Making the Smart Home Work for You: Wrangling Energy and Demand Benefits Out of Connected Tech

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ABSTRACT

Smart home devices have the potential to reduce energy consumption, manage demand, support time-of-use rate structures, and share valuable energy data with customers. However, although smart thermostats have seen widespread success in utility programs, other options—such as smart lighting, smart plugs, smart water heating, smart electric vehicle charging, and full smart home systems comprising multiple devices—have seen limited adoption to date. To better establish what energy and non-energy opportunities different products may offer, we combine a meta-analysis of robust research on the potential energy and demand benefits of various smart devices with market and ethnographic research on adoption and customer perceptions of these products and lessons learned from utility pilots and programs. Outside of smart thermostats, smart window coverings and plugs currently appear to offer the most potential for utilities from an energy savings perspective, while smart electric vehicle (EV) charging and water heating offer the most potential for load shifting and demand management. However, more research is needed to establish savings from these devices, and each offers unique challenges that utilities will need to address before incorporating them more widely into programs.

Moving beyond individual devices, many vendors now offer customized smart home systems or home energy management offerings, but the rapid evolution of the market may make more open platforms especially appealing to utilities depending on the specific goals they hope to achieve. Three in particular—the ENERGY STAR Smart Home Energy Management Systems (SHEMS) specification, the If-This-Then-That (IFTTT) platform, and voice-responsive virtual assistants like Alexa and Google Assistant—promise a number of benefits for utilities and their partners if used effectively.

Introduction

Smart home technology—which is typically wirelessly connected and offers automation, information, or other helpful services—is gaining ground and maturing rapidly. For utilities and the energy service providers they work with, these devices and systems have potential to help meet a variety of different goals, from energy efficiency and demand response (DR) to revenue generation, customer engagement, and decarbonization. The number of utility initiatives focused on smart home technology have grown in recent years, and there are now more than 20 utility smart home pilots or programs (defined as including at least two or more connected devices) in the US and Canada, and 53 online utility marketplaces selling smart devices, along with a handful of smart home demonstration projects and bring-your-own-device (BYOD) DR programs (Snell, Rieves, and Dunphy 2020).

Ethnographic research performed for the E Source E Design 2020 initiative suggests that the three primary considerations drive smart home device ownership:

- Saving time
- Peace of mind

- Saving money

Secondary drivers include the “cool” factor associated with owning high-tech smart home devices, and energy savings (Wilshire, Pullman, and Crisman 2019). Interestingly given these drivers, smart speakers have seen the single largest market penetration to date, though a range of other smart devices also continue to be adopted as well, from thermostats and lighting to smoke detectors and door locks (**Figure 1**).

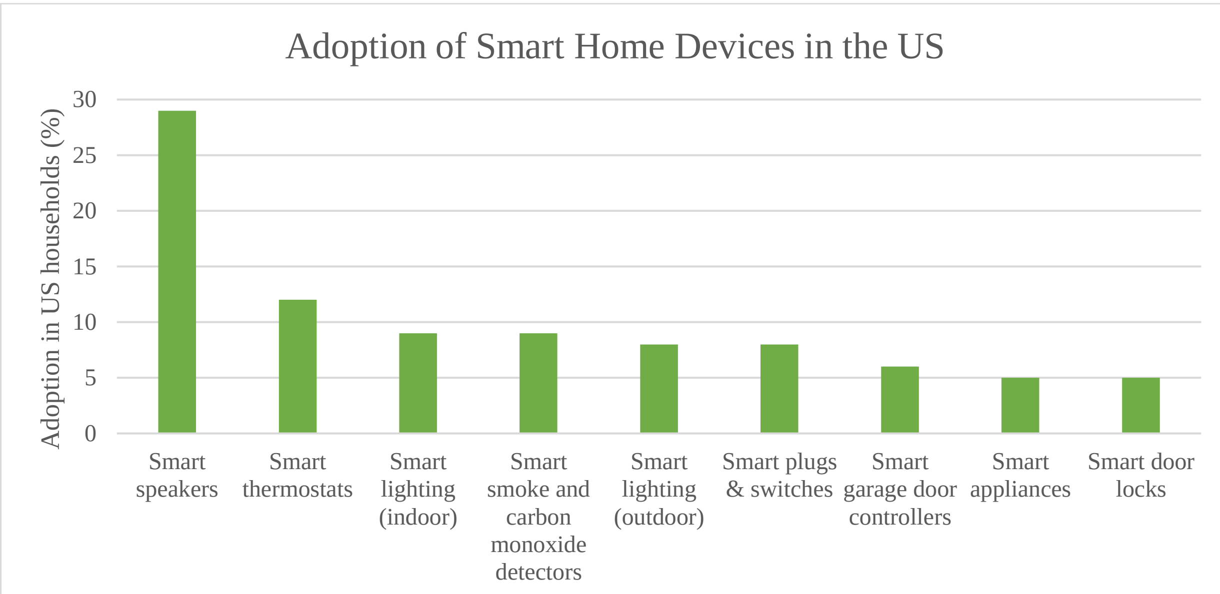

Figure 1. 2019 US adoption of smart devices. *Source:* 2019 Claritas Technology Behavior Track

Because adoption of smart devices is still less than 10% for most technology types, there’s plenty of room for utilities to promote products and systems that can help customers better manage their energy use. Below, we provide a look at the potential energy and demand benefits that different devices can offer, insights into ongoing utility initiatives, and an overview of some promising open platforms with potential to bring together multiple devices and facilitate more advanced home energy management.

An Energy Overview of Individual Smart Devices

Although there are now thousands of smart products available in the market, only a handful offer potential energy and demand benefits. We’ve provided a deeper look at some of the most promising smart end uses below—thermostats, lighting, plugs, appliances, water heating, EV charging, and window coverings—sorted roughly by level of current market adoption.

Smart Thermostats

Smart thermostats offer widespread appeal to both users and utilities, and have seen rapid adoption since their introduction in 2011. At present, 12% of US households claim to have one and another 23% are considering purchasing one, according to the 2019 Claritas Technology Behavior Track. Thermostats are easily the most successful smart technology to be incorporated into utility demand-side management (DSM) programs, and data from [E Source DSMdat](#)

suggests that there are currently 168 DSM programs with smart thermostats across the US and Canada. More recently, they've also seen widespread success in online utility marketplaces, with 49 marketplaces currently selling smart thermostats (Snell, Rieves, and Dunphy 2020). And since smart thermostats have the ability to prioritize occupant comfort, they offer an unprecedented opportunity for utilities to scale DR programs beyond the segment of customers that are willing to accept some discomfort during events.

Utility research and evaluations have demonstrated HVAC energy savings ranging from -5% to 22% (Valentine et al. 2018), though most research suggests that HVAC savings in the neighborhood of 10% are typical. As research has become more robust, savings estimates are increasingly making their way into utility technical reference manuals (TRMs), and data from E Source Measure Insights suggest that North American TRMs currently claim deemed HVAC savings ranging from 6-20% for residential smart thermostats.

With regards to DR, smart thermostats deliver cooling load reductions similar to legacy direct load control switches—typically ranging from 0.5-1.5 kW per device, on average (Valentine 2019). Unlike traditional strategies, though, smart thermostats offer algorithms that can enable a variety of load management strategies, maintain occupant comfort, and even respond dynamically to time-varying rates.

As smart thermostat market penetration increases, utilities can enroll existing devices to deliver cost-effective DR programs to the broader market. In the increasingly popular "bring-your-own-thermostat" (BYOT) program model, utilities recruit customers with existing eligible smart thermostats, eliminating costs associated with direct installation. This program model is inherently low-risk; since utilities don't own the devices, they avoid the potential for stranded assets. Furthermore, since BYOT programs support multiple vendors, the programs avoid the risk associated with investing in products from a single manufacturer.

Vendor diversification, however, is also a key challenge for smart thermostat programs, particularly with regards to evaluation, measurement and verification (EM&V). Smart thermostat energy savings and load reductions can depend on proprietary algorithms, which vary based on vendor. Utilities don't have insights into these algorithms, and they can't predict how products may change as vendors tweak the software through remote updates. Current EM&V processes are inadequate for capturing the intricacies of these algorithmic approaches and their changes over time. To compound the problem, vendors share varying amounts of data in different formats, and disparate data can be challenging to manage, manipulate, and compare.

Despite its challenges, the ephemeral nature of software-based strategies is also a strength. For instance, vendors can improve their products, drive higher load reductions, and roll-out more customer-centric features—all through an over-the-air software update. As utilities, program implementers, and manufacturers continue to collaborate, BYOT and marketplace-based programs increasingly show potential for scale.

Smart Lighting

As costs have come down, smart lights have grown in popularity. These products most often take the form of screw-in A-lamp LEDs and enable users to turn them on/off and dim them remotely through a mobile app, set on-off schedules, and, in some cases, control them based on occupancy. A number of products also allow users to change the color of the light, offering a host of non-energy benefits, from changing a room's ambiance to setting up visual alerts for mobile notifications.

Smart lights are now in around 9% of homes in the US, and an additional 22% of people are considering purchasing them, according to the 2019 Claritas Technology Behavior Track. Of those who aren't intending to purchase smart lights, the top three reasons cited are that current lighting products meet their needs, that smart lights are too expensive, and that they simply don't see or understand the benefits that smart lights may be able to provide. To drive increased adoption of smart lighting going forward, the latter two concerns could potentially be addressed through utilities or retailers providing more information about costs and benefits.

Despite their growing adoption, potential energy savings associated with smart lights are still unclear. A 2016 study in Vermont found that smart LED bulb products reduced lighting energy consumption by 27% in a sample of 15 homes when compared with traditional LED bulbs due largely to users' ability to dim lights that previously remained either fully-on or off (Bonn et al. 2016). However, a subsequent field study of 15 homes in New York found that, in comparison with traditional LED bulbs, savings from smart bulbs varied widely depending on the user behavior, particularly with regards to whether they used dimming functionality and/or the remote and schedule features (Earle et al. 2019). The researchers also noted that "[smart light bulbs] are generally easy to install so they are a good candidate for DIY measures. Making sure that existing rebates for LEDs can be used for smart bulbs and offering higher rebates for the more expensive smart bulbs will likely increase uptake." As more research on smart lighting becomes available, we expect that typical savings will become better established alongside best practices to help ensure predictable and persistent savings.

On the demand side, the load management opportunities for residential lighting are minimal. Compared to water heating and space conditioning, lighting comprises a relatively low percentage of load in the home, particularly in residences with LED lighting (a typical A-lamp LED only draws around 9 watts). Moreover, most residential lighting use occurs in the evening, which often doesn't coincide with electric system peaks in the late afternoon.

Unsurprisingly given the available data on potential energy and demand benefits, smart lighting has yet to be widely adopted into utility DSM programs in the US and Canada (though some smart bulbs may qualify for existing LED rebates). Only a few utilities offer DR opportunities around residential lighting. In the Southern California Edison service territory, for example, customers can participate in third-party DR programs that include connected lighting amongst other devices, such as smart thermostats, water heaters, and EVs. This example illustrates the primary opportunity for connected lighting in load management programs—as utilities increasingly develop BYOD programs, connected lighting could provide incremental load reductions alongside more impactful devices.

Smart Plugs

Smart plugs offer an easy way to control and monitor a variety of plug loads. Unlike advanced power strips (sometimes referred to as "smart strips"), which offer generally provide 6 to 12 outlets and work by autonomously turning devices on or off based on the power draw of a single control device (such as a computer or TV), occupancy, or a preset schedule, smart plugs are Internet-enabled and typically just offer one or two controllable outlets. These devices allow users to set schedules for their plug loads, turn them on or off remotely via a mobile app or voice assistant like Alexa, and some allow users to monitor each plug load's power draw.

According to the 2019 Claritas Technology Behavior Track survey, smart plugs are now in 8% of US homes, and an additional 19% of customers are considering purchasing them. However, these devices are often marketed for the non-energy benefits they may provide, such as simplified control of plug loads like plug-in lamps, fans, window air conditioners, and other appliances (particularly when users can use a voice assistant such as Alexa or Google Assistant to control them). They also feature the ability to turn things off when users are on vacation for peace of mind, or to set up on/off schedules to simulate occupancy when users are away to increase security. With that in mind, it would likely be beneficial for utilities and their partners to highlight the potential energy benefits smart plugs can provide, and provide educational material to customers to help them use them effectively.

Because energy savings depend on the kind of plug loads connected to the smart plug, current usage behavior, and how well users set up an efficient schedule (or occupancy-based control strategy), estimates can vary widely. Previous studies have suggested savings ranging from 8-21% of connected loads are typical (Snell 2016), and some utilities have included savings estimates of 21.6-79.0 kWh annually into their TRMs, according to data from E Source Measure Insights. However, a recent field study in New York found inconclusive results; while some individual plug loads saw reductions in energy consumption as high as 50%, others saw no meaningful change, suggesting that users didn't set up an effective schedule or control the device in a more efficient way through a mobile app or voice assistant (Earle et al. 2019).

Smart plugs can also enable control of connected devices for DR. In particular, over the past decade, utilities have used smart plugs to cycle or administer temperature setbacks on window air conditioners. In 2011, for example, Consolidated Edison launched the CoolNYC program to target these devices for load management. Early results found average load reductions of about 0.4 kW, demonstrating the technical potential of these devices. In the mid-2010s, more utilities, such as CPS Energy and Consumers Energy, began piloting similar offerings.

Results suggest that these approaches achieved load reductions of about 0.2 kW per unit, on average. But their success has been limited by programmatic challenges with scaling and participant retention. Consolidated Edison reported that their program wasn't cost-effective in 2018 or 2019, due to declining growth in program enrollment and decreases in load reduction from the utility's changes to the device settings. The CPS Energy program was discontinued after 2016, due to high attrition—only about one-third of the devices enrolled during the first year came online in the following year.

Utilities continue to pursue window air conditioner programs, but largely as a component of non-wires alternatives initiatives, such as at PSEG Long Island and National Grid. These targeted programs may see more success than mass market programs, since they don't necessitate scale. Beyond window air conditioners, some utilities are testing ductless heat pump controls, such as Con Edison and Green Mountain Power, though these pilots are too new for results. Outside of DR initiatives, utility efficiency programs generally focus on advanced power strips instead of smart plugs, though a variety of utilities do offer smart plugs through online marketplaces and smart home kits.

Smart Appliances

Adoption of smart appliances (such as refrigerators, laundry equipment, dishwashers, stoves, microwaves etc.) is beginning to grow as more manufacturers add Wi-Fi connectivity to their product lines. Although 5% of households in the US have purchased a smart appliance, another 20% are considering purchasing a smart appliance in the future, according to the 2019 Claritas Technology Behavior Track.

Most smart appliances are now marketed on the basis of convenience, and are not designed to be inherently more energy-efficient than "dumb" appliances (though many are ENERGY STAR-qualified). Likely given the lack of customer awareness and interest in demand management, most manufacturers have yet to focus on incorporating DR functionality into their products, though there is plenty of potential to add such features to smart appliances (Snell 2016). However, many smart appliances can provide some level of insight into their usage, leaving opportunities for utilities and 3rd party home energy management vendors to incorporate that data into mobile apps or online portals designed to help customers better understand and manage their energy consumption.

Unsurprisingly, given the current lack of energy benefits, we have not identified any utilities featuring smart appliances in their DSM programs. However, ten utilities do include one or more smart appliances in their online marketplaces alongside a host of other smart products.

Smart Water Heating

Although market adoption is currently low, smart water heaters (and smart controls for existing "dumb" water heaters) offer a host of potential grid benefits, and potentially some energy savings to boot. Because water heating is typically the second-largest energy load in homes behind HVAC, and because it tends to be less visible to end users (most customers don't think about their water heater unless they run out of hot water), smart water heating offers enormous potential for residential energy management.

When comparing connected vs. non-connected water heaters, incremental energy savings could theoretically be derived from several smart features:

- Reducing the number of unnecessary reheats
- Reducing unnecessary overheating
- Increasing the convenience and use of vacation mode

The energy savings from these capabilities, however, aren't well-studied. For example, recent studies of the Aquanta retrofit water heater controller produce conflicting energy savings results—one study from the Gas Technology Institute found savings ranging from 2.3% to 9.3%, depending on analysis method (Gunn et al. 2018). Another study from Pacific Gas & Electric found no substantial energy savings (Nazemi 2017). Older studies on water heaters with built-in controls are similarly conflicting; some approaches showed slightly decreased energy usage while others increased overall energy usage, depending on the load management strategy. In studies that found energy savings, these savings were primarily the result of inadequate water heating, rather than the kinds of smart features described above.

Though potential energy savings remain unclear, smart water heating shows immense potential for flexible load management. While utilities can use water heaters for traditional DR events, they can also use this technology for load shifting or even ancillary services (such as demand accreditation, energy arbitrage, spin and supplemental services, and frequency regulation). Moreover, utilities could capitalize on these multiple value streams while minimally affecting customer experience—since water heaters effectively retain heat, participants are unlikely to notice changes to water heating time.

The exact load impacts from smart water heating can vary significantly based on demand management strategy, water heater type, season, and more. (For example, electric resistance water heaters generate higher load impacts than heat pump water heaters, simply because the former are less efficient and thus draw more power.) Studies have found load impacts below 0.1 kW and above 0.5 kW, depending on these factors. While these demand reductions are smaller than those available from space conditioning, significant opportunity exists at scale. As mentioned above, the unobtrusive customer experience could increase the pool of willing participants. Furthermore, as utilities increasingly pursue electrification, water heater control can allow electric utilities to manage and shape oncoming load.

As utilities attempt to assess the value of the various DR and grid services smart water heaters may provide, they also struggle to find cost-effective approaches to implementation. Direct installation of retrofit controls is expensive, particularly relative to the load impact of individual devices. The BYOD approach is challenging because consumers don't consider utility-specific load management functionality when purchasing a new water heater, and they don't think about their water heater when it's working properly.

One promising delivery approach, however, is through market transformation. Utilities in regions with a high market penetration of electric water heaters—particularly the Northwest—are pursuing upstream approaches to increase the number of DR-enabled devices, through the open standard CTA-2045. Like the standard for a USB port, CTA-2045 specifies a port that accommodates a DR-enabled module. In this program model, manufacturers would design water heaters with this port, and utilities would then mail plug-in modules to customers. When customers insert the module, their water heater would become DR-ready. This program approach avoids complicated installations, and the open standard aspect helps utilities avoid vendor-centric design.

Bonneville Power Administration, in partnership with eight utilities in the Pacific Northwest region, completed the largest CTA-2045 study in 2018, assessing the load impacts and business case based on a 277-participant pilot (BPA 2018). In addition to a range of promising results, this study had far-reaching policy impacts—in early 2019, Washington State passed House Bill 1444, which requires that all electric storage water heaters sold in the state have a CTA-2045 compliant port, beginning in 2021. Similarly, California is exploring standards for demand-flexible devices, though not exclusively water heaters. In late 2019, the state passed Senate Bill 49, which will require the California Energy Commission to adopt "standards for appliances to facilitate the deployment of flexible demand technologies."

Smart EV Charging

Smart charging of EVs—including both managed (V1G) and vehicle-to-grid (V2G) charging—is still nascent. Although utilities and research organizations are increasingly rolling out smart charging projects, these projects face non-trivial hurdles as a distributed, flexible grid resource. Many of these hurdles stem from the fact that utilities need to compete with owners for control over the EVs they wish to use as flexible grid resources, so they have limited control and confidence in how they can use those assets.

While the optimal load management approach for EVs remains unclear, the expected load growth is an opportunity for utilities to proactively address oncoming demand, instead of reactively designing mitigation strategies. Ideally, utilities shouldn't administer traditional DR approaches to EVs—rather, they should design rates and offerings that "valley fill," resulting in little coincidence between EV load and peak times. For such initiatives, there are large potential demand benefits: a pilot from Avista Corporation found that residential EV charging could be curtailed by 75% (a peak demand reduction of 4.8 kW per charger) for 4 hours in the evening with no impact on customer satisfaction (Farley, Vervair, and Czerniak 2019).

In an effort to balance EV charging with grid needs, utilities commonly use time-of-use rates to encourage customers to schedule charging in off-peak periods, or signal smart charging infrastructure to delay the charge until an "optimal" time period. And while EV time-of-use rates can effectively prevent charging coincident with system peaks, they're not without their problems—including increased metering costs and technical complications relating to meter communication and billing integration. These complications have led utilities like Sacramento Municipal Utility District (SMUD) to instead offer whole-home TOU rates due to their lower expense and easier implementation. As an alternative to time-based rates, some utilities pursue programmatic approaches, like the Con Edison SmartCharge New York program. This initiative gives customers “points” for avoiding summer peak hours, charging off-peak, referring a friend, and more, and participants can redeem these points for financial rewards.

As utilities increasingly shift toward intermittent renewables, however, simple time-of-use rates and programs may become insufficient to encourage charging behavior that aligns with off-peak times. One emerging idea to address this challenge is renewable-optimized managed charging (Rieves 2020). It’s unclear how this approach would affect charging and energy use in the smart home, but we expect elegant load management strategies like this to evolve in the coming years.

Smart Window Coverings

Smart window coverings like automated blinds offer the potential to manage energy consumption by regulating the amount of sunlight entering a home and, in some cases, improving the insulation levels of existing blinds. By helping homes regulate both heat gain and ambient light levels, smart window coverings may be able to yield both energy and demand reductions while also improving indoor comfort.

As noted in research from Pacific Northwest National Laboratory (PNNL), window shade automation is currently available in the market, but it tends to be paired with more expensive systems, is frequently marketed as a convenience and security feature, and often does not include energy-optimized control algorithms (Cort et al. 2018). For this reason, current adoption of smart window coverings for energy savings is essentially negligible. That may be poised to change, however, given the creation in 2018 of the Attachments Energy Rating Council (AERC), an independent, public interest, non-profit organization whose mission is to rate, label, and certify the performance of window attachments.

AERC is currently working with a variety of utilities, manufacturers, national laboratories, and other organizations to better understand and quantify the potential energy and demand impacts of window coverings, including products with smart controls. However, previous modeling from Lawrence Berkeley National Laboratory suggests that shades with automated controls could potentially reduce overall home energy consumption by around 12-13% (Yazdanian et al. 2015). More recent research from PNNL suggests that even simple control strategies can yield energy savings, but that those savings can vary widely (Cort et al. 2018).

When considered for DR, the picture is less clear. PNNL research found that, when smart blinds were paired with thermostats and deployed for DR events, homes saw increased energy savings and improved comfort compared with thermostat-only approaches (Cort et al. 2018). Although those results are promising, such a pairing could also potentially decrease overall predictability of dispatchable load, given uncontrollable factors like cloud cover and user behavior. Additionally, because window coverings don’t directly control the energy usage of any specific end use, utilities would likely face challenges quantifying and claiming the indirect load impacts. Nonetheless, the potential comfort benefits alone may make such pairings attractive options to consider as part of increasingly complex multi-device DR programs in the future.

At present, there don't appear to be any active utility DSM programs focused on smart window coverings. Because these products are still emerging and relatively expensive, they may be excellent candidates for additional research and utility pilots going forward, though energy savings are likely to vary widely based on such factors as building size, shape, orientation, number of windows, local climate, and control strategies. With regards to DR programs, smart window coverings aren't ideal dispatchable resources in and of themselves (since they don't directly control an energy end use), but they may offer benefits if paired with automated integrated controls to supplement existing smart thermostat temperature setbacks and help improve occupant comfort during events. It's also possible that they could offer persistent energy savings during peak periods, though these savings could cannibalize the load available for DR through other approaches. With this in mind, utilities should carefully consider the interplay between energy efficiency and DR when simultaneously deploying multiple smart home technologies.

Emerging Open Platforms for Home Energy Management

A growing number of vendors are creating energy-focused smart home systems and services, from home energy management platforms that provide energy data and analysis with limited smart device control to smart home-as-a-service offerings that focus on energy as just one component of a broader system. There are also a handful of open platforms that are free or low-cost and are largely vendor agnostic, and which may offer a range of opportunities for utilities and their partners.

ENERGY STAR SHEMS Specification

In September 2019, ENERGY STAR released a specification for Smart Home Energy Management Systems. An ENERGY STAR-qualified SHEMS consists of a system with multiple connected devices that's intended to save energy by automatically adjusting device settings based on occupancy. It focuses on HVAC, lighting, and plug loads, though other end uses (such as EVs or automated window shades) could be incorporated into later versions of the specification as they mature. The specification also includes mandatory DR support for at least one connected device in the system and requires devices to be able to respond to time-of-use electricity rates when applicable. Additionally, the specification supports reporting energy data to end users, which could create new opportunities for utilities to engage with customers.

Potential energy savings from a SHEMS is currently unclear, but ENERGY STAR intends to use anonymized field data from qualified systems to better understand typical savings and create a robust energy savings metric for its version 2.0 specification (which will likely be released in 2021). In the meantime, ENERGY STAR's strong industry presence may help drive manufacturers to create more energy-focused and integrated smart home offerings, and qualified SHEMS products could be well worth consideration for utility pilots given their potential to save energy, manage demand, support time-varying rate structures, and engage and educate customers.

If-This-Then-That

IFTTT is a free service for users that is designed to help connect a wide range of apps and devices and facilitate DIY automation. It can allow users to create their own automation algorithms (called applets) to save energy and determine how their smart devices respond to dynamic pricing or DR events. Relatively few utilities have explored IFTTTs potential to date, but ComEd in Chicago is running two separate pilots—Peak Time Savings and Hourly Pricing—with the goals of providing real-time electricity price data and DR signals; sharing applets that customers can use to respond to those signals; and allowing customers to create their own applets dictating how their connected devices should (or shouldn't) react. This approach opens up opportunities to leverage existing connected products to yield demand reductions during DR events—or facilitating bill savings under time-varying rate structures—all while giving customers control over every aspect of their devices' responses. ComEd sees this as an advanced example of a behavioral demand management program, and results have been very positive, with thousands of participating customers and evaluations that have shown cost-effective demand reductions.

Although IFTTT provides a flexible open platform, there are some potential challenges for use in utility DSM programs. One such barrier is the lack of two-way communication, since the utility doesn't connect directly with the customer's device, and that device may not be set up to collect or share energy or runtime data. As a result, utilities will have to use other data streams (like smart meter data) to understand the impacts that their control signals are actually having in practice. Another issue surrounds potential changes in smart device interoperability. For instance, when Google decided to end the "Works with Nest" program in favor of a new approach, it created still-unresolved concerns about whether Nest thermostats would continue to work with platforms like IFTTT.

Voice-Responsive Virtual Assistants

Since Amazon's introduction of the first Alexa-enabled smart speaker in 2014, smart speakers have exploded in the market. As of 2019, 29% of homes in the US now have at least one smart speaker, according to the Claritas Technology Behavior Track survey, making them among the most quickly-adopted consumer electronic devices ever and dwarfing the adoption rates of other common smart home devices like smart thermostats. And because virtual assistants like Amazon's Alexa and the Google Assistant provide a simple conversational user interface with which to control smart home devices that negates the need to scroll through multiple apps and menus, it's unsurprising that they've helped to drive interoperability across different smart home ecosystems and product lines. In particular, partnership between Amazon, Apple, Google, and the Zigbee Alliance around the Connected Home over IP project (announced in 2019) is intended to build a common framework for smart home devices to communicate and share data that could greatly improve interoperability going forward.

As of March 2020, just under 30 utilities had created a voice app (called a skill for Alexa or an action for Google Assistant)—up from four at the beginning of 2018. These voice apps still largely focus on providing relatively basic functionality, such as sharing the current account balance, generic efficiency tips, or miscellaneous information on billing or rate structures. However, there's plenty of room to expand beyond these kinds of features to offer more sophisticated functionality, such as connecting customers with utility programs, helping them understand new time-variant rates, expanding educational campaigns, improving the customer experience, promoting trade allies, and helping customers control smart devices to better manage their energy use, among others (Snell 2018). SCE is among the first utilities to conduct DR pilots using smart speakers as a primary interface point, and we expect to see other utilities conducting additional efficiency or load management pilots incorporating virtual assistants in the future.

Despite ongoing user concerns about data privacy with regards to virtual assistants, their rapid adoption and strong customer engagement suggest that they will become an increasingly important channel for utilities to use to engage customers, share information, and offer new services and functionality. In the near-term, however, the current lack of in-built support for automation across devices connected to smart speakers will make them challenging for utilities to incorporate into their efficiency and DR portfolios, though other applications may nonetheless make it worthwhile to invest in skill or action development.

Conclusion

With the possible exception of smart thermostats, there is a clear need for further research into the potential energy benefits that different smart devices and systems can provide, and each type of smart device has unique opportunities and challenges when considered for utility programs. Unfortunately, because many smart devices rely on some combination of site-specific automation and behavior change elements in order to drive energy and demand savings, current EM&V frameworks aren't very well-suited to evaluating these technologies, and utility savings assumptions often don't account for software-based measures whose energy benefits can change dramatically through over-the-air updates on short notice. Nonetheless, from an energy-saving perspective, our research suggests that the most promising devices currently include smart window coverings, thermostats, and plugs. From a load management perspective, smart EV charging, thermostats, and water heating appear to offer the largest opportunities for demand reductions and load shifting. And some smart devices—such as smart lighting and smart appliances—currently offer relatively little in the way of energy or demand benefits, but they are appealing to customers based on the non-energy benefits they provide and may help utilities make smart home kits or more comprehensive offerings more appealing.

Moving beyond individual devices, smart home systems meeting the ENERGY STAR SHEMS specification are likely to be well-suited to utility programs given their potential to yield energy, demand, rate, and educational benefits, but potential energy and demand reductions are currently unclear. IFTTT offers a flexible platform that may be especially effective in engaging and supporting more tech-savvy customers, though it may complicate EM&V efforts and could run into ongoing interoperability challenges with individual devices. Finally, voice assistants like Alexa and Google Assistant are seeing tremendous market adoption and could offer myriad potential benefits for utilities as a new communication and engagement channel, but more work is needed before automated smart device coordination for energy management purposes may be a viable opportunity.

Given the rapid market evolution in the smart home space and the myriad potential benefits for utilities, we expect smart devices and smart home systems will become increasingly important components of residential utility efficiency, load management, customer engagement, and decarbonization initiatives going forward. However, a number of technical and programmatic challenges remain, and utilities and their partners will need to adopt new approaches to better understand real-world performance, assess actual energy benefits, and fit each technology or system to the needs of their customers.

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