Small Utilities and Big Data – Cooperative and Municipality Programs in the Digital Future

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Abstract

Modern data generation, processing, and communication capabilities are accelerating—paving the way for smart homes. In the energy efficiency space, the most recognizable herald of innovation is the smart thermostat, a device that is transforming the market by offering remote connectivity and improved usability over its predecessors. Right behind it is smart appliances, smart bulbs, smart outlets, and a wealth of other home electronics (connected or otherwise).

For organizations implementing energy efficiency programs on behalf of cooperatives and municipalities, these changes can be daunting. However, it is important to recognize that technology—especially digital, personal, and connected technology—historically removes geographic barriers in the realm of information services. Therefore, smart devices and data may become extremely effective, low-cost tools for enabling energy efficiency and engaging customers remotely.

The notion of incorporating these new technologies into energy efficiency programs raises a number of questions, such as: How can small utilities with limited staff effectively work with advanced metering infrastructure (AMI) data and demand response (DR)-capable devices while avoiding exorbitant costs? How can implementers for these utilities incorporate smart devices into their programs, short of becoming product gurus? How do device manufacturers or software makers fit in to the picture, especially without ENERGY STAR® labels to distinguish their products?

This paper shares insight gained through program design, implementation, and analysis for a collaborative of cooperatives and municipalities, including those gained from a pilot program for Wi-Fi connected, DR-capable thermostats. It outlines pitfalls and strategies for harnessing the capabilities of big data on a budget, and for working with devices in the market today. Finally, the paper looks forward to the future integration of evolving consumer technologies into energy efficiency (EE) programs.

Introduction

Modern information and communication infrastructure has evolved to encompass devices and systems that had previously existed autonomously. The transformation of technologies from disconnected to connected, and from analog to digital, is of obvious interest to electric utilities—that can stand to benefit if they can harness this glut of information to meet customer demand smoothly. For instance, the combination of AMI and DR-capable devices provides the opportunity to better forecast demand and shed load without specialized equipment, presenting an immediate value proposition.

Residential energy efficiency programs can benefit from the same infrastructure and technology advances, but must overcome financial, technical, and attitudinal barriers to entry. Strides are being made by investor-owned utilities (IOUs) to surmount these barriers, evidenced by a variety of data-oriented pilots and programs throughout the last five years. Municipal and cooperative utilities face additional obstacles to using information technology to drive energy efficiency savings. This paper investigates the myriad of challenges and opportunities for public power utilities in harnessing data and devices for residential EE programs. In addition to cited sources, the analysis draws from WECC's decades of program administration and implementation experience (working with cooperatives and municipal utilities), and interviews with utility, consulting, and energy data services professionals.

Cooperative and Municipal Utilities
Electric distribution cooperatives are member-owned nonprofit electric utilities, typically servicing a widely dispersed, rural customer base. Unlike IOUs, which generate investment returns for their shareholders, cooperatives return all profits as capital credits to their members or reinvest them into capital improvements. Utility decisions are made by a board of directors elected from the cooperative's members. The average electric distribution cooperative serves 20,000 members and employs just 48 full time workers, selling less than one-twentieth the electricity of a typical IOU (NRECA 2012). While cooperatives account for only 14 percent of electric sales nationally, they cover 75 percent of the United States' total distribution territory.

Municipal electric utilities are nonprofit electric providers owned and operated by the local city government. Unlike cooperatives, their territory is necessarily compact as it is defined by municipality boundaries. However, like cooperatives, they reinvest profits into infrastructure improvements for their customers. They are also typically small, providing service for an average of 18,000 customers and selling about one-twenty-fifth the electricity of an IOU (EIA 2014).

The nearly 1,700 municipal and cooperative utilities in the United States provide a combined 26 percent of retail electricity to customers and members. While regulating energy efficiency of for-profit utilities is an expedient path to energy savings, the nonprofit electric utility sector continues to hold vast, untapped potential. There is a gap between mandatory efficiency efforts in PPUs and IOUs encoded in states' Energy Efficiency Resource Standards (EERS), which are often worded to exclude municipal and cooperative utilities. A map of which states include nonprofit distribution utilities in their EERS, along with how many are in each state, is shown in Figure 1. This map does not paint the whole picture, however – some of the larger cooperatives and municipal utilities lead the field in implementing energy efficiency programs voluntarily, citing their commitment to represent their members' interests as a driver.

Common barriers to implementing energy efficiency programs in general for public power utilities.
Cooperative and municipal utilities face a number of challenges in implementing energy efficiency programs, before data-driven programs are even considered. Some of these barriers can be overcome through the use of data, while others carry forward into considerations about forward-thinking programs.

The first and most obvious barrier to implementing EE programs for PPUs is budget. The 0-2 percent energy efficiency spending requirements for utilities make sense from a program design perspective if those companies earn over $250 million per year, but start to become unrealistic anywhere below $100 million. Planning and delivering a cost-effective portfolio of several programs meeting even relaxed standards for EM&V is challenging for less than $1 million. Cooperatives in particular have difficulties because their member base is diffuse and their territory often surrounds but does not include cities—increasing costs to cover the territory and enhancing free ridership in retail programs.

The second barrier is regulatory. Many of these smaller utilities are exempted from state efficiency standards either explicitly or implicitly. Half of the states with EERS apply efficiency regulations only to IOUs, or exclude utilities with less than 100,000 customers. Cooperatives and municipal utilities in the remainder can request exemptions from EERS. Given the economies of scale in planning, tracking, delivering, and evaluating energy efficiency programs, such exemptions are a necessity for utilities whose average mandated efficiency budget is $400,000 (less than the budget for many pilot programs at the IOU level). Moreover, penalizing nonprofit utilities that fall short of goals, when they are legally bound to pass those penalties onto customers or forego system improvements as a result, would be a damaging policy choice. However, an exemption doesn't help members or customers overcome initial costs to implement energy efficiency measures. The breakdown by state of electricity sales, and which sales qualify when counting utility revenue, is shown in Table 1. A graph of qualifying sales by state is shown in Figure 2. The most salient feature is the difference between the first row and the last. While the percentage of all electricity sold nationwide by IOUs (61 percent) is close to the percentage of all electricity under regulation in states with an EERS (57 percent), the percentage drops significantly for cooperatives and municipal utilities (approx. 13 percent down to 4 percent). In other words, only about one-third of PPU sales in states with energy efficiency regulations are included mandatorily.

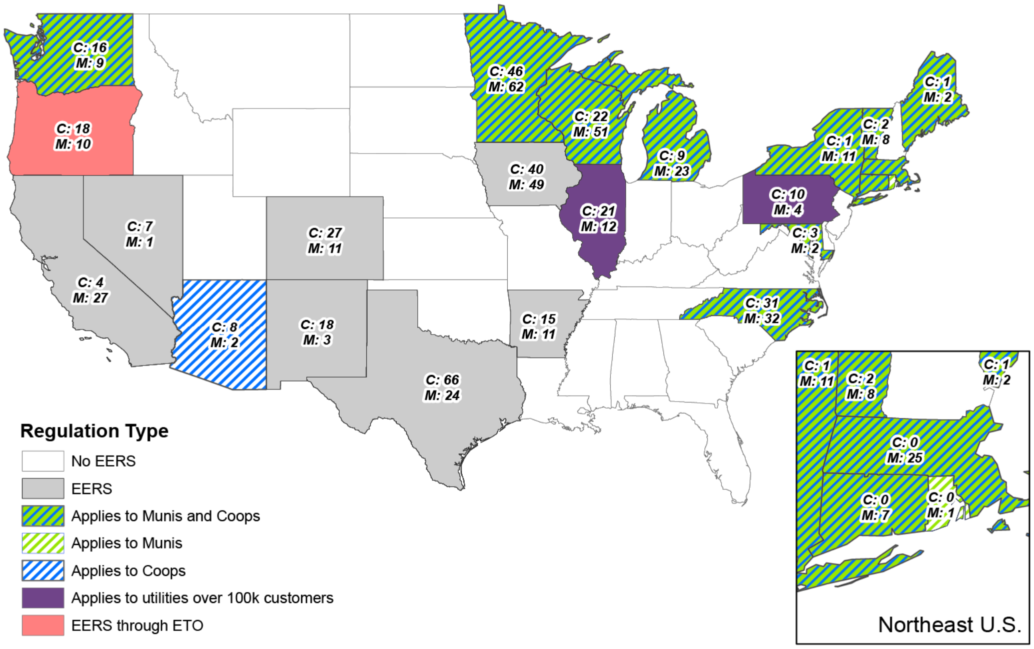

Figure 1: EERS regulation status by state, with standards that apply to municipal utilities and cooperatives shown. Each state with an EERS is labeled with the number of cooperatives and municipal utilities operating within it (EIA 2014).

Table 1. Utility electricity sales and percent that count towards EERS (EIA 2014)

	Investor Owned	Cooperatives	Municipal utilities
Percent of all electricity sold (nationwide)	60.5%	13.5%	12.4%
Electricity sales that count towards EERS as percent of sales within utility type	48.1%	13.8%	18.1%
Electricity sales that count towards EERS as percent of all electricity (nationwide)	29.1%	1.9%	2.2%
Electricity sales that count towards EERS as percent of all electricity (states with EERS)	56.5%	3.6%	4.4%

The third barrier is utility-side capability. Given their size, PPUs may dedicate only one or less than one staff member's time to overseeing energy efficiency efforts (one person out of 48 people equates to about half of a person). The difference between one staff member and less than one is particularly striking. When it is the entire job of one person, that person can think more carefully and critically about what they want from implementers and programs. That personal investment creates an advocate for effective programs within the utility. When EE is only part of a staff member's job, that person is more likely to treat it as an external service to manage as opposed to a utility function.

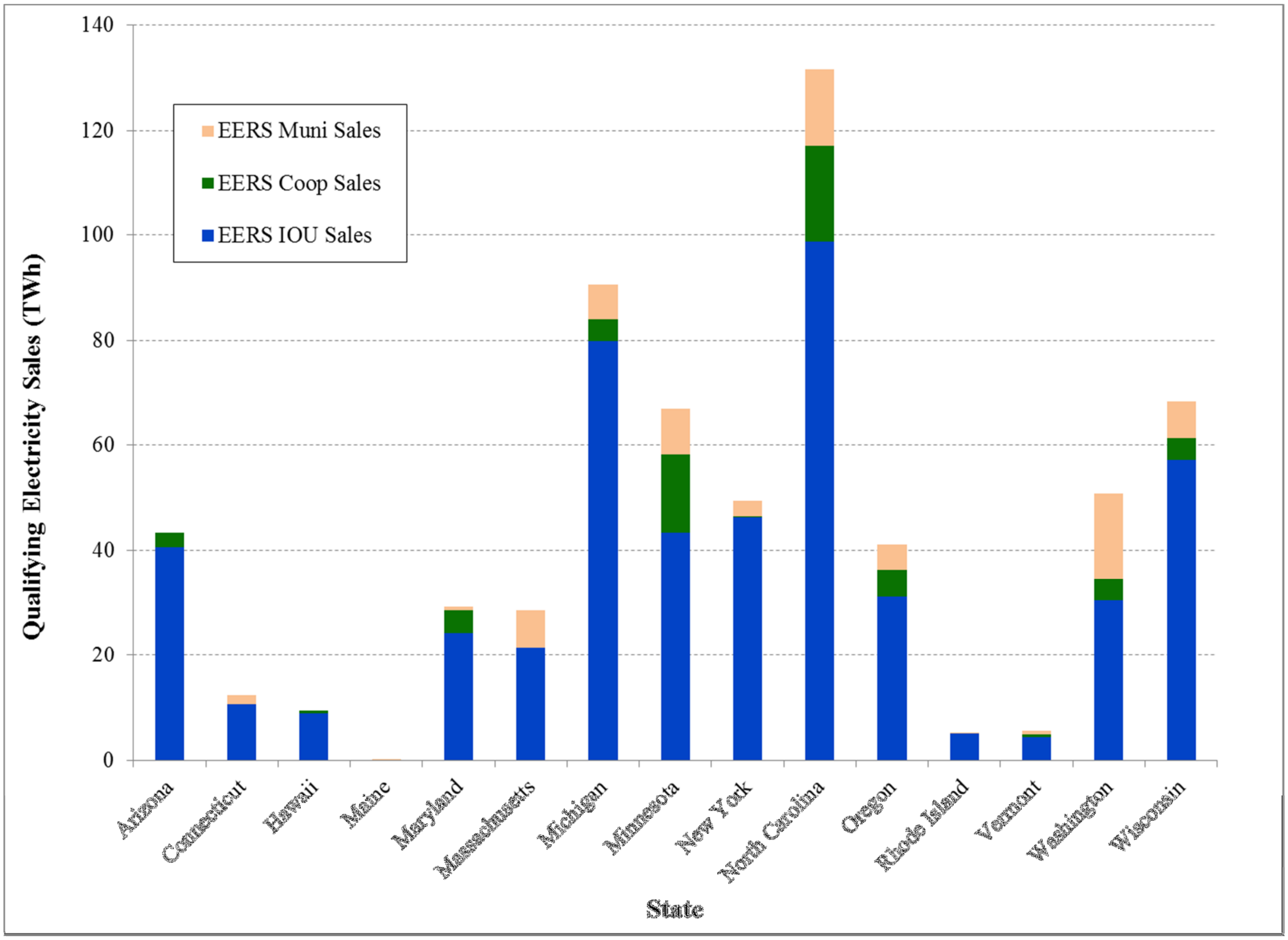

Figure 2. Qualifying Electricity Sales by State

In addition to an insufficient number of staff, the aging utility workforce is also a barrier (Lave 2007). Most employees at these small utilities entered the workforce before EERS existed, resulting in a lack of regard for energy efficiency as a status quo utility function. Such a perspective can result in a utility-side lack of engagement. As older workers retire, this perception will shift, but the replacement workforce must overcome its skills gap before affecting internal change.

The final barrier is demographics. Cooperatives are regulated by a board elected from their membership, and are therefore obligated to represent their members. They cover a dominantly rural territory, where residents tend to be more conservative. Conservatives generally have a less favorable view of energy efficiency (Gromet 2013), which creates pressure for their member-owned utilities to seek exemptions from energy efficiency regulation.

Unlike the first three barriers, this barrier is not between the utility and service to its members—but instead between the utility and members versus regulation. Cooperatives may truly represent the will of their membership by abstaining from energy efficiency initiatives. Cooperatives also serve 90 percent of the counties experiencing “persistent poverty” in the United States (NRECA 2014). For residents of these areas, upfront costs for EE improvements are often not a consideration. With that in mind, reducing energy bills in these areas can provide an economic boost by freeing up incomes for other goods or services.

Solutions for public power utilities. Especially for smaller utilities, the most effective solution to the above barriers is funding aggregation for external services. Whether banding together with other cooperatives and municipals to hire an administrator and implementer for programs, or simply directing customers to online virtual audits and upgrade information, aggregation addresses the first three barriers by allowing the utilities to act as a larger entity. However, such an arrangement adds complications, further expanding sprawling territories for EE programs and diminishing the decision-making power of each individual utility in determining program direction and scope. It is nonetheless a path forward in a difficult environment to implement energy efficiency programs.

Municipal utilities, who have fewer challenges due to their compact territories, still gain significantly from partnering with the cooperatives or IOUs that encompass them. With unbroken geographic coverage, trade allies and retail programs can cross town borders without foregoing efficiency-promoting rebates, and can centralize their program credential registration. Program implementers often must be cautious about program activity at territory borders due to the possibility of free ridership. Therefore, both cost and free ridership are driven down by these partnerships.

Data and Devices

Embedded sensors, processors, and communication components allow devices to join "the Internet of Things," the host of connected objects that are generating value for consumers through their ability to be either controlled or monitored remotely. By virtue of containing electronics, most of these objects draw electricity, but may offer feedback or controllability that energy efficiency programs can use to drive savings.

The first and most well-established set of connected things, from the utility perspective, are the utility-side metering and control devices. Advanced metering infrastructure (AMI) deployment continues to rise, cresting 50 million smart meters deployed nationally in 2014 (IEI 2014). Additional devices that utilities have deployed include demand response (DR) controllers or switches and facility submetering. These technologies are usually owned by the utility and are investments with a value proposition outside of energy efficiency. For energy efficiency programs, smart meters installed across a customer base offer the opportunity for several forms of targeting. Residential behavior programs are essentially targeted messaging to consumers about their energy consumption, often compared to neighbors or similar homes. Remote building analysis uses the same AMI dataset alongside weather, demographic information, and other public data to characterize homes as a pre-screening for targeted messaging about programs, from retrofits to appliance recycling (ACEEE ICT 2015).

The second set is comprised of customer-owned devices that have value beyond energy efficiency, but have direct efficiency outcomes through standard operation. Unlike the utility-owned devices, the current energy efficiency benefits of these devices stem from their ability to be controlled by algorithms and external applications. Notable examples are residential smart thermostats, smart plugs, and smart lighting systems. These devices each replace an existing device and unlock previously inaccessible energy savings through learning, scheduling, and communication features. When utility programs are granted access to their data, connected thermostats and lighting systems provide real observations of user behavior that can also be used for targeting (Cadmus 2015). The combined benefit of having both immediate energy savings and added potential in the device's recorded data is that a system can be installed on its energy-saving merits and later incorporated into a data-driven program.

The last set is made up of connected devices that use energy, and are either new to market, seeing greater numbers per home, or increasing in individual energy usage. Always-on devices such as home digital assistants and quick-start modes for game consoles or computers fall into the first category, along with proprietary hubs for each connected product. These products provide new services to their users, and draw energy continuously to do so. Smart products that are increasing penetration include modems, wireless routers, home wireless repeaters, computers, game consoles, chargers for portable devices, and televisions. Finally, some products are using more energy despite ENERGY STAR designations due to consumer choice. Televisions are increasing in size, from 32" on average in 2002 to 60" in 2016. The maximum power draw

(P_{on_max}) when turned on to meet ENERGY STAR specifications for a 32” TV in 2002 was 54 W, while the maximum draw for a 60” TV in 2016 is now 60 W—an 11 percent increase even for energy-efficient TVs (ENERGY STAR 2006, 2015). Even as products become more efficient, plug loads from “miscellaneous” loads and electronics are increasing.

It is the connected, controllable aspect of the last group that can unlock energy efficiency opportunities. Many connected devices can sense user presence—or, can be controlled by a system that can—allowing for the transition to standby or off mode. Unlike the group of devices with direct energy efficiency applications, this group tends to come with energy-saving features disabled. In this case, the quickest path to energy efficiency is helping users to enable those features.

A secondary barrier is the currently fractured field of communication protocols and smart device hubs. Protocols currently include Zigbee, WiFi, Bluetooth, Thread, AllJoyn, and Open Interconnect Protocol. Because the market has not settled on how devices should be controlled, there can be many smart hubs in a home, some of which control other hubs. This setup is unnecessarily complicated, as it is easy to imagine all data and control features centralized in a single device—simplifying ease of control for all connected home devices. Not only would this streamline the software of efficiency for connected devices, it would decrease the number of hubs drawing continuous power as they wait for commands.

Insights from Pilots and Programs

Connected Thermostat Pilot

From 2011 to 2014, WECC planned, implemented, and analyzed a connected thermostat pilot for three utilities—one municipal and two cooperative—within a statewide utility collaborative. The pilot was designed to test the dual features of connected thermostats as a demand response technology and as an energy-saving measure. The selection of the thermostat model took place in 2011, before smart thermostats had any appreciable market share, so the model selected for the pilot (the Honeywell VisionPRO 8000) would not qualify as a smart thermostat in EE programs today.

Participants were given a free thermostat and professional installation, with the installer programming the device initially and delivering education on thermostat operation. Hourly consumption data from utility AMI systems and runtime, indoor temperature, temperature set point, and user interaction data from the thermostats themselves were collected for all 334 participants. Impact analysis revealed winter energy savings for homes whose heating fuel consumption data we had access to (electricity) and analysis of thermostat data revealed a high defection rate as seen in other studies (Cadmus 2015). However, the insights gained from working with the customer base and the utilities themselves offered a unique look into the readiness of PPUs for running data-centric programs.

The data to be conferred to WECC and an independent evaluator were sizable, at least from the perspective of the utilities involved. In order to evaluate demand response effectiveness, 15-minute interval data was requested from the AMR systems of all three utilities. The analysis method was quasi-experimental, and as such the data for the entire customer base was requested from each utility. For the largest utility, this amounted to a 1 gigabyte file for every month requested, or about 30 GB for the 30 months of the study.

Challenges of the collaborative. Although collaboration allowed the utilities involved to aggregate funding for a larger pilot, startup time and associated costs do not benefit from economies of scale when multiple systems are involved. Although all three utilities had AMI systems, each had different storage and retrieval systems, and one had a different, older type of smart meter. Each utility had little experience exporting such granular data in batch from their systems. From the perspective of the pilot, this meant that three separate problems had to be solved in three physically separate locations in order to extract the data for analysis. From the perspective of startup costs, the combined entities involved spent significantly more time and money than would be the case for a single, large utility.

The PPUs involved had differing fluency and flexibility with their systems, a consequence of limited ability to allocate staff time to energy efficiency. For one utility, the EE manager came from a technical background and had a good relationship with other technical staff, and navigated the requirements for retrieving the data relatively quickly. For another, the EE manager had little technical experience and had to engage other utility staff they did not normally work with, lengthening timelines and the communication chain. In both cases, energy efficiency was not the manager's primary job, resulting in gaps of time between problems and problem-solving. At an IOU with even a small EE department, dedicated staff with differing skillsets have a much greater chance of quickly and effectively addressing such problems.
A final challenge was one of inclusion. For this particular pilot, an AMI system was required. As noted above, each variant of AMI data required more time on the part of the utility and implementer. The majority of member utilities either did not have AMI systems or were not confident that they could devote the resources to engage with the pilot. This would not be problematic if the utilities changed for each endeavor, but historically the member utility with the highest revenue has been the best candidate for every pilot and program offered.

Data Insights from Other Pilots and Program Implementation

The PPUs were highly resistant to releasing customer data in a number of other pilots and programs. This resistance is a result of data privacy policies within the utility that are not granted exceptions for EE program purposes. In one pilot, billing data from nonparticipating customers was required to create a control group. This data was not released to WECC, even stripped of identifiers, on grounds that the utility had a policy against releasing data to third parties. At a different utility, an opt-out behavior program with a third-party provider was halted on similar grounds. It should be noted that one of these utilities uses third-party services to perform power supply analysis on customer AMI data, and another uses a third-party service to process customer data for their website.

Information Technology and Public Power Utilities

Cooperative and municipal utilities can benefit from advances in information technology. With the possibility of Clean Power Plan regulation ramping up energy efficiency programs, the combination of declining cost to implement energy efficiency programs using connected systems and large untapped savings potential could encourage PPUs to contract with Software-as-a-Service (SaaS) providers. Attitudes towards these services and the accompanying transfer of customer data vary among utilities, but tend to generally be negative. It is expected that as savings requirements deepen, attitudes towards these low-cost services may improve and PPUs will come to view third party data analysis efforts for EE as similar to their other contracted third party services within the utility proper.

It is clear that funding aggregation is an effective means of delivering energy efficiency programs. If these utilities are to begin working with customer data in a meaningful way, solutions need to be sought that remove barriers for their contracted services. A unified standard within the collaborative for exported AMI data would be ideal on the utility side. On the customer-facing side, co-branded materials (collaborative and utility) have been effective for other energy efficiency programs, and should be utilized to avoid exorbitant material generation costs. Any branding or data compromise that lessens the burden of tailoring services to each utility aids the delivery of data-centric programs.

Analysis of Customer Data

Behavioral programs have been successful at IOUs. A number of data analysis and behavioral messaging already have a mature business model, and deliver validated cost-effective energy savings. Although startup costs to run such a program for multiple utilities would be a barrier, costs in general have declined over the last nine years, making them competitive with other EE programs for IOUs. Larger cooperative and municipal utilities can already shoulder those costs independently.

Customer targeting is a particularly cost-effective endeavor in an underserved energy efficiency market, and is further bolstered by its ability to reduce cost to deliver a program across a wide territory. Remote building analysis and segmentation efforts using AMI data are largely in the pilot phase, so the cost would likely be prohibitive for small utilities. As methods are proven out, this service can be delivered at a lower price. However, it is recommended that small utilities within a distribution collaborative work to a common consumption data formatting standard. This standard would have multiple benefits. It would allow in-house or third party grid optimization software to be shared between utilities with minimal adjustment, while providing more consistent data for EM&V and customer targeting.

Utilities, including PPUs, are preparing for a smarter grid by developing more robust internal capabilities for dealing with their customer data. This process can take years at a larger utility, because their data has become “siloed,” requiring consolidation before it is ready to be analyzed. The consolidation effort may bring departments together that had never even spoken previously. Smaller utilities have an advantage in this respect, because they tend not to have IT staff working in separate departments that do not communicate. The consolidation effort to prepare data for external analysis could be significantly shorter, and should be undertaken as soon as possible.

Devices

Energy-saving features of smart devices are an inexpensive pathway to efficiency. Because data generation is central to the operation of these devices, value can be created from the data without utilities having to weather the headaches of data management. Smart thermostats are paving the way for other device-based business models with both add-on demand response programs and energy efficiency programs that run by adjusting customer set points at certain times of year. These types of energy-saving features are remarkable because they are essentially software-only measures that can be applied massively across the installed base within a utility territory. While vendor home energy management systems can control smart plugs, smart lighting, and other appliances, no preferred hub and protocol for the connected home has yet emerged. As prices continue to come down for connected products, it is hoped that a paradigm emerges for controlling these systems. With that in place, inexpensive software options should appear that allow utilities to offer software-based energy-saving measures for the whole home. Because different devices may gather different types of information that can inform energy-saving algorithms, such a solution will likely become more effective the more connected devices are in the network.

Data from connected devices is significantly more desirable than AMI data for customer targeting across multiple small utilities, given the widely varying data management practices of different utilities. A given device has the same operating system in one territory as another, and records data the same way. However, data privacy concerns often prevent these data from being used for energy efficiency outcomes. Device manufacturers and SaaS providers should work individually or in tandem to harness the power of their recorded information to help their customers find energy efficiency programs if they need them. Targeting need not be a utility function—a business model could conceivably involve device manufacturers analyzing their own base of customers and advertising utility programs to those in need, with some level of compensation paid from utility to manufacturer for leads. The usefulness of device data for energy efficiency targeting efforts, especially if the Clean Power Plan reaches implementation, will warrant a conversation between manufacturers and utilities on how best to use it while protecting customer data. PPUs in particular will benefit from whatever solution arises, as device data circumvents the problems with using utility data from different systems.

Conclusion

Through working with AMI and device data, cooperative and municipal utilities can drive inexpensive energy savings on a large scale. Some services, such as behavioral messaging and smart thermostat remote setback programs, are mature and provide program-ready, validated savings. Utilities that are comfortable with third party SaaS providers can buy into these services today, although startup costs for AMI-based services may be prohibitive for collaboratives of small utilities. Residential customer targeting services are in their infancy, but could help drive down costs, especially for cooperatives with large territories. Similar services delivered with device data and with control delivered to devices besides thermostats should be expected in the future. By relying on data in standard formats that manufacturers collect as part of day-to-day business, these methods may be the least expensive of all. The software-based energy efficiency efforts of the future will be more inclusive and scalable, and should remove many of the analysis and data management burdens from public power utilities.

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