities have not been pursuing this value.

There are at least two potential explanations for the behavior of electric utilities. First, the value of information to consumers may be less than the remaining costs to provide and use the data. Second, even if the consumer value is greater than the remaining costs, utilities might not be positioned to capture the value or may even be harmed by how consumers will likely respond to the new information.

As far as the first reason goes, the author believes that investments made by the author’s company, Tendril, and other technology companies, demonstrate that many market participants believe there is an opportunity to create profitable businesses that rely on electricity usage information. The fact that utilities are not pursuing this value points to the second reason, i.e. utilities are not positioned to capture the value. The author believes this is primarily due to misaligned incentives that are an outgrowth of the way electric utility rates are regulated.

Roughly speaking, a utility’s retail rates are set by a regulator so that the utility can recover its costs, including operating and capital costs, plus earn a regulated rate of return on capital. The return on capital is essentially calculated as the authorized rate of return multiplied by the utility’s net investment in generation, transmission and distribution facilities, also known as the ratebase. A utility’s regulated return on equity is in effect the utility’s profit. A utility does not generally earn a profit or mark-up on operating expenses, although differences between forecast expenses and actual expenses could result in transient profits and losses during certain time periods.

The opportunity to increase the ratebase, and thus profits, provides a utility a strong incentive to make new capital investments, including investments in advanced meters, provided that the regulators will approve the recovery of the investments in rates. However, taking the next step and providing consumers with access to the data measured by advanced meters does not involve a material capital investment. As a result, utilities have little incentive to provide access to data.
Even worse, the risk that information will cause consumers to reduce their energy use could harm a utility for at least two reasons.

First, a drop in electricity sales could prevent a utility from recovering fixed costs and the associated rate of return. This is because rates typically include a variable, i.e. per kilowatt-hour, component, that may be greater than the component of utility costs that are variable. This is especially the case for typical residential rates, which are primarily volumetric for most utilities. Many utilities have mechanisms in place to adjust rates upwards when sales decrease, such as through a decoupling or lost revenues recovery mechanism. However, not all utilities have these mechanisms, and even where the mechanisms exist, they may not keep the utility whole in all situations. For example, lost revenues mechanisms may allow a utility to adjust rates upwards when savings decline due to documented and measured energy efficiency programs, but might not adjust rates for reductions in sales that are due to independent actions taken by a customer.

Second, even a utility with a rate adjustment mechanism may be concerned that reductions in sales will cause the long-term energy and capacity forecast to decline, reducing future investment opportunities in distribution, transmission and generation infrastructure that would otherwise be needed to accommodate growth. A lower level of investment translates to a smaller ratebase and lower future earnings.

Given the lack of a capital investment-driven incentive and the potential for consumer energy savings harming utility earnings, it is not surprising that utilities have been slow to enable access to energy data.

Regulators and policymakers are beginning to compensate for the lack of utility incentives through mandates and voluntary challenges.

5. EARLY EFFORTS TO ENABLE CONSUMER ACCESS TO INFORMATION

The State of Texas initiated the first large-scale effort to put advanced meter data in the hands of consumers following the passage of Texas House Bill No. 2129 in 2005 and the adoption of advanced metering substantive rules by the Public Utility Commission of Texas in 2007.\(^{16}\) As an element of the advanced meter system being deployed in Texas, the electric transmission and

\(^{16}\) Public Utility Commission of Texas, Electric Substantive Rules, §25.130 Advanced Metering.
distribution utilities built a statewide web portal called Smart Meter Texas through which consumers can download their two-day old, 15-minute interval backhaul meter data. The portal can also be used by competitive retail providers of electricity to access their customers’ data. Smart Meter Texas also manages the connection of HAN devices directly to smart meters. Smart Meter Texas launched in 2010. Enhancements to facilitate consumer-directed access to data by companies that are not retail electricity providers are still being developed, so it is still too early to gauge the impact of Smart Meter Texas on the marketplace.

While no other state has followed the path of Texas and established a statewide web portal to facilitate access to energy data, California has pursued a different set of policies intended to get to a similar end. The first of the three large investor-owned utilities in California started installing advanced meters in 2006, and by the end of 2012 the three utilities will have installed about 12 million advanced meters. In approving the investments, the California Public Utilities Commission (CPUC) endorsed a utility projection that household access to real-time energy data would result in quantifiable benefits. For example, the CPUC endorsed one utility’s projection that households adopting in-home display devices that provided real-time electricity usage feedback would reduce their average energy consumption by 6.5% as a result of the feedback.17

Despite these forecasts, the utilities have not, thus far, enabled consumer access to data. In response, the CPUC issued several decisions mandating that each utility provide access to delayed backhaul data and real-time HAN data.18 As in Texas, the implementation of information access is incomplete, so the impact on consumer behavior and the marketplace cannot yet be discerned.

6. WIDESPREAD INFORMATION ACCESS BEGINS—THE GREEN BUTTON

Until late 2011, efforts to make energy usage data available to households were very limited outside of Texas and California. However, that began to change in October 2011 when the US Chief Technology Officer, Aneesh Chopra, issued a challenge to the utility industry to voluntarily

make energy data available to consumers in a standardized format, which Chopra dubbed the “Green Button”.\(^{19}\) Chopra based the Green Button on an initiative that has made personal health information more accessible and downloadable for millions of consumers, known as the Blue Button. Chopra hoped that making energy data available in a standardized, electronic format would spur the development of new consumer applications and devices. The data that is available through the Green Button initiative is the delayed, backhaul data that the utility collects, not the real-time, HAN data.

The process by which a utility customer accesses his or her Green Button data involves several steps. First, a customer must securely log onto his or her utility website. Second, the customer downloads a data file containing historical interval usage data going back up to thirteen months. The data file is in the standardized, Green Button format. Third, the customer uploads the data file to a third party application or service that does something with the data. Each time the customer wants the third-party application to have updated data, the customer must log back into the utility website and download a new data file.

In January 2012, the Green Button was launched by the first two utilities, Pacific Gas and Electric Company and San Diego Gas and Electric Company. Many more utilities have implemented or committed to implement the Green Button since then. As of September 2012, 23 utilities serving approximately 40 million households have committed to make data available in the Green Button format, of which six utilities have actually done so.\(^{20}\)

While the type of data available through the Green Button, i.e. delayed, backhaul data, cannot provide a consumer real-time feedback to link consumption decisions to quantities consumed, the data represents a substantial leap relative to what has been available up to this point. Green Button data can potentially feed behavioral feedback applications, such as those described above, as well as other analytical and diagnostic tools.


\(^{20}\) For list of utilities see <http://www.greenbuttondata.org/greenadopt.html>. Number of households calculated by the author.
In fact, the early evidence is that software developers and technology companies are rapidly responding to the availability of data in a standardized format and the potential for a nationwide market for energy management products and services. For example, 57 software applications were developed in just two months in response to the US Department of Energy’s “Apps for Energy” contest in 2012, which required that the application developers demonstrate the use of Green Button data. Tendril has also committed resources in this area. In total, at least 34 technology companies have developed or committed to develop application and services that use Green Button data. However, the outcomes in terms of consumer adoption, consumer value, energy saved, etc. have not yet been determined.

Given the aforementioned discussion of misaligned incentives, why are utilities enabling consumer access to information through the Green Button initiative?

Several, explanations are possible. First, in official press releases utilities have cited a desire to help their customers manage their energy use and save money and to provide customers with access to advanced technologies. Second, utilities could be motivated to demonstrate the benefits of advanced metering investments to consumers, especially in the face negative publicity related to claims that the meters are inaccurate and that the wireless communications pose a health risk. Third, utilities may perceive a benefit from being responsive to a White House initiative. Utilities may hope for better regulatory or policy outcomes from the federal government as a result. Finally, utilities may be skeptical that making Green Button data available will translate to consumers saving energy, thus they see no downside financial risk to making Green Button data available. It is likely that all of these explanations are partly or wholly true.

7. WHAT'S NEXT?

The deployment of advanced meters by many US utilities has greatly expanded the amount of information that is available to utilities regarding when and how residential consumers use

21 Ibid.
electricity. However, due to misaligned incentives, prior to 2012, there were relatively few examples of utilities actually providing energy data to consumers and authorized third parties. Starting in earnest in 2012, policies that require utilities to provide energy data in a standardized format have gone into effect, quickly stimulating technology companies to introduce new services, with the expectation that consumers will pay for products and services that are enabled by energy data.

So, what’s next?

The transaction cost barrier to consumer access to personal electricity usage data is just beginning to crumble, but remains formidable.

Green Button access is expanding rapidly, but is still unavailable to most US households. Green Button data is also inadequate for some potential consumer applications, since the data is not real-time and downloading the data requires a multi-step process that must be repeated by the consumer to update the data. In other words, the Green Button initiative has introduced new transaction costs.

Utilities, starting in California and Texas, are working toward putting in place an automated download process that will allow a consumer to make a one-time authorization so that data becomes available to a chosen third party on a continuous basis, on the same timeframe that the utility collects the data. This is expected to be a material improvement on the current Green Button approach.

Access to real-time information directly from the meter is also beginning, again starting with Texas where over ten thousand HAN devices have been connected to advanced meters, some of which are real-time monitoring devices. Additionally, the CPUC is considering utility plans to enable consumers to connect HAN devices to meters in California, thus providing real-time information feedback.

7. CONCLUSION

24 cite.
It is a dynamic time in the evolution of the consumer-side of the electricity industry. Residential consumers are beginning to get access to timely, energy usage information that was, heretofore unavailable. Low cost access to this information will reduce a transaction cost that has been limiting residential consumers’ elasticity of demand for electricity. New technologies are poised to enable consumers to make use of this information, thereby enabling dynamic residential consumer demand and improving market efficiencies. These new technologies are well timed given the emerging challenges posed by increases in intermittent and distributed renewable generation.

However, given utilities misaligned incentives, it is unlikely that utilities will expand consumer access to information without further government intervention through regulation and/or legislation. Regulatory initiatives in Texas and California and the federally led Green Button initiative are promising, but more government intervention will be needed before all US residential consumers have the ability to more fully understand and manage electricity use and improve the efficiency of electricity markets.