Home Performance Coalition

Redefining Home Performance in the 21st Century

How the Smart Home Could Revolutionize the Industry and Transform the Home-to-Grid Connection

By: *Kara Saul Rinaldi and Elizabeth Bunnen*

October 2018

Redefining Home Performance in the 21st Century

How the Smart Home Could Revolutionize the Industry and Transform the Home-to-Grid Connection

Kara Saul Rinaldi and Elizabeth Bunnen

October 2018

Acknowledgements

The authors thank the many individuals in the energy efficiency, smart technology, and home performance industries who contributed their insights, expertise, guidance, and engagement as we developed this report. Contributions came from those who produced the research, technology, and presentations we culled through as well as those with whom we debated and discussed issues at policy conferences and side meetings. However, we are particularly thankful to those who provided in-depth interviews and/or offered valuable feedback on the numerous drafts of this report, including the following:

Keith Aldridge, Home Performance Coalition; Jennifer Amann, American Council for an Energy-Efficient Economy; Michael Blasnik and Richard Counihan, Google; Brian Bovio, Bovio Heat-ing Plumbing Cooling & Insulation; Elena Chrimat, Ideal Energy; Leticia Colon de Mejias, Energy Efficiencies Solutions Inc. and Green Eco Warriors; Abigail Daken, U.S. Environmental Protection Agency; Joan Glickman and Marina Sofos, U.S. Department of Energy; Matt Golden, Open EE; Aaron Goldfeder, EnergySavvy; Ethan Goldman, VEIC; Matthew Johnson, EnergyHub; Kara Jonas, Midwest Energy Efficiency Alliance; Emily Kemper, CLEAResult; Julie Michals, E4TheFuture; Claire Miziolek, Northeast Energy Efficiency Partnerships; Scott Needham, Princeton Air Conditioning, Inc.; Nkechi Ogbue, Ecobee; Kumi Premathilake, Ryan Esch, and Mak Tarnoff, Aclara; Suzanne Shelton, Shelton Group; and Dan Thomsen, Building Doc-tors.

Deep appreciation to Sabine Rogers, Research Associate at the AnnDyl Policy Group, for her invaluable research, writing/editing skills, and detailed interview notes. Finally, we gratefully acknowledge the U.S. Department of Energy (DOE) for its financial support of this project. While any report that aims to capture a moment in time of an evolving industry will soon be out of date, we hope this report will help to challenge and inform some of that change and support a robust home performance industry of the future. Any errors, omissions, views, opinions or premature conclusions made here are ours alone.

Kara Saul Rinaldi and Elizabeth Bunnen
AnnDyl Policy Group for the Home Performance Coalition

Contents

Introduction

Smart technology has been an evolving vision for centuries. Since simple clock and watch gears took the place of sundials, humans have learned that technology can make our lives easier. But can technology learn, evolve, and react to the specific needs of specific people? Science fiction has long tantalized us with both malevolent and benevolent robots, with "artificial intelligence" placed in devices that allow them to problem solve and learn. In homes, machine automation of-fers a vision for making lives easier, requiring little owner direction to optimize systems. But homeowners are not the only ones utilizing the brains of the devices. As homes become "smart," residential demand response programs have emerged to use smart thermostats and water-heaters to shift energy loads at the utility's convenience and the bill payer's profit. But there is a tendency to forget the "dumb technology," such as insulation and duct work, double paned windows and weatherstripping, that is more passive but most effective at reducing energy consumption. These traditional technologies must also be optimized to ensure that health and comfort are part of a smart, efficient home package.

Untapped potential exists to use smart home technologies to target leaky, inefficient homes that cannot hold a constant temperature when a demand response event is called as part of a utility program. Furthermore, ensuring home performance contractors who meet with a homeowner to upgrade their insulation or HVAC unit feel confident about "smart home" technology is critical so that efficient home retrofits include intelligent efficiency elements in the installation. Security and entertainment companies expanding into the smart technology space need also to recognize smart home design energy elements, so homeowners see their

home as an energy system, linked through intelligent communication.

There continue to be challenges for the "smart home" as the interoperability of appliances, systems, and gadgets seamlessly communicating with each in an easily installed manner remains elusive and often complex. Further, the residential "buildings to grid" conundrum faces policy challenges as homes that produce energy from solar power and save energy through efficiency change predict-ed demand curves and should integrate more fully in grid infrastructure design.

This report aims to identify and address many of the evolving obstacles to synergy between home performance and smart home technologies with the ability to make "intelligent" homes more energy-efficient, comfortable, and grid-responsive.

The Boom of Smart Devices and Home Energy Management

The number of internet-connected smart devices and technologies available for residential use has exploded. These smart technologies are offering homeowners new ways to interact with their homes and new opportunities for homes to have a two-way connection to the grid.

The Basics

What are "smart home" technologies? In general, smart home technologies enable users to remotely monitor and control residential devices and appliances. They are "smart" because they are equipped with sensors to detect and respond to conditions and are typically able to make automatic adjustments to save energy. Thanks to wireless communications protocols and the proliferation of Wi-Fi and cloud-based interfaces, these technologies have been able to explore advanced communications between devices, with the homeowner, and with the utility. They provide data on energy use in the home and can help homeowners and utilities control energy demand remotely. In addition, some have a "learning" functionality that allows them to absorb data and respond based on past requests and behaviors. Some of the most common smart home technologies currently on the market include the following:

Smart Meters. Like their predecessors, smart meters track whole home energy usage for the utility, but they also provide "smart" functionality by automatically transmitting hourly (or more frequent) meter readings to the utility without an individual collecting the information directly from the meter. While not consumer-facing, the smart meter's energy savings innovation is its potential to provide a two-way connection between homes and the utility. Smart meters allow utilities to send price signals and alerts, and enable homeowners to monitor energy usage and costs. In contrast with the other smart home technologies listed below, utilities control smart meter installation and management. As of 2016, according to the U.S. Energy Information Administration (EIA), nearly half of all residential electricity consumers nationwide had smart meters, although state adoption rates vary widely from nearly complete penetration to almost no smart meters.[1]

Smart Thermostats. Like their predecessors, smart thermostats control the heating and cooling of a home, but are "smart" because they are Wi-Fi enabled or imbued with wireless communications protocols, making it possible to control them from anywhere and ultimately giving users greater control over temperature in the home. In addition, smart thermostats may receive input from wireless sensors (monitoring temperature, humidity, lighting, and occupancy in different rooms)

1 U.S. Energy Information Administration, "Nearly half of all U.S. electricity customers have smart meters," 6 December 2017. Retrieved June 1, 2018, from https://www.eia.gov/todayinenergy/detail.php?id=34012.

and make automatic adjustments to optimize home heating, ventilation, and cooling (HVAC). Smart thermostats also help to achieve energy savings through programmable and learned schedules, and low-energy "away" modes. Utilities may also use them to support grid reliability, changing set temperatures to address peak demand as part of demand response programs.

Smart Water Heaters. Smart water heater controls, which can be retrofitted to conventional devices, and water heaters with built-in smart functionality improve energy efficiency by automatically adjusting the temperature setting to align with hot water use schedules. Homeowners can change settings through a user interface, and utilities can make adjustments remotely for demand-side management (i.e., heating water during off-peak times). Smart water heater controls are typically for electric water heating, but can be used with newer gas water heaters.

Smart Appliances. Smart refrigerators, washers and dryers, and room air conditioners are a few examples of smart appliances that offer increased convenience and safety through remote monitoring and control and alert transmission when the appliance is left on or a problem is detected. These appliances can help with load shifting (e.g., scheduling to run at off-peak hours) and use detection features to run more efficiently (e.g., a clothes dryer automatically turning off when it senses clothes are dry).

Smart Lights. Smart lights can be wirelessly controlled, allowing users to turn them on or off and control dimming from another room or from outside the home, and can be programmed to follow personalized routines. These lights may also have sensors that detect occupancy or daylight and make automatic lighting adjustments and can be integrated into home control packages.

Smart Plugs. These plugs go into AC power wall sockets and enable smart control of any device plugged into them. Smart plugs can be turned on and off remotely through an app on your smartphone, and many are also capable of automating control using "time scheduling, motion sensing, or load detection to cut off power to devices that are not in use."[2] They can connect to the grid to respond to changes in the price of electricity. Smart plugs often include energy monitoring, providing real-time information about how much electricity devices are consuming.[3]

Smart Hubs. Smart hubs wirelessly connect to multiple smart home devices and allow homeowners to manage them all in one place, delivering commands through an app or voice assistant. Hubs serve as a communication gateway, translating between different communication protocols (most commonly Z-wave, Zigbee, and Wi-Fi) so devices can talk to one another. Hubs can also take the form of a computer platform that can analyze and make sense of different energy signals within a home. Just in the last few years, smart speakers like the Amazon Echo and Google Home have come to dominate the smart home market, offering centralized control through a voice interface. Most smart speakers, however, are only able to connect to devices through Wi-Fi or Bluetooth, meaning they still need to be paired with an additional hub (one that is equipped with the proper radio antennae, such as Samsung SmartThings or Wink Hub) in order to operate with Zigbee or Z-wave electronics. Many devices do not need hubs and directly connect to the internet utilizing virtual gateways in the cloud.

Smart Gadgets. Smart gadgets are not specifically designed for energy management but may be a gateway for homeowners to embrace smart home technology. Connected devices, such as smart speakers, locks, doorbells, cameras, and smoke and carbon monoxide detectors, provide additional convenience and security that engage the homeowner with the home's performance, and often open the door to further business opportunities in a given home.

2 Jen King, "Energy Impacts of Smart Home Technologies," April 2018, *American Council for an Energy-Efficient Economy*, iv.

3 Rebecca Ford et al., "Assessing Players, Products, and Perceptions of Home Energy Management," November 2016, *Pacific Gas and Electric Company*, 36.

The smart home technology market is characterized by rapid innovation and change. While efforts have been made to catalog and categorize the vast range of devices on the market—most notably in PG&E's 2016 Home Energy Management Report[4] and a 2015 report by NEEP[5] — a lack of consensus remains regarding classifications and terminology. As technology continuously evolves, new products offer multiple functionalities and blur the lines between distinct technology categories, leaving other technologies and definitions outdated or obsolete. This is the case with the evolution of home energy management technologies.

Home Energy Management Systems (HEMS)

The term Home Energy Management Systems (HEMS) is used to describe a wide array of energy consumption management technologies and solutions in the home. HEMS encompasses many smart devices, but not all smart devices are HEMS. NEEP defines HEMS as "any hardware and/or software system that can monitor and provide feedback about a home's energy usage" and/or "enable advanced control of energy-using systems and devices in the home."[6] HEMS are typically real-time energy dashboards that enable consumers to monitor and control their energy use and any renewable energy systems that may be attached to the home. These platforms connect an array of smart home devices under one system, typically letting devices talk to one another, and allowing homeowners to coordinate and automate multiple devices' schedules. HEMS may also facilitate a two-way integration of electric vehicles and provide tailored recommendations on how to reduce energy use and leverage renewable energy. Most importantly from an energy efficiency perspective, HEMS provide information that empowers the household, utility, or third parties to make decisions that optimize energy use.

Home energy management technologies and solutions have evolved rapidly, with dramatic changes and new opportunities developing over just the past five years. At the turn of the last decade, in-home displays such as the TED 5000, which worked with Google's PowerMeter software, were at the forefront of HEM technology. These dedicated screens would connect to and receive data from meters and from any technology that could connect at the time (certain thermostats and plugs) to display energy usage and signals to the homeowner. Yet these dashboards had limited devices with which to connect (the Blackberry was still the most popular smartphone) and a very niche group of homeowners wanting to see energy spikes due to using the toaster or hairdryer. As smartphones have become increasingly prevalent, with 77 percent of American adults owning one as of 2018[7], they have rendered the standalone physical display more or less obsolete. Furthermore, the boom of apps has made it simple for phones to connect to new technologies. New software solutions now allow customers to view their energy consumption and manage energy systems from a single app on their phone.

Figure 1: Evolution of HEM Technology

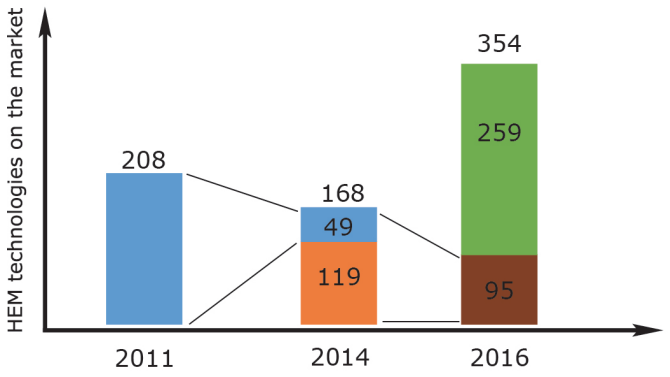

Figure 1: Evolution of HEM Technology. Adapted from "Assessing Players, Products, and Perceptions of Home Energy Management," by Rebecca Ford et al., November 2016, *Pacific Gas and Electric Company*, p.39.

4 Ibid.

5 Emily Kemper et al., "Opportunities for Home Energy Management Systems (HEMS) in Advancing Residential Energy Efficiency Programs," August 2015, *Northeast Energy Efficiency Partnerships.*

6 Ibid, 7.

7 Pew Research Center: Internet & Technology, "Mobile Fact Sheet," 5 February 2018. Retrieved June 25, 2018, from http://www.pewinternet.org/factsheet/mobile/.

As these technologies have changed, so have the companies that first brought them to us. EnergyHub, for example, started out in the hardware market for HEMS technologies and has since evolved into a software solution provider, providing distributed energy resource management (DERMS) software to support integrated communication and control between utilities and connected device manufacturers, helping utilities get more value out of these devices. MyEnergy (formerly EarthAid) which used data algorithms to help homeowners analyze their energy use, was acquired by NEST Thermostats in 2013, which Google (which had recently abandoned its PowerMeter) in turn bought in 2014.

Other companies are working on combined hardware and software solutions that offer real-time whole-home monitoring through a single platform, disaggregating energy usage information down to individual appliances. Sense, CURB, Whisker Labs, Neurio, Smappee, and others have all developed different load monitoring hardware that installs directly onto a home's breaker panel and measures circuit level electricity draw, sending that data into the cloud. Their connected software platforms analyze this data in real time and use machine learning algorithms to detect different appliances in use based on the unique "electrical signature."[8] As these non-intrusive load-monitoring technologies continue to develop and improve, they could ultimately provide consumers with detailed insight into every end-use in their home—displaying energy consumption and generation patterns, identifying phantom loads, sending alerts about appliances—all through a single app on their smartphone.[9] This offers a vision of what the future smart home might look like—a home where all energy systems can be easily understood and controlled through a single interface.

Perhaps the newest trend in home energy management systems is the integration of voice technology. With recent artificial intelligence and far field voice recognition[10] advances, voice assistants are now at the forefront of home automation, allowing consumers to more easily engage with and control connected devices in the home. Many industry experts say that voice technology is a game changer in the home energy management space, and that voice will likely be the smart home interface of the future, allowing for a more user-friendly and responsive home.[11] Voice assistants are now being integrated with HEMS products. For example, ecobee's newest smart thermostat and smart light switch come with Amazon Alexa built in to allow occupancy, temperature detection, and lighting control capability throughout a home.

Benefits and Opportunities of Smart Device

Smart devices, technologies, and HEMS present many benefits and opportunities to homeowners, the grid, and home performance professionals alike.

Benefits and Opportunities to Homeowners

Smart devices and HEMS allow homeowners to truly "interact" with their homes' various systems (including HVAC, lighting, smart appliances, large electronics), making management of energy use simpler and more transparent, and ultimately enabling homeowners to create a safer and more comfortable living environment

8 Smappee, "How does Smappee detect appliances?," 1 February 2017. Retrieved June 24, 2018, from https://www.smappee.com/au/blog/blog_smappee-appliance-recognition/; Sense, "How Does Sense Detect My Devices?," 16 February 2016. Retrieved June 24, 2018, from https://blog.sense.com/articles/how-does-sense-detect-my-devices/; Neurio, "Appliance Monitoring Analytics," 2018. Retrieved June 24, 2018, from https://www.neur.io/appliance-monitoring-analytics/.

9 Neurio, "Home Energy Monitoring," 2018. Retrieved June 23, 2018, from https://www.neur.io/home-energy-monitoring/; Smappee, "Our Technology," 2018. Retrieved June 23, 2018, from https://www.smappee.com/us/our-technology; Sense, "Product," 2018. Retrieved June 22, 2018, from https://sense.com/product.html; Sense, "What is 'Always On' Power?," 31 March 2017. Retrieved June 22, 2018, from https://blog.sense.com/articles/what-is-always-on-power/.

10 Where the microphone is far from the user.

11 General thoughts expressed by the following industry experts during interviews conducted in June 2018: Emily Kemper (CLEAResult), Nkechi Ogbue (ecobee), Julie Michals (E4TheFuture).

12 A recent NYSERDA pilot of 50 NY homes showed homes with total HEMS saved an average of $268/year.'

while generating energy savings that translate into lower energy bills.[12]

While programmable thermostats, for example, have been around for decades and allow users to schedule automatic temperature setbacks, the majority of homeowners do not actually program them, according to a survey by the U.S. EIA, and therefore fail to realize energy savings.[13] Smart thermostats, in contrast, "observe household behavior and create a temperature-setting profile without the need for user intervention."[14] By reducing the effort needed from homeowners, smart technologies can potentially make it easier to optimize energy use and achieve savings. According to an ACEEE analysis, "[residential] sector [energy] savings could reach as much as 17 percent if every U.S. household adopted smart technology for each major end use—HVAC, water heating, lighting, kitchen and laundry appliances, and home office and entertainment equipment."[15] For example, the maximum savings potential for space heating (from smart HVAC, smart thermostats, and smart window coverings) is 29 percent, which represents an estimated 7 percent of total residential energy use.[16]

The boom in smart devices also offers homeowners an unprecedented level of granularity when it comes to their energy bills, which is one of the only bills generally accepted with no specific cost breakdown. For example, it would be unacceptable to visit a store and purchase several items but not receive a receipt detailing each item's cost. Similarly, a phone bill that did not provide a breakdown of charges to help identify the reason behind a particularly high bill in a given month would not be acceptable. What most consumers currently receive every month from their utility are two numbers—amount of energy used and the cost. But with smart devices, identifying how much energy was used for heating or cooling, doing laundry, or watching television on given days (or even given hours) is possible. With this kind of information at their fingertips, consumers have the ability to make mindful adjustments to their energy consumption patterns. Utilities like PG&E are already working to develop energy bills that offer their customers disaggregation by end-use[17], and third-party companies like Aclara recently started offering new home energy reports with appliance-level insights disaggregated from smart meter data.[18]

Benefits and Opportunities to the Grid and Utilities

As HEMS becomes more widespread a huge opportunity exists for utilities to engage the residential sector to create a more dynamic, reliable, and efficient grid. With the ability to interact with millions of homes, the ability to use technology to create more desirable load shapes will emerge. America's homes and buildings can be, and in many places are, a part of the grid. Homes produce or offset energy generation (via solar or geothermal power), store and transfer energy (via battery and thermal storage, smart water heating, and electric vehicles), and respond to grid demands (via demand response programs or direct consumer engagement)—making homes miniature power plants. Through data and automation, homes outfitted with HEMS are more responsive to electric grid conditions, essentially turning them into a dynamic grid asset that can help shift and reduce load.

Demand response and time-of-use (TOU) pricing smart meters and smart technologies enable help to lower electricity demand during peak periods and reduce utilities infrastructure costs. Crucially, this also "helps avert system stress, enhancing the reliability of the

13 U.S. Energy Information Administration, "One in eight U.S. homes uses a programmed thermostat with a central air conditioning unit," 19 July 2017. Retrieved June 19, 2018, from https://www.eia.gov/todayinenergy/detail.php?id=32112.
14 Ibid.
15 Jen King, "Energy Impacts of Smart Home Technologies," April 2018, *American Council for an Energy-Efficient Economy*, vi.
16 Ibid, 27-28.
17 Jennifer Amann, ACEEE, interview, June 2018.
18 Kumi Premathilake, Mak Tarnoff, Ryan Esch, Aclara, interview, June 2018.
19 David Nemtzow, "Buildings and the Grid 101: Why Does it Matter for Energy Efficiency?," 12 September 2017, *U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy*. Retrieved June 1, 2018, from https://www.energy.gov/eere/buildings/articles/buildings-and-grid-101-why-does-it-matter-energy-efficiency.

entire grid."[19] Smart meters and other energy monitors offer increasingly granular datasets, which improve grid visibility and allow utilities to monitor power flows with greater accuracy and timeliness. Utilities can now use software to automate load-shedding based on what is happening on the grid. "Grid-interactive water heaters, for example, know exactly when to turn on or off the electric heating elements to reduce power use during moments when the utility system reaches peak demand…or to shift power consumption to when the utility system has excess capacity."[20] These load-shifting capabilities can in turn improve the integration of renewables into the grid. For example, excess wind power at night could be used to power connected water heaters, using the water heater storage tanks as thermal batteries to store that energy.

Software solutions can also help to manage two-way energy flows between the customer and utility, integrating electric vehicles (EVs), renewables, and storage technologies with the grid while supporting stability. For example, according to Kumi Premathilake, Senior Vice President of Advanced Metering Infrastructure at Aclara, these solutions "can help the consumer and the utility really play well together, in terms of their energy supply and usage…where you may generate some energy as a consumer, you may continue to use that energy in your home or you may decide to sell that energy back into the grid."[21] The increasingly large and comprehensive datasets of residential sector energy smart meters and HEMS can also help to inform utilities' integrated resource planning.

Benefits and Opportunities to Home Performance Professionals

Smart technologies and HEMS can help contractors and home performance programs predict energy savings and better meet those predictions by more accurately identifying inefficiencies in homes. While thermal imaging and blower door tests will tell a great deal about a home's insulation and air sealing, smart meter data collected over the past year, combined with a smart thermostat's set point and temperature trends, would inform a contractor on how well a home is maintaining its temperature and how efficiently the HVAC is running. HEMS expand on traditional Evaluation, Measurement and Verification (EM&V) with real-time energy performance data and can provide real-time performance feedback that, when weather normalized based on past data, offers a comprehensive understanding of an insulation or HVAC upgrade's impact. HVAC contractors can, for example, tune a home's (smart) central heating system and remotely assess how well it functions afterwards. Smart home technologies also enable remote troubleshooting, predictive maintenance, continuous commissioning, and generally a more holistic approach to whole home energy savings. As Brian Bovio of New Jersey-based Bovio Heating Plumbing Cooling & Insulation points out, these diagnostic and monitoring capabilities can provide big benefits to home performance contractors and have the potential to bring significant changes to day-to-day operations.[22]

In addition, smart technologies can potentially greatly expand demand for home performance jobs in a number of ways. First, smart home technologies can help "de-seasonalize" the business. One of the hardest aspects of the home performance industry is its seasonality—characterized by huge spikes in workload when temperatures are more extreme, followed by lull periods in between. But as Scott Needham, President of Princeton Air Conditioning, points out, "you don't need a season to smarten up a house."[23] Indeed, installation and servicing of smart home technologies could help to provide a steady work stream during the traditional slow seasons.

20 Ibid.
21 Kumi Premathilake, Aclara, interview, June 2018.
22 Brian Bovio, Bovio Heating Plumbing Cooling & Insulation, interview, August 2018.
23 Scott Needham, Princeton Air Conditioning, interview, August 2018.

Second, smart home products can help identify sales leads. As Needham points out, lead generation and customer acquisition are very expensive, often costing hundreds of dollars per lead. Smart home technologies offer important lead generation opportunities by helping contractors "get in the door" of homes that might not otherwise be looking for home performance services. Smart home technologies can also motivate customers to invest in other home efficiency improvements and thus serve as an upsell mechanism. For example, most homeowners would not invite their neighbors into their home to show off new insulation, but many people will happily show off their smart thermostat or other piece of technology. NEEP outlines several different smart home technologies that can help drive other efficiency work:[24]

- *Smart thermostats* are a "visually appealing reminder of home performance work done" and are relatively easy to install.
- *Health/safety monitors* (indoor air quality, carbon monoxide, etc.) are a smart leave-behind, have increasing consumer interest, and are relatively easy to install.
- *Smart lighting* is a gateway product into the smart home-low cost with an opportunity for upsell, and with high visual impact.
- *Smart home apps* show energy savings from work performed, are easy to set up and often free.
- *Other smart home devices* (smart door locks, smart doorbells, home cameras/monitors) are fun for consumers and offer additional professional installation opportunities.

Indeed, home performance professionals have the opportunity to grow their businesses by incorporating relevant smart technologies into their portfolio of services. Contractors could bundle traditional retrofits with smart technology and sell a package of solutions for a smart, comfortable, *and* efficient home. This bundling is discussed in greater detail, below.

Finally, in the face of workforce shortages and an aging home performance contractor population, home performance professionals could attract and recruit more young workers by integrating smart home technologies into their business model and framing home performance work around these new innovations.[25] According to Needham, incorporating smart home technology services into a business can indeed serve as a workforce development opportunity, attracting younger workers with job titles like "Smart Home Technician" and leveraging the tech savvy nature of a generation that has grown up with smart technologies.[26]

24 Claire Miziolek, "Contractor's Guide to the Smart Home," December 2017, *Northeast Energy Efficiency Partnerships*. Retrieved May 23, 2018, from http://neep.org/sites/default/files/resources/ContractorsGuidetotheSmartHomeFinal.pdf.

25 Ibid.

26 Scott Needham, Princeton Air Conditioning, interview, August 2018.

Redefining Home Performance

Traditional home performance means looking at the home as a system—incorporating the building envelope, HVAC and other systems, and appliances—to ensure all parts work in unison to maximize the home's energy performance. But in the age of technology, for a home's optimal energy performance, all of the parts must be talking to each other, to the homeowner, and to the grid in a way designed to maximize efficiency, comfort, and overall performance. A smart home can inform and encourage behavior change and communicate to utilities to offer further incentives for improving energy efficiency.

The inclusion of smart devices in home performance does not mean we devalue traditional home performance measures like improvements to the building's envelope or upgrades to HVAC systems—those remain critical necessities to residential energy efficiency. A home can be smart and not energy efficient, and vice versa, but smart *and* energy efficient homes can be a utility's greatest asset. Furthermore, as demand for smart home technologies moves beyond the tech-savvy DIY installers and becomes more mainstream, the home performance industry must be willing and ready to meet the demand. As Scott Needham of Princeton Air puts it, "if we don't fully embrace smart tech and become a leader in the market, we're just going to get passed by."[27] Dan Thomsen, CEO of California-based Building Doctors, feels similarly. When asked about what he thinks of the smart home, he replied, "It's the future, it's the future, it's the future. Anyone that isn't thinking about the smart

27 Ibid.

home will be left behind. You better start learning it now so you can continue to help your homeowners for years and decades to come."[28]

The Pillars of Smart Home Performance: Data-Sharing, Behavior Change, and Experience

Integrating traditional home performance measures with smart devices and technologies is a crucial next step to advancing whole home energy efficiency. The data these technologies create can be used to more effectively and precisely identify energy savings opportunities, thereby strengthening both home performance and demand response programs. The data may be crucial to measuring program success and the behavior change important to lasting energy savings, but the homeowner is buying the experience.

As a Trane HVAC dealer in Arizona, Elena Chrimat of Ideal Energy LLC installs Nexia products that are compatible with the air conditioners her company installs. Not only will Ideal Energy install the connected thermostat, but also the lighting and door locks that all connect to the same phone app. The smart home is "definitely a part of the future," notes Chrimat, who welcomes the new technology for increasing home performance.[29] As security firms like Alarm.com and entertainment companies like Comcast and Verizon feature energy-saving technologies, energy professionals are expanding their markets as well.

A smart home's performance insights and enhanced monitoring and control also help maximize the benefit of energy efficiency improvements to the home. According to ACEEE, home performance upgrades that incorporate smart technologies and effectively result in a "smarter" home can often achieve greater energy savings when compared to a typical home that has just received traditional home performance measures which rely on manual inputs and often go unmanaged post-installation.[30] In addition, by analyzing data from smart devices and HEMS within the home, contractors can "educate residents about their energy use and influence their behavior."[31] Behavior change is the ever elusive factor in any energy efficiency methodology. Unlike renewable generation which only has to worry about the unpredictability of the weather, energy efficiency generation can be thwarted by the unpredictability of human behavior—the counterfactual. Here is where smart technology helps because education about energy consumptions can lead to behavior change or, the "Prius effect ".[32] Utilities can also be more engaged, sending real-time alerts about savings opportunities or spikes in energy use directly to a customer's devices, which can incentivize homeowners to tweak their energy use behavior, facilitating energy and cost savings for homeowners and utilities alike.

Residential Demand Response Driving HEMS

One of the most important parts of *smart* home performance will be residential demand response programs. Utilities have historically offered demand response programs to large commercial and industrial facilities, but in recent years, have expanded these programs to include residential. For example, San Diego Gas & Electric, National Grid, Florida Power and Light, and Oklahoma Gas & Electric have programs that have achieved reductions in residential peak demand using automated demand response technologies. In addition to curbing peak demand, which can reduce or avoid the need to build new power plants to meet peak demand needs, these residential demand response programs also present the opportunity to reduce energy costs for

28 Dan Thomsen, Building Doctors, interview, August 2018.
29 Elena Chrimat, Ideal Energy LLC, interview, August 2018.
30 American Council for an Energy-Efficient Economy, "Boosting your home's IQ delivers savings and improves comfort," April 2018. Retrieved June 10, 2018 from https://aceee.org/blog/2018/04/boosting-your-home-s-iq-delivers.
31 Ibid.
32 When the Prius was first introduced by Toyota in Japan in 1997 and the U.S. in 2000, researchers discovered that the dashboard panel that showed real-time energy use impacted a driver's behavior and they began to drive more gas efficiently as a result of the information.

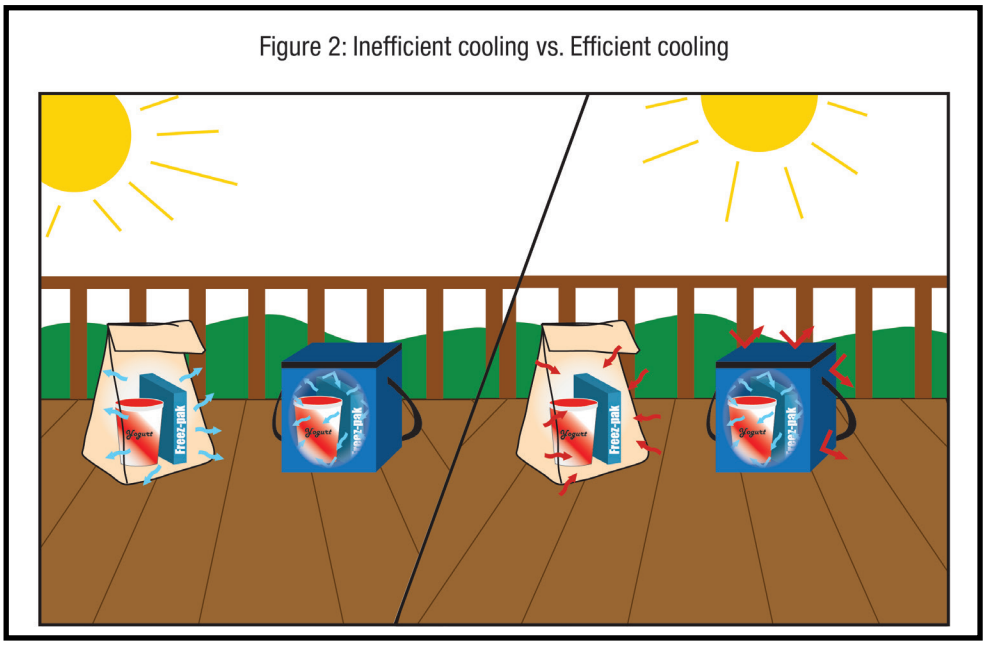

Figure 2: Inefficient Cooling vs. Efficient Cooling

In this image, a yogurt with an ice pack in a paper bag is placed on the porch in the hot sun to symbolize how a homeowner would react to an uninsulated home that has been pre-cooled for a demand response event in the summer. The paper bag will quickly lose its comfortable cool temperature, and the yogurt will spoil. Conversely, a yogurt in a similar sized insulated cooler with the same icepack in the same sun represents a homeowner in an insulated home. When the home is insulated, a demand response event can be called to alter thermostat setting to ease the strain on the grid without compromising comfort.

consumers—a win-win when designed well.

Demand response programs have become a primary driver for utilities to advance HEMS because of their ability to remotely change the thermostat setting during a peak demand event. Maintaining grid reliability has a high value to the utility. However, HEMS should not be viewed as a replacement for insulation, air sealing, and HVAC; in fact, demand response programs should require insulation for homes to maintain their temperatures during demand events. Well-designed demand response programs will pair insulation, smart thermostats, and demand response program participation. One use of smart thermostats has been to "pre-cool" homes prior to peak demand periods of as long as five hours. Pre-cooling an inefficient home will not hold temperatures for five hours. Imagine placing a yogurt and an ice pack in a paper bag and letting it sit on your porch for five hours—this is an uninsulated home that has been pre-cooled (*see Illustration A above*). Conversely, place the yogurt in a similar sized insulated cooler with the same icepack and place it on your front porch for five hours. The yogurt represents the homeowner on a hot day when a demand response event changes their thermostat setting to ease the strain on the grid, and their comfort may be compromised if they live in an uninsulated house. When utilities invest in smart thermostat managed demand response programs, they should also ensure a minimum amount of insulation is in the home to assure that ratepayer dollars will not be wasted on pre-cooling a paper bag.

Program Accountability and Pay-for-Performance

Home performance programs have traditionally aggregated the predicted energy savings from a home retrofit based on the deemed savings of the installed measure(s)—the savings anticipated from a lighting, HVAC, or insulation upgrade. However, this does not take into account the behavior of the homeowner—how they set their thermostat, how many people live in the home, when they take vacations; multiple factors can lead to a home not performing as predicted. Furthermore, the quality of the installation can lead to uneven realization rates for program participants. With the advent of smart devices, programs have the ability to measure a home's energy savings based on weather normalized past data, to know if a home is performing as predicted and if installed measures are meeting their deemed expectations. Utilizing data can not only make the program more cost-effective, but can help celebrate high-quality contractors and reward high-performing

homeowners.

Smart technologies, along with advances in cloud-computing, have enabled automated measurement and verification, often referred to as auto-M&V (or M&V 2.0, Automated M&V, or Advanced M&V).[33] Cloud-based software can process large volumes of data and perform analytics at high speeds, offering more immediate and precise energy savings estimates at a lower cost.

With auto-M&V 2.0, program administrators can gain the information they need to improve programs, and contractors receive timely feedback on the performance of individual home improvement installations, enabling them to identify and correct any operational issues.[34] Furthermore, utilizing home energy management devices enabled to provide near real-time data to programs can demonstrate a project's successful completion and reduce both costs to the program and burden on the contractors and homeowners.[35]

These advances in measurement and verification are helping to make pay-for-performance a viable model for incentivizing energy efficiency. An emerging policy practice, pay-for-performance (often referred to as P4P) connects rewards with actual energy savings measured at the meter (rather than predicted savings based on deemed values). In lieu of a deemed level of savings being anticipated for each job, P4P models only pay out incentives based on realized energy savings, where energy savings are equal to the projected baseline (which includes adjustments for factors that affect energy usage, such as weather and building occupancy) minus the actual metered usage after an energy efficiency improvement. Important to policymakers, this policy paradigm aims to move away from programs and become a part of utility procurement, allowing utilities pay for demonstrated energy savings from installed measures. Because the savings are aggregated, those who save more offset those who save less, thereby mitigating the risk of not succeeding in meeting an energy savings policy or procurement. The aggregators provide potential homeowner rewards, allowing the market to set the incentive.

PG&E is running a residential pay-for-performance program using pre- and post-intervention smart meter data to measure energy savings. Through the program, the utility pays third-party energy efficiency program aggregators (such as program implementors, tech providers, finance companies, etc.) per kWh[36] for demonstrated energy savings across their portfolios of projects.[37] Matt Golden of OpenEE notes that this program design is the first of many with an ability to value energy savings properly and will help programs understand the pricing of products and the energy saving impact of different energy measures.[38] Golden notes that by paying for measured performance this policy design "sends a price signal to companies that there is value in producing stuff that works. It is about being able to properly value the load impacts of energy efficiency and electrification as a grid resource and enable markets to respond."

Smart technology has a potential to support these P4P program models as smart devices can send signals

33 Automated M&V" or "auto-M&V" is a process that utilizes analytic tools and services that provide automated, ongoing analysis of energy consumption data in order to monitor and measure the energy savings in a home. By understanding how the home used energy before and after a retrofit on a near-real-time basis, a program can better understand if energy savings are being realized and if the project was installed properly. With the investments in the smart grid, interval meters, home energy monitoring systems, and equipment with embedded communications technology, there is growing discussion about using these data analytic tools to complement and/or replace expensive and intrusive EM&V. It is also referred to as, or as a part of, "EM&V 2.0."

34 Ellen Franconi et al., "The Status and Promise of Advanced M&V: An Overview of 'M&V 2.0' Methods, Tools, and Applications," March 2017, *Rocky Mountain Institute*, 11-12. Retrieved July 2, 2018, from https://www.rmi.org/wp-content/uploads/2017/03/Advanced_M_and_V_Report_March2017_RMI.pdf.

35 Kara Saul Rinaldi et al. Weatherization and Home Performance: Recommendations for Mutual Success and Collaboration, March 2017, *Home Performance Coalition*.

36 A second version of the program being launched now goes beyond kWh and pays triple the rate for savings during the steep rise in demand from 4-8pm (see duck curve).

37 Julia Szinai, "Putting Your Money Where Your Meter Is: A Study of Pay-for-Performance Energy Efficiency Programs in the United States," January 2017, *Natural Resources Defense Council,* 59; Matt Golden, CEO, OpenEE, Interview June 2018.

38 Matt Golden, CEO, OpenEE, Interview June 2018.

to utilities, contractors, and/or aggregators if a home is meeting, exceeding, or under achieving based on predictions. This model will enable the proper valuation of the load impacts of energy efficiency as a grid resource and allow markets to respond. Monitoring thousands of homes can help identify positive themes (homes retrofit by certain contractors or that use certain energy measures exceed their energy savings predictions) that can be further incentivized.

The Importance of Non-Energy Benefits

Non-energy benefits of a smart home include increased comfort, health, convenience, and security. These non-energy benefits are often what matter most to consumers and have the greatest impact on their daily life. Smart home technologies can appeal to these goals, while also achieving energy savings, thereby advancing the market for smart home performance.

According to home performance experts and contractors, most homeowners care more about comfort and convenience than energy savings.[39] Through home automation, smart technologies offer convenience and enhanced security, and can help improve comfort. In fact, linking smart technologies to health and security may be key to gaining traction.[40] One example of this is Reliant, of Texas, which has created a total home automation service that offers a basic security package and then builds on additional energy-saving smart technologies, leveraging smart security as an on-ramp to adopting smart home energy management solutions.[41]

Convenience and "cool" features will drive the smart home market more than the desire to save energy. Smart home technology that makes life easier or better is an important part of the energy savings package. Interesting and fun features packaged with energy savings will pull more people into participating in home performance programs, made simpler due to new technology. In fact, the energy savings may emerge from the smart home, not the other way around. The smart home promises convenience and comfort but there is no guarantee that the smart home will deliver energy savings. This is the opportunity that policymakers could miss if they do not act to ensure manufacturers and installers have easy solutions that offer clear value to including energy saving smart technology.

The Value Proposition of the Smart Home Package — Expanding the Home Performance Contractor Business Model

As mentioned previously, combining energy savings with non-energy benefits together into one holistic smart home package could significantly increase the value proposition of a smart, energy-efficient home to the consumer and significantly increase the home performance market. As discussed above, smart home technologies not only help "de-seasonalize" the industry, they also offer important lead generation and upsell opportunities. The price points speak for themselves—$13,000[42] may provide an HVAC and insulation upgrade to the home, and the homeowner will feel the comfort with mild bill savings from an expense that is largely invisible. However, $2,000 could add a plethora of smart devices that help the homeowner engage and communicate with the home—contractors combining these services in a package will be able to expand on their service model and demonstrate value.

Indeed, home performance professionals have the

39 Jen King, "Energy Impacts of Smart Home Technologies," April 2018, *American Council for an Energy-Efficient Economy*, 29; Claire Miziolek,, "The Smart Energy Home and Cross-Promotional Opportunities in Energy Efficiency," December 2017, *Northeast Energy Efficiency Partnerships*, 3. Retrieved May 24, 2018, from http://neep.org/sites/default/files/resources/SmartEnergyHomeCrossPromotionGuidanceFinal.pdf; Robin LeBaron and Kara Saul Rinaldi, "Bringing on the Boom and Beating the Bust: A Framework for Developing a Roadmap to a Successful Home Performance Industry," April 2013, *National Home Performance Council*.

40 Suzanne Shelton, Shelton Group, interview, June 2018.

41 Essie Snell, "Smart Home Pilots and Programs: A Catalog of Current and Recent Utility Initiatives," February 2018, *E Source,* 11.

42 Small sample from a few states. Region, contractor, unit brand and efficiency rates as well as home size will impact the cost up or down.

opportunity to grow their business by incorporating relevant smart technologies into their portfolio of services. These bundles could even be marketed in theme-like packages, for example a "New Parent Package" with technologies geared towards the health, safety, and monitoring of newborns. Or a regular "Parent Package" with technologies designed to help parents keep an eye on their school-age kids, knowing when they unlock the door and use their technology. Or an "Aging in Place Package" to help the elderly stay in their homes longer, but offer remote temperature and safety monitoring that gives their Baby Boomer children peace of mind. And for the hip homeowner with fur-babies that wants smart technologies in their home, a "Pet Package" with technologies that allow them to keep track of their pets during the day while they are at work and allow them to give a treat remotely for getting off the sofa.[43]

Dan Thomsen, CEO of California-based Building Doctors, has already found this approach particularly useful with expecting parents. "Expecting mothers get consumed with getting their house ready for their baby," he says, "and traditional measures to improve air quality, along with newer cameras, monitors, CO detectors, and the like are a logical part of that process." Thomsen's company runs a social media campaign called "Is Your Nest Ready" specifically to get the attention of this important potential customer base.[44] The smart home becomes a part of a person's story as their life changes.

Selling the Smart Home with Stories

In order to leverage smart home technologies to increase demand for services, it is important to understand *who* is buying these smart home technologies in the first place, *where* opportunity exists to expand the market, and *how* to communicate with customers in a way that increases demand. According to a 2015 Shelton Group report, early adopters of smart home technologies have been predominantly male, millennial, educated, high income, and homeowners.[45] This presents a huge opportunity to reach a larger audience, since women are making a majority of the decisions in the home.[46] The Shelton Group report cites health and safety, convenience, comfort and aesthetics as issues that matter the most to women, and so the industry could target women with a message that focuses on how smart home solutions provide comfort, health, and greater ease in managing the home.[47]

NEEP also conducted research[48] looking at the demographics across the energy efficiency and the smart home technology markets. They found that age and gender represented the greatest divisions between the two markets—with women and older consumers more likely to invest in energy efficiency upgrades, while the market for smart home devices was skewed towards younger male consumers. Certain values, however—to *protect*, *nurture*, and *conserve*—were shared among consumers in both markets and motivated their investments.[49] Speaking to consumers' values and focusing on how smart technologies and solutions can support their own goals will help to bring more people on board with the smart home.

Scott Needham of Princeton Air Conditioning, who has been on the forefront of incorporating smart home technologies into his company's business model, has one key piece of advice when it comes to selling homeowners on smart tech: tell a story. Needham points out that

43 Brainstorming session comments during Contractor's Guide to the Smart Home Session, 2018 National Home Performance Conference & Trade Show, Philadelphia, PA, April 2018.

44 Dan Thomsen, Building Doctors, interview, August 2018.

45 Shelton Group, "The Smart Home Gender Gap: What it is and how to bridge it," 2015, 2. Retrieved June 11, 2018, from https://sheltongrp.com/energy-pulse-2015-special-report-smart-home-gender-gap/.

46 Suzanne Shelton, Shelton Group, interview, June 2018.

47 Shelton Group, "The Smart Home Gender Gap: What it is and how to bridge it," 2015, 6. Retrieved June 11, 2018, from https://sheltongrp.com/energy-pulse-2015-special-report-smart-home-gender-gap/.

48 Claire Miziolek, "The Smart Energy Home and Cross-Promotional Opportunities in Energy Efficiency," December 2017, *Northeast Energy Efficiency Partnerships,* 5. Retrieved May 24, 2018, from http://neep.org/sites/default/files/resources/SmartEnergyHomeCrossPromotionGuidanceFinal.pdf.

49 Rebecca Ford et al., "Assessing Players, Products, and Perceptions of Home Energy Management," November 2016, *Pacific Gas and Electric Company*, 60.

contractors are often overly focused on the technical aspects of a home performance solution, as opposed to what that technology can mean to a family. "We have to be storytellers," says Needham. Leticia Colon de Mejias[50], CEO of Connecticut-based Energy Efficiency Solutions, agrees. "It's all about the story. The happy customer story needs to be told," says Colon de Mejias. Stories can help elicit emotional responses and help a homeowner see a piece of technology not as a widget, but as a tool to increase their life's health, safety, and comfort. Needham suggests coming to a home with a pre-packaged story about the technologies you are trying to sell.[51] These stories emerge from happy technology users:

- The story of the health benefits for the couple sleeping in a room with slightly lower temperatures facilitated by a smart thermostat,
- The story of peace of mind a new mom experiences after putting a sensor over her baby's crib and programming her HVAC system to respond to the temperature around the crib during naptimes, or
- The story of parents whose teens want to be trusted with a late curfew but who want to get a text notification stating what time their children have come home, so they can tell their smart lock to lock the door behind them and turn off the lights left on before they went to bed.

These kinds of stories can sell the smart products, and sometime the energy saving technologies.

---

50 Leticia Colon de Mejias, Energy Efficiency Solutions, interview, August 2018.
51 Scott Needham, Princeton Air Conditioning, interview, August 2018.

New Initiatives and Opportunities

Many utilities, energy efficiency program managers, home performance contractors, and other industry stakeholders are trying to figure out their role in advancing the smart home. Over the past several years, utilities and efficiency program administrators around the U.S. have stepped into the smart home arena and presently are testing a variety of new initiatives and opportunities to harness the potential of smart home technologies. For example, in 2015, California passed Assembly Bill No. 793 requiring the integration of Home Energy Management (HEM) technologies into utility energy efficiency programs. This is in stark contrast to a number of states which still provide no energy efficiency rebates.

While incentives and programs advancing smart home technologies vary tremendously from state to state, examples of exciting initiatives involving customer engagement and education, demand response and efficiency programs, and other areas of the home performance industry are beginning to emerge across the country.

Customer Engagement and Utility Initiatives

Smart home technologies offer a big opportunity to advance customer engagement and satisfaction—a primary focus for many utilities. A 2016 Industry Assessment from PG&E suggests that utilities are in a "unique position to leverage HEM technologies for customer engagement on a continuous basis, to help educate them about how their decisions can impact energy consumption...[which] has the potential to create

behavioral changes that can support long-term grid sustainability."[52] Aaron Goldfeder, CEO of EnergySavvy, believes consumers are the primary asset for utilities in an evolving energy sector where maintaining a reliable and efficient grid is a priority. Smart technologies are transforming the home and fundamentally changing how people interact with their energy systems, driving a whole new set of activities related to customer experience, including analytics, behavioral programs, customer service and omni-channel communication. "For the utility," says Goldfeder, "that means more choices for the customer, more opportunity to add value, more opportunities to understand the customer, to be a trusted advisor, but also more need to interact in ways that feel personalized to each customer."[53] The smart home opens up many new opportunities to understand and interact with customers while more extensive data helps utilities better serve and more effectively engage with the customer.

New and attractive smart home devices can help to capture homeowners' attention, while their connectivity gives utilities new opportunities to interact with customers directly through their smart phones. AEP Ohio, for example, has a free mobile app—"It's Your Power"—that allows customers to pay their bills, set budget goals, and track their electricity usage minute by minute using smart meter data. Through the app, the utility offers efficiency tips and sets energy-saving challenges by which customers can meet certain goals to earn points.[54] San Diego Gas & Electric (SDG&E), meanwhile, offers free smart home tours in its Energy Innovation Center to educate consumers on these new technologies.

In addition to these utility-led efforts, a number of third-party solution providers offer software tools for customer engagement. EnergySavvy uses a business-to-business-to-consumer model, and its products are used by utilities to better engage with customers, understand how they are using energy to offer more personalized recommendations, as well as to manage and measure EE programs themselves. Aclara's Adaptive Consumer Engagement (ACE) platform functions as a seamless extension of utility websites and apps, and will allow utilities to communicate with customers through multiple channels, such as email, text, and smart speakers, in the future. These cloud-based platforms allow utilities to interact and share information with customers in more proactive and personalized ways. Omni-channel communication, data and analytics, and targeted recommendations for customers all enhance customer engagement with their energy use.

Energy Efficiency and Demand response Program Initiatives

As mentioned previously, residential energy efficiency and demand response programs offer a new array of opportunities for smart home performance. While energy efficiency programs have been around since the 1970s, some utilities have started incentivizing smart technologies that can improve energy efficiency in the home and are also capable of responding to demand response events. These rebates are generally for smart room AC units or retrofit kits, smart lighting, and smart appliances, such as dishwashers and refrigerators or smart thermostats.[55]

Many residential utility programs have focused on smart thermostat opportunities, given their potential to control and provide insight into heating and cooling which account for a large portion of home energy use. In Bring Your Own Thermostat (BYOT) programs, utility customers are incentivized to enroll their own devices in utility demand response programs, in contrast

52 Rebecca Ford et al., "Assessing Players, Products, and Perceptions of Home Energy Management," November 2016, *Pacific Gas and Electric Company*, 6.

53 Aaron Goldfeder, EnergySavvy, interview, June 2018.

54 Essie Snell, "Smart Home Pilots and Programs: A Catalog of Current and Recent Utility Initiatives," February 2018, *E Source*, 3.

55 Jen King, "Energy Impacts of Smart Home Technologies," April 2018, *American Council for an Energy-Efficient Economy,* 33.

to traditional programs in which the utility owns and installs the device.

Kansas City Power & Light (KCP&L) offers eligible Missouri customers a free NEST thermostat and installation, provided they agree to enroll in the utility's demand response program, allowing NEST to make small automatic temperature adjustments during peak demand periods.[56] The KCP&L program[57] also has a Bring Your Own Thermostat (BYOT) option where customers can enroll their own thermostat in the program. Smart thermostats allow the utility to adjust the air conditioner settings during the summer to reduce demand and high energy use (if the utility is summer peaking). Customers can override the demand response event at any time by turning down the temperature. But if they do, they forfeit the incentive for successfully completing the event. For example, in New York, Con Edison's BYOT program offers a rebate to purchase a Con Edison-approved thermostat, and over the course of a two-year period, the utility may make up to ten adjustments to the homeowner's central air conditioner for no more than 4 hours each time. The customer always has the option of overriding the temperature adjustment by changing the thermostat settings.[58]

While providing the option to override a temperature adjustment may at first seem counterproductive to the overall goal of energy savings, it actually provides very important information if the program tracks homes with temperatures rising beyond comfortable levels during an event. The houses that drop out of demand response programs because they are unable to maintain a comfortable temperature could help identify homes most in need of efficiency upgrades. According to the Home Performance Coalition, "[w]hen a utility pulls a customer out of an event, or when a customer opts out because the temperature is rising too quickly, a virtual audit has essentially been done on that home, and the homeowner should be contacted and made aware that the home may benefit from efficiency improvements."[59]

Grid-interactive water heaters are becoming another focus of utility load-shifting and demand response efforts. Some programs offer direct installation of control switches onto customers' water heaters, allowing utilities to remotely turn off the water heater during periods of peak electricity demand. Florida Power & Light Company's On Call program offers customers a monthly credit when they have a control switch installed on their water heater and agree to participate in these demand response events.[60] Portland General Electric has a similar connected water heater program[61] that is for large multifamily properties and provides incentive payments per participating water heater to property owners.[62]

These more simple, direct install programs focusing on single devices can turn into more comprehensive programs that leverage more complex technologies and whole home energy management systems for behavior change and/or demand response, which can then evolve into load leveling, targeted customer engagement, real time M&V, and continuous whole home optimization.

ComEd of Illinois, for example, expanded its smart thermostat program into a Bring Your Own Device program, and now allows customers to program how their own connected devices will respond to the utility's dynamic pricing and demand response signals, using If This Then That's free third-party web service.[63]

56 Kansas City Power & Light, "Thermostat for Home," 2018. Retrieved June 18, 2018, from https://www.kcpl.com/save-energy-and-money/for-home/rebates-and-programs/thermostat.

57 Program managed by CLEAResult.

58 Kara Saul-Rinaldi and Julie Caracino, "The Evolution of Smart Home Performance and Its Benefits to the Grid," 26 July 2017, Home Energy Magazine. Retrieved May 21, 2018, from http://www.homeenergy.org/newsite2011/public/index.php/show/article/nav/trends/id/2197

59 Ibid.

60 Clearly Energy, "Residential Demand Response Programs," 10 October 2016. Retrieved June 18, 2018, from https://www.clearlyenergy.com/residential-demand response-programs.

61 Program managed by CLEAResult.

62 Portland General Electric, "Connected Water Heaters," 2018. Retrieved June 19, 2018, from https://www.portlandgeneral.com/business/get-paid-to-help-meet-demand/connected-water-heaters.

63 Essie Snell, "Smart Home Pilots and Programs: A Catalog of Current and Recent Utility Initiatives," February 2018, *E Source*, 5.

AEP Ohio offers a combined hardware and software energy management solution from Powerley for free to customers who have smart meters. The Powerley Energy Bridge is a smart home hub that enables a connection between a consumer app and the home's smart meter as well as any smart home device with ZigBee, Z-Wave, Wi-Fi, Bluetooth, or Thread. Customers can view their smart meter electricity data in real time and control connected devices through the smartphone app.

On the backend, a whole industry of utility-facing software companies and platforms have emerged as intermediaries between utilities and smart home device vendors, providing cloud-based solutions that enable residential demand response. Companies, such as AutoGrid, EnergyHub, and Itron, provide back end services that give utilities the power to communicate with and leverage a variety of Wi-Fi-connected devices—such as smart thermostats, grid-interactive water heaters, and other home automation devices—for demand response.[64] Matthew Johnson, Vice President of Business Development at EnergyHub, explains that the company controls partners' thermostats via cloud-to-cloud API integration, allowing "a utility that wants to control a Nest thermostat for demand response to log into EnergyHub's portal and schedule an event. At that point a control signal travels form EnergyHub's cloud to Nest's cloud, and [from] Nest's cloud down to the device."[65] Through these software platforms, utilities can manage device enrollment, DR event dispatch, incentive payments, and even measurement and verification.

Interoperability Initiatives

As detailed below in the *Obstacles* section of this report, interoperability remains a significant barrier to the advancement of the smart home industry. Fortunately, many companies and organizations are working to solve this issue.

The CTA-2045 port, developed by the Electric Power Research Institute, serves as a standard interface (comparable to the USB port on computers) for appliances. The CTA-2045 port allows any number of communication devices or "modules" to plug into the appliance to make it grid-interactive and capable of responding to demand response signals.[66] The port can be built in or retrofitted to appliances, such as water heaters, EV chargers, and pool pumps,[67] and supports interoperability by enabling "any product to connect to any type of demand response system [and home network]."[68] The Bonneville Power Administration, which has been working on a test project of CTA-2045 ports for demand response, says that if the port becomes standard practice, it will make it simpler for customers to choose to participate in a utility DR program: "Their equipment will already have the port, and all they have to do is plug in the communication device from any provider."[69] Furthermore, ports could "future-proof" the device so that appliances can shift programs and wireless protocols without having to replace the appliance. One concern about imbedding smart technology into appliances is that the appliance has a useful life much longer than new wireless technology that is rapidly innovating. Ports may simplify that by making it easier to provide an intelligence upgrade independent of the appliance.

Software solutions can also help to improve coordination of connected devices and appliances across the home. Volttron, developed by PNNL, is an example of an open

64 Rebecca Ford et al., "Assessing Players, Products, and Perceptions of Home Energy Management," November 2016, *Pacific Gas and Electric Company*.

65 Matthew Johnson, EnergyHub, interview, June 2018.

66 Jen King, "Energy Impacts of Smart Home Technologies," April 2018, *American Council for an Energy-Efficient Economy*, 14.

67 Ibid.

68 National Institute of Standards and Technology, "NIST Smart Grid and CPS Newsletter," March 2017. Retrieved July 13, 2018, from https://www.nist.gov/engineering-laboratory/smart-grid/nist-smart-grid-and-cps-newsletter-march-2017.

69 Bonneville Power Administration, "Technology Innovation Project 272a: EPRI P170 Supplemental: CTA 2045 Standard Modular Communications Interface for Demand Response," 2017. Retrieved July 13, 2018, from https://www.bpa.gov/Doing%20Business/TechnologyInnovation/TIPProjectBriefs/2017-DR-TIP-272a.pdf.

source software platform for executing control functions that enables communication across different devices and protocols, and thereby aids in carrying out building optimization.[70] Foresee, developed by NREL, is another example of a user-centric HEMS that can help optimize how a home operates to meet the homeowner's needs, learn their preferences, and maximize a home's energy use, including use of home appliances, photovoltaic systems, and battery storage.[71]

In all interoperability, communications are key. Language, even digital language, is important to ensure a German dishwasher can communicate with a thermostat built in China. The transfer of data in the same useful format is critical. Home Performance XML (HPXML) is a set of common terms and definitions, based on Building Performance Institute's BPI-2100 and BPI-2200 data standards, for home retrofit attributes that provide the computing language needed to transfer data between contractors, programs, and other market actors.[72] The IEEE 2030.5 standard, which defines an open communications protocol that any connected product can use, supports information exchange for applications, such as demand response, time-of-day pricing, and distributed energy resource (DER) integration.[73] In 2016, the California Public Utility Commission made IEEE 2030.5 the default communications protocol for integrating DERs with the grid, and NIST is currently working on a fourth version of the *Framework and Roadmap of Smart Grid Interoperability Standards*[74], which includes a list of smart grid standards identified for implementation.[75]

70 https://www.energy.gov/eere/buildings/volttron

71 Xin Jin et al., "Foresee: A user-centric home energy management system for energy efficiency and demand response," 2017, *Applied Energy*.

72 http://www.hpxmlonline.com/

73 James Mater and Rudi Schubert, "California's Push for Managing Distributed Energy Resources (DER)," 15 September 2016. Retrieved July 16, 2018, from https://beyondstandards.ieee.org/general-news/californias-push-for-managing-distributed-energy-resources-der/.

74 NIST is convening stakeholder workshops from June 2018 through October 2018. The results will emerge after the publication of this report.

75 National Institute of Standards and Technology, "Smart Grid Framework: NIST Framework and Roadmap of Smart Grid Interoperability Standards, Release 4.0," 2018. Retrieved July 16, 2018, from https://www.nist.gov/engineering-laboratory/smart-grid/smart-grid-framework.

Additional New Initiatives and Opportunities

Virtual Home Audits – New initiatives are underway to use connected thermostats, smart meters, and data analytics to remotely and automatically identify household-specific retrofit opportunities. These include opportunities to reduce heating or cooling energy consumption, quantify expected retrofit energy savings, and validate post retrofit energy performance. Smart thermostats can collect large volumes of data, including data on HVAC equipment runtime. Ecobee thermostats, for example, can provide predictive and diagnostic services that can help to determine HVAC system degradation levels.[76] These datasets—especially when paired with energy use data from smart meters—can provide a picture of the home's overall energy performance.[77]

Online Utility-Branded Marketplaces - Utility-branded marketplaces for energy efficient and smart products are online platforms designed to increase the visibility of energy-saving and grid-interactive products. These online marketplaces provide an opportunity to strengthen the relationship between the customer and utility.[78] Enervee is an energy efficiency software company that operates utility-branded marketplaces for utilities, such as ConEdison, AEP Ohio, and several California investor-owned utilities (IOUs).[79] The Enervee platform gathers data on how consumers interact with information online (what products and features people look for when they go on the site) and offers those insights to the utility. Simple Energy offers marketplaces for Utilities like ComEd. Their platform uses data to create platforms that appeal to people's interests while informing them about their energy

76 Nkechi Ogbue, ecobee, interview, June 2018.

77 The HomeIQ feature of the ecobee customer web portal also allows customers to track their HVAC energy use and runtimes from month-to-month and firsthand.

78 Jennifer Amann, ACEEE, interview, June 2018.

79 The California Energy Commission has mandated that all California IOUs operate marketplaces and include HEMS in their offerings.

use.[80] Utility-branded marketplaces commonly feature a streamlined rebate process, and even instant point-of-sale rebates for some products, making these incentives easier and more accessible for customers.

Research and Data Sharing - Some utilities and program administrators (e.g., NYSERDA, Efficiency Vermont, Eversource) have begun conducting pilot studies on a small number of residential homes to evaluate the energy savings potential of HEMS technology packages, including smart lighting controls, HVAC controls, and plug load controls.[81] The results of this research will be important to informing the development and refinement of future smart home packages to maximize energy savings potential. Additional important research is underway thanks to ecobee's Donate Your Data initiative, which gives customers the option to share their data for scientific research. The program, launched in October 2016, allows customers to share their real-time thermostat data with universities and non-profits, giving researchers access to a wealth of information that would otherwise be difficult and costly to gather. The data, which is anonymous and free of any personally identifiable information, can be used to support many different lines of research. In Indiana, for example, independent evaluators used ecobee thermostat data from 100 households to demonstrate cost-effective demand response potential of connected thermostats.[82] This type of data sharing and research could be vital to advancing state energy efficiency programs and promoting continued technological innovation.

Benchmarking and Labeling - Smart home interfaces (e.g., smart thermostats, mobile apps) can strengthen residential energy labeling and benchmarking initiatives by providing a platform for homeowners to be reminded of, engage with, and be motivated by their home energy score.[83] Reciprocally, according to Julie Michals of E4TheFuture, the recognition of smart technologies and home energy management systems in home energy efficiency certification programs could help increase the value of smart homes along with associated energy efficiency investments.[84] The U.S. Environmental Protection Agency is also getting into the game, recently announcing that its popular labeling program, ENERGY STAR, may soon have a category for Smart Home Energy Management Systems (SHEMS). Indeed, the recognition of smart thermostats with the ENERGY STAR label in January 2017 was key to helping programs and consumers identify the most energy saving products.

Renewables - A study by Rocky Mountain Institute demonstrates that smart home technologies, by enabling demand flexibility, can support the development and profitability of renewables. A key challenge to integrating renewable energy into the grid is that renewables generate much of their energy during off-peak times, when demand is lower, and therefore are not used to their full capacity. To address this mismatch, utilities can call on smart home technologies to shift demand to different times of the day so they can utilize larger amounts of clean energy.[85] Alectra Utilities in Canada already has plans to incorporate HEMS into its residential solar storage program to support load management.[86]

Residential New Construction - Opportunities exist to partner with builders and incentivize the construction of energy efficient homes outfitted with integrated smart home technologies. As builders and policymakers look to new energy code adoption, the inclusion of

80 https://simpleenergy.com/marketplace/

81 For example, VEIC has published their HEMS lighting study: https://www.efficiencyvermont.com/news-blog/whitepapers/smart-lighting-smart-hub-diy-install-does-yield.

82 Nkechi Ogbue, ecobee, interview, June 2018.

83 Claire Miziolek, "The Smart Home Interface: A Tool for Comprehensive Residential Energy Efficiency," *Northeast Energy Efficiency Partnerships*, December 2017.

84 Julie Michals, E4TheFuture, interview, June 2018.

85 Robert Walton, "Grid-connected appliances help utilities harness demand, spur renewables development, RMI finds," 28 February 2018, *Utility Dive*. Retrieved July 2, 2018, from https://www.utilitydive.com/news/grid-connected-appliances-help-utilities-harness-demand-spur-renewables-de/517739/.

86 Essie Snell, "Smart Home Pilots and Programs: A Catalog of Current and Recent Utility Initiatives," February 2018, *E Source*, 3.

smart devices, or efforts to ensure that the home is compatible with smart devices, is key to the future built environment. The California Energy Commission completed a 2019 revision of its Title 24 Building Codes and is starting to plan the 2022 revisions with some stakeholders requesting the inclusion of smart thermostats.

Obstacles

Advancing the smart home performance industry is certainly not without significant challenges. At this early stage, a lack of standardization and consensus impedes the smart home market. The uncertain value of these technologies, concerns over security and data access, and the need for increased awareness among consumers and home performance professionals are additional impediments.

Market Is In Early Stage

One of the biggest obstacles is the nascency of the industry. According to a 2017 report from Navigant, "the [smart home] market is at such an early stage that an agreed upon definition for the smart home does not exist. It is fragmented with various standards and protocols that have plagued the residential space with interoperability issues."[87] PG&E also concluded in a recent report on home energy management that "there remains significant unanswered questions about how best to engage in such a new, rapidly evolving, and in some cases volatile, market."[88] The report outlines potential barriers, including interoperability issues leading to poor usability and confusion among consumers, and an unclear HEM technology value proposition for.[89]

In this early market stage, technology is evolving rapidly, which can sometimes result in glitches and performance issues. In a smart home demonstration project, Emily Kemper of CLEAResult encountered such issues, finding that the HEMS was unable to control high-performing HVAC equipment in the home, and the connection to the HEMS platform had caused the motherboard in the heat-recover ventilator to fail.[90] Examples like these can decrease confidence during a time when the market needs it the most. Furthermore, concerns about installation difficulties or performance quality, real or perceived, can have a lasting impact.

As in many emerging markets, cost is also a factor.

87 Navigant, "The Smart Home: Integrated Hardware, Software, and Service Platforms for the Smart Home: Global Market Analysis and Forecasts," 2017. Retrieved May 21, 2018, from https://www.navigantresearch.com/research/the-smart-home.

88 Rebecca Ford et al., "Assessing Players, Products, and Perceptions of Home Energy Management," November 2016, *Pacific Gas and Electric Company*, 6.

89 Ibid.

90 Emily Kemper, "Mind the Gap: Lessons Learned in Two Smart Home Demonstration Projects," presented at HPC 2018 annual conference.

While prices for some smart home technologies have started to fall, high upfront costs remain an obstacle to broader market adoption. According to a 2018 report from ACEEE, "current adopters tend to be tech-savvy, upper-middle income households."[91] Furthermore, many of these technologies require broadband internet access, which can be another significant barrier for low-income, rural, and older populations. Karlin et al. drilled down further in their recent study of HEMS owners, noting a significant difference between the type of smart appliance owners and owners of other HEM products. These differences are due in part to the relative cost and permanence of the device and if the device owner rents or owns the home. Thus, "smart appliance owners were older than smart thermostat and smart light/plug owners. They had a lower income than smart thermostat owners, but were similar to this group in other ways. Both smart appliance and smart thermostat owners were less likely to rent (and more likely to own) their home and expected to remain in their home longer compared to light/plug owners."[92]

While many of the obstacles associated with a nascent market will likely work themselves out over time, it is important to recognize that the smart home market is and always will be different from the traditional residential energy efficiency market, and industry stakeholders and policymakers must be very cognizant of that as the industry advances. The traditional regulatory framework and standards for energy efficiency programs require a long process of pilots, research to determine deemed savings, cost-effectiveness testing, and finally, government approval—a process which has not yet adapted to connected home solutions. Aaron Goldfeder of EnergySavvy maintains that these classic approaches cannot keep up with the pace of technological change and innovation and are instead slowing down the deployment of the latest smart technologies. Goldfeder argues that there is a need for new protocols through which technologies can quantify energy savings while still being able to change at their own pace.[93] Jack Mayernik of the U.S. Department of Energy points out that "[m]any of these challenges are similar to those faced by traditional energy efficiency efforts (e.g., higher first cost, under-appreciation of value, the hassle of learning a new system, not fully appreciating the benefits). And just like traditional energy efficiency efforts, many of these challenges are already being addressed—for example, DOE's Grid Modernization Lab Consortium is working on building consensus around interoperability and working on processes to identify and respond to cyber threats."[94]

Policies with both the flexibility to welcome new technologies that stretch home energy performance and the regulatory rigor to support public confidence and privacy protection in the market require a bit of newly inventive policy-yoga. Arguably, if the standards are in place to build the products, the policies can follow.

Interoperability and the Need for Standardization

The current smart home market lacks standardized communication protocols. There are many different vendors, manufacturers, hardware devices, and software platforms and none of them have an overarching framework to connect with one another.[95] According to Mayernik of the U.S. Department of Energy, "[f]or the widespread adoption and utilization of grid-interactive technologies to yield positive benefits, the system must be able to work as a single unit. This means that all technologies will need to be interoperable, much like

91 Jen King, "Energy Impacts of Smart Home Technologies," April 2018, *American Council for an Energy-Efficient Economy*, vi.

92 Beth Karlin, Angela Sanguinetti and Rebecca Ford, "Smart Home Energy Management (HEM) Products: Characterizing and Comparing Adoption, Experiences, and Outcomes," 2018, *ACEEE Summer Study on Energy Efficiency in Buildings*.

93 Aaron Goldfeder, EnergySavvy, interview, June 2018.

94 Jack Mayernik, "Buildings and the Grid 101: Challenges," 19 October 2017, *U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy*. Retrieved June 1, 2018, from https://www.energy.gov/eere/buildings/articles/buildings-and-grid-101-challenges.

95 Emily Kemper, CLEAResult, interview, June 2018.

email is—whether you use a Mac or PC or are looking your email up on a phone or smartwatch, you can access your email. Building consensus around a strategic vision for interoperability is a major challenge that needs to be overcome for the successful realization of BTO's GEB [grid-interactive efficient buildings] vision."[96]

The lack of interoperability presents a major barrier to communication across devices and to the integration of various technologies into a single grid-interactive smart home system. According to David Nemtzow of the U.S. Department of Energy, "[o]nce installed there is no guarantee that different equipment will work together to make the building itself grid-responsive—without interoperability, utilities can't fully engage with buildings and their occupants."[97] Interoperability issues also impede functionality and ease. Jen King of ACEEE notes that "[m]ost communications protocols [for smart home devices] are proprietary to each product manufacturer. Their control networks require independent hardware, hubs, and access nodes, all of which must be managed individually."[98]

To make matters even more complicated, the interoperability issue exists at many different levels. A 2016 report from PG&E points out that while "two products may use the same communications protocol (e.g. Zigbee, Z-Wave etc.) they may remain non-interoperable because the higher software layers are not compatible. This makes navigating the HEMS space non-trivial, suggesting a greater need to explore the interaction between consumers and HEM technologies."[99]

Where standards do exist, they are generally technology-specific and not inclusive. Existing mesh network provider standards, for instance, risk shutting out innovation. As industry experts from Aclara point out, some standards are so technology-specific and exclusive that they shut out participation and innovation.[100] More inclusive open standards build a community of developers, scale quickly, and drive innovation. Having established open standards in the smart home industry would help customers avoid vendor lock-in, making it easy to add devices and avoiding stranded assets. This could help the smart home achieve the interoperability apparent in smartphones today, where, regardless of brand of service provider, phones can communicate with one another, and cellular, Bluetooth, and Wi-Fi all function seamlessly within each phone.[101]

If the various physical technologies in the smart home space are not interconnected at the data-level, data will not be able to flow freely, and consumers will not be able to control all their devices from a single point, which could greatly reduce appeal and stymie the market.

Education and Awareness

1. **Education or the Consumer.** A significant obstacle to investment in energy efficiency and smart home performance is lack of consumer awareness or motivation. According to the Shelton Group's 2016 consumer study on energy efficiency, "47% of consumers think their homes are already energy efficient" and "84% have little to no knowledge about what to do to make a home more energy efficient."[102] For consumers satisfied with the way things are, or convinced they already have a high-performing home, smart home solutions and the promise of

96 Jack Mayernik, "Buildings and the Grid 101: Challenges," 19 October 2017, *U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy*. Retrieved June 1, 2018, from https://www.energy.gov/eere/buildings/articles/buildings-and-grid-101-challenges.

97 David Nemtzow, "Buildings and the Grid 101: Why Does it Matter for Energy Efficiency?," 12 September 2017, *U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy*. Retrieved June 1, 2018, from https://www.energy.gov/eere/buildings/articles/buildings-and-grid-101-why-does-it-matter-energy-efficiency.

98 Jen King, "Energy Impacts of Smart Home Technologies," April 2018, *American Council for an Energy-Efficient Economy*, 30.

99 Rebecca Ford et al., "Assessing Players, Products, and Perceptions of Home Energy Management," November 2016, *Pacific Gas and Electric Company*, 6.

100 Kumi Premathilake, Mak Tarnoff, Ryan Esch, Aclara, interview, June 2018.

101 Kumi Premathilake, Mak Tarnoff, Ryan Esch, Aclara, interview, June 2018.

102 Suzanne Shelton, "The Consumer Perspective on Smart Home Technology," presented at HPC 2018 annual conference.

improved efficiency will not be attractive. There is a need to educate consumers about their home's actual energy performance and what specific opportunities exist to make improvements.

Concern about the perceived complexity of these technologies and challenges with interoperability across multiple devices are cited as main barriers to wider consumer adoption.[103] A recent survey by iQor found that more than a third of U.S. adults experience issues setting up or using a connected device.[104] Furthermore, according to PG&E's 2016 assessment, consumers are generally aware of some smart home devices, but typically do not know about the extensive variety of products and services that exist, and are confused about the role of hubs, software platforms, and different communication protocols.[105] The authors conclude that "education is required across the entire consumer journey to support their awareness and knowledge of the market, address motivations to purchase, support decision making processes during purchase, help customers install and set up products, and encourage them to use HEM technologies to deliver energy saving benefits."[106]

On a broader level, a lack of basic building science knowledge also presents a challenge. Leticia Colon de Mejias, CEO of Energy Efficiency Solutions, points out that most people in this country do not understand basic building science principles. She suggests the Department of Energy develop PSA-style ads to increase awareness among the population, with a focus on whole home performance and new technologies that could help capture audience attention. These ads might help more people understand the benefits of energy efficiency and smart energy management.[107]

2. **Education for the HP Workforce.** A key challenge to the integration of smart home technologies into home performance is that building trade professions remain relatively separate from the smart home market. Many home performance contractors have little knowledge about smart technology and are resistant to changing their business models to include these devices. Some resistance is because incorporating smart home technologies is difficult to profit from, and some of it is due to the fractured nature of the home performance industry. As Colon de Mejias points out, "you've got the HVAC guys, the electrical guys, the plumbing guys; you've got the assessment guys who live in the world of 'assess and propose'; and then you have the insulation guys. There are very few contractors that are holistic."[108]

   This fractured nature and specified roles and responsibilities isn't just seen across the home performance industry, but also within individual home performance companies. As Dan Thomsen, Founder of California-based Building Doctors, notes, "we try to cross train all of our guys in building science. A couple guys know smart tech well enough to talk about it. But big picture, it's just not possible to train all employees like that. Some of our guys focus on insulation, some on running wires, and others need to be on top of plumbing. It just doesn't make sense to have them all up to date on every new piece of technology that hits the market."[109]

   Brian Bovio, Owner and CEO of New Jersey-based Bovio Heating Plumbing Cooling & Insulation, agrees that it doesn't make sense to have every

103 Claire Miziolek, "The Smart Energy Home and Cross-Promotional Opportunities in Energy Efficiency," December 2017, *Northeast Energy Efficiency Patnerships*, 5. Retrieved May 24, 2018, from http://neep.org/sites/default/files/resources/SmartEnergyHomeCrossPromotionGuidanceFinal.pdf.

104 Business Wire, "The Smart Home is Creating Frustrated Consumers: More than 1 in 3 US Adults Experience Issues Setting up or Operating a Connected Device," 30 January 2018. Retrieved July 12, 2018, from https://www.businesswire.com/news/home/20180130005463/en/Smart-Home-Creating-Frustrated-Consumers-1-3.

105 Rebecca Ford et al., "Assessing Players, Products, and Perceptions of Home Energy Management," November 2016, *Pacific Gas and Electric Company*, 7.

106 Ibid.

107 Leticia Colon de Mejias, Energy Efficiency Solutions, interview, August 2018.

108 Ibid.

109 Dan Thomsen, Building Doctors, interview, August 2018.

employee trained up on smart home technologies, partially because that's not what customers hire them for. "No one asks our guys about anything tech related other than smart thermostats," says Bovio, "they don't see us as tech guys because that's not what we are."[110]

It is important to recognize that many home performance contractors feel threatened by smart home technology, fearing that smart machines will eventually replace their jobs.[111] To leverage the potential of smart home performance, contractors will need to see how these technologies can help them do their jobs better, faster, and with greater customer satisfaction—essentially, helping their businesses earn more money, rather than threatening their bottom line. As smart home technology continues to improve, the potential for these solutions to add value to contractors' work may become more apparent.[112]

Finally, the small segment of home performance contractors that have embraced smart home technologies are often not adequately communicating the need for and benefits of these technologies. As mentioned above, most contractors tend to focus on the tech/energy savings as opposed to stories about how the technologies can improve the health, safety, and overall performance of a home.[113]

3. **Education for Realtors.** Realtors informed about smart home technologies and educated on the smart home more broadly can make their clients aware of a home's smart features—like a Wi-Fi-connected thermostat or a smart meter—and the benefits associated with these technologies. According to Kara Jonas of the Midwest Energy Efficiency Alliance (MEEA), consumers are most likely to sign up for a utility program, such as demand response or time-of-use pricing, when they first move into their home. The real estate community, therefore, has a unique opportunity to influence homebuyers and "help drive participation in utility programs."[114] Opportunities are missed when realtors are unaware of available options with the utility or if they don't know how to identify or talk about smart home technologies. In an effort to address this issue, MEEA has a forward-looking training program that educates realtors on the smart grid, home energy management, and specific residential utility programs in their region—providing realtors with information and tools they can then share with home buyers.[115]

Ultimately, informed realtors can help boost consumer awareness and participation, and elevate the market value of a smart home with energy saving features. A good example of this is a new pilot program in Connecticut called "Save Energy Save Dinero." The program is a partnership between Energy Efficiency Solutions, a Connecticut-based full service energy conservation company, and Real Estate Recycles, a group of agents from different real estate companies, in which Real Estate Recycles pays for a building performance assessment as part of the closing costs. Colon de Mejias, of Energy Efficiency Solutions, says it's a perfect opportunity to engage with homeowners at one of the few times they are actually thinking about home upgrades—point of sale—and she's seeing a lot of new realtors joining Real Estate Recycles, as it becomes increasingly seen as something to set them apart from other realtors.[116]

110 Brian Bovio, Bovio Heating Plumbing Cooling & Insulation, interview, August 2018.
111 Suzanne Shelton, Shelton Group, interview, June 2018.
112 Ibid.
113 Scott Needham, Princeton Air Conditioning, interview, August 2018.
114 Kara Jonas, Midwest Energy Efficiency Alliance, interview, June 2018.
115 Illinois Science and Energy Innovation Foundation, "Funded Programs: Grants we've awarded since our first cycle in 2013, updated every cycle," 2017. Retrieved June 20, 2018, from https://www.iseif.org/funded-programs/#midwest-energy-efficiency-alliance.
116 Leticia Colon de Mejias, Energy Efficiency Solutions, interview, August 2018.

Data Access

In order to leverage the power of detailed energy usage information to inform and prompt action, data needs to be accessible. With the spread of smart metering technology, utilities have amassed extensive granular datasets of residential energy use. Yet, significant barriers remain for customers, contractors and other solution providers accessing that data. Mission: data, a coalition of technology companies advocating for improved energy data access policy in the U.S., maintains it is crucial for customers to easily access their energy data from the utility and authorize third-party data sharing to auditors, contractors, and software companies that can help interpret usage information and identify issues and opportunities for action.[117]

This is the idea behind the Green Button[118] initiative, created in the wake of a 2012 White House call-to-action to provide electricity customers with easy access to their energy usage data in a consumer-friendly and computer-friendly format. Utilities could participate in the program in two ways: "Green Button Download My Data" (utilities had a Green Button on their website where customers could download their energy consumption data and provide the data to a third party if they wished, and "Green Button Connect My Data" (which allows utility customers to create a secure transfer of a customer's energy usage data to authorized third parties, based on affirmative (opt-in) customer consent and control). The initiative has continued to evolve and expand over the past few years, partnering with increased numbers of utilities and industry stakeholders.[119] The initiative now also supports natural gas- and water-use data in addition to electricity.[120]

In the current landscape, data-sharing policies vary widely between utilities and many hurdles exist that make it difficult and costly for third-party solution providers to gain access to customer data.[121] More consistent and customer-centric data access and data sharing policies implemented at the state or federal level could create consistency for service providers, including those that work directly with homeowners and those that work with utilities, thus helping advance the market. These data access and sharing policies do not have to stand on their own. These efforts could be coupled with or incorporated into efforts to create interoperability standards (i.e., with NIST or another open source platform).

According to ecobee's Manager, Regulatory Affairs, Nkechi Ogbue, greater consistency in how customer data access authorization policies are implemented across states will reduce obstacles to third parties in their provision of value-added energy management services. This is particularly important because customer data access authorization processes, incorporated into the software and firmware associated with such services, are often applied across the entire population of end users (i.e., it is multi-jurisdictional).[122] Program implementers also need data to understand if certain technologies or retrofit measures were effective.

Privacy and Security

While data access is essential to connecting various technologies and optimizing performance, data accessibility is inextricably linked with privacy and security issues, both of which are unresolved in the smart home space.[123] Julie Michals of E4TheFuture points out

117 Michael Murray and Jim Hawley, "Got Data?: The Value of Energy Data Access to Consumers," January 2016, *Mission:data*, 2. Retrieved June 5, 2018, from https://static1.squarespace.com/static/52d5c817e4b062861277ea97/t/56b2ba9e356fb0b4c8559b7d/1454553838241/Got+Data+-+value+of+energy+data+access+to+consumers.pdf.

118 http://www.greenbuttondata.org/

119 DOE worked to develop a protocol for landlords to gain access to multifamily energy use. A similar protocol for single family residential may be needed.

120 http://www.greenbuttondata.org/

121 Michael Murray and Jim Hawley, "Got Data?: The Value of Energy Data Access to Consumers," January 2016, *Mission:data,* 3-4. Retrieved June 5, 2018, from https://static1.squarespace.com/static/52d5c817e4b062861277ea97/t/56b2ba9e356fb0b4c8559b7d/1454553838241/Got+Data+-+value+of+energy+data+access+to+consumers.pdf.

122 Nkechi Ogbue, ecobee, interview, June 2018.

123 Rebecca Ford et al., "Assessing Players, Products, and Perceptions of Home Energy Management," November 2016, *Pacific Gas and Electric Company*, 7.

that the need for customer-level data must be balanced with concerns about security at many levels—from the grid to the consumer—as well as with consumer privacy.[124]

At the highest level is grid security. According to Mayernik at the U.S. Department of Energy, "systems must be secure from cyber and even physical attacks. Cyber-security is needed both to make sure the system works properly and to help protect personal information."[125] Indeed, grid security has quickly become a major focus of government, the private sector, and academia.

One question recently examined by a group of Princeton University security researchers was: what if hackers controlled a botnet composed of thousands of silently hacked smart home devices, particularly power-hungry ones, such as air conditioners, water heaters, and space heaters.[126] The researchers ran a series of simulations to see how many of those devices would need to be simultaneously hijacked to disrupt the stability of the power grid. While the research doesn't identify any vulnerabilities in specific household devices or indicate how they could be hacked, it does posit that a large number of smart home devices/appliances could somehow be compromised and silently controlled by a hacker to cause mass blackouts. While most experts agree that this type of attack would not be possible today, as smart HVAC units (as well as the smart thermostats that control them) become more prevalent in homes and buildings across the country, a demand-based attack like the one the Princeton researchers describe could become more practical than one that targets grid operators.[127]

In terms of data privacy, there is concern between manufacturers, utilities, and different service providers about who owns the data all of these smart devices are collecting, and therefore, who it can be shared with and how it can be protected.[128] Some argue that the customer owns the data, so the customer should be empowered to share their data if they so choose. Another position is that, while utilities want access to all thermostat data, vendors should keep the raw data protected and instead share specific outputs from that data, using open source analyses, for example.[129]

It is important to note that *consumers trade their privacy for convenience every day*. With the ubiquity of smart phones and social media, forgoing privacy and security for convenience has become commonplace. Consumers willingly sign onto insecure Wi-Fi networks at hotels and coffee shops and send sensitive emails or log onto bank accounts after immediately hitting the "accept" button, ignoring the lengthy legal forms that tell them they are on an insecure network and inform them of the risks.

However, consumers remain concerned about spying, data breaches, and even how their data is used to target advertising. Suzanne Shelton of the Shelton Group suggests that consumers, after having relinquished privacy in so many other aspects of their lives, may decide they have hit their limit and dig their heels in when it comes to the smart home. Shelton suggests that these fears could be a barrier to the adoption of smart home technologies, as customers worry, "Who's spying on me? And what are they learning? And what are they going to do with it?"[130]

Indeed, the key tradeoff is that the smart home of the future has to know a lot about the consumer. Cutting edge technologies shaping the smart home space, such as voice recognition and occupancy sensing, also present greater privacy risks with microphones that are always

124 Julie Michals, E4TheFuture, interview, June 2018.
125 Jack Mayernik, "Buildings and the Grid 101: Challenges," 19 October 2017, *U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy*. Retrieved June 1, 2018, from https://www.energy.gov/eere/buildings/articles/buildings-and-grid-101-challenges.
126 Andy Greenburg, "How Hacked Water Heaters Could Trigger Mass Blackouts," 13 August 2018, *WIRED*. Retrieved August 15, 2018, from https://www.wired.com/story/water-heaters-power-grid-hack-blackout/.
127 Ibid.
128 Kumi Premathilake, Mak Tarnoff, Ryan Esch, Aclara, interview, June 2018.
129 Rick Counihan, Google, interview, June 2018.
130 Suzanne Shelton, Shelton Group, interview, June 2018.

listening and advanced sensing that sees where and when people are moving around in the house.

Security protocols are already being established. For example, Consumer Technology Association (CTA) published a smart home security white paper to inform contractors "involved in the professional installation and maintenance (moves/adds/changes) of smart home systems and components."[131] The paper outlines best practices for the secure installation of smart technologies to help protect customers. The Online Trust Alliance (OTA) has also developed, with multi-stakeholder input, the Internet of Things (IoT) Trust Framework which speaks to privacy and security best practices. According to Suzanne Shelton of the Shelton Group, utilities are currently one of the most trusted entities with consumer data in the US[132], and the consensus across the industry is that utilities are trusted energy advisors. According to the E Source catalog of utility smart home initiatives, PG&E is one of the first utilities "that provides customer education on smart home security on its Securing Your Smart Home web page."[133] PG&E's web page references the OTA's guidelines for smart home security.

The big privacy question remains: does the convenience of smart energy saving technology outweigh the real, if remote, chance of privacy concerns? While the home energy data that details a consumer's energy use patterns may have minimal current value, what about the technologies it connects to, including locks and cameras? Privacy protection is an issue, but if online banking and remote location detection on phones provide protections sufficient to make them commonplace, surely the smart energy devices have the same future.

---

131 TechHome Division of Consumer Technology Association, "Connected Home Security," 2017. Retrieved July 16, 2018, from https://www.cta.tech/cta/media/Membership/PDFs/ConnectedHomeSecurityWhitepaper.pdf.

132 Suzanne Shelton, Shelton Group, interview, June 2018.

133 Essie Snell, "Smart Home Pilots and Programs: A Catalog of Current and Recent Utility Initiatives," February 2018, *E Source*, 11.

Recommendations

The new ideas, obstacles, and opportunities detailed above help to set a baseline for where the smart home performance industry is today and how new home innovations can provide more convenience and energy savings to the built environment. Where do we go now? There are many stakeholders in this evolving industry creating a new paradigm of energy efficiency and communications: energy program administrators, government agencies, utilities, utility and air regulators, researchers, technology companies, non-profits, home performance contractors, communications and security providers, homeowners, and innovators and entrepreneurs yet to emerge. It is important that those with the ability to champion the increasingly interwoven issues of energy and intelligent technology work together to decrease barriers and advance the smart home market and smart home performance industry. Stakeholders should consider the following recommendations:

1. ***Combine smart home technologies and solutions with home performance retrofit programs to maximize home performance program efficiency.***

   Typical home performance retrofits have focused on improving the thermal quality of the building shell and increasing the efficiency of HVAC and other appliances. Smart home technologies add a third efficiency strategy: better control and as such becomes the third leg supporting an overall efficiency strategy. In addition, smart home technologies provide extremely valuable byproducts: data and granular level monitoring capabilities. This data and monitoring capability provide an unprecedented ability to conduct near real-time quality control for

home improvement installations. Time is money. For the utility anticipating energy savings from home predictions, for the contractor who has to fill out endless forms for evaluations, for the programs that pay evaluators to tell them if their programs are performing to expectations. Programs should utilize all their smart tools (meters and HEMS) to do near real-time evaluations, address poor performing or over-predicting contractors, and reward contractors with work that exceeds expectations. By reducing evaluation and paperwork costs, programs can reach more customers and have more opportunity to meet energy savings targets. The smart home interface should also be leveraged to connect customers with home performance contractors. For example, local qualified contractor recommendations could be displayed on the customer's HEM app when a problem is detected with equipment in the home, or a voice assistant could contact the contractor directly on behalf of the homeowner.

2. ***Use Smart Home Technology to reach low-income families with home performance and energy efficiency programs.***

   Low-income weatherization programs—including the federal Weatherization Assistance Program (WAP)—have access to energy meter data. The DOE Residential Building Integration Program, working together with the Office of Weatherization and Intergovernmental Programs, could use smart home technologies in weatherization as a way of reducing program costs, streamlining EM&V, and providing real-time feedback on performance to weatherization contractors and program participants. Data from smart home devices can be used to support traditional EM&V, reducing the costs of evaluation and providing real-time or near real-time performance feedback to contractors, programs, and program participants. The DOE should consider pilot programs that would aim to test auto-M&V and utilize home energy management devices, such as smart thermostats and smart meters enabled to provide near real-time data to programs to demonstrate a project's successful completion. By utilizing an auto-M&V system, the pilot would test the 100 percent quality control currently used by WAP in an effort to reduce both costs to the program and the burden on the contractors and homeowners.

3. ***Use performance-based policies and incentives.***

   Smart home technologies enable automated measurement and verification (or M&V) and make it possible to estimate actual energy savings from measured performance rather than deemed savings. Moving beyond prescriptive approaches that provide a predetermined savings value for specific measures, performance-based programs set targets for energy savings and allow program administrators and energy service companies to use a variety of technologies or approaches to reach those goals. Technology-neutral goals would help create new opportunities to use smart home technologies to advance energy efficiency and give flexibility to programs and contractors.

4. ***Incentivize interoperability.***

   For smart home solutions to be able to provide all of the benefits outlined in this report, different technologies within the home and across the grid must be able to communicate and work together. Improved interoperability supports functionality and flexibility, giving consumers and utilities the greater choice among products/technologies and making it easier/possible to add in new solutions as they emerge. Utilities should take the lead in promoting interoperable products, platforms, and systems.

   Open standards are key to promoting interoperability across technologies, and communications standards for smart devices and the smart grid should be promoted. Whether the IEEE 2030.5 standard for open communications protocols, universal communications ports like the CTA-2045, or HPXML for standardized data transfer are used, it is important that products and tools are speaking the

same language and have a 'mix and match' option amongproducts. While all technology providers want to have their own 'secret sauce' to corner the market, the increased opportunity and flexibility that come with options may increase the overall market .

5. ***Improve data access, data transfer policies, and increase data sharing.***

   Customers should be able to securely and easily access—*and* authorize third-party providers to access—their energy use data and any other data the technology in their homes creates. While there are efforts in states to provide this access, these efforts should receive federal and state level support through the legislative and regulatory process, and smart meter data should be more easily accessible to help consumers and third parties analyze a building's energy use. Furthermore, data about a home's energy savings measures should be transferred via HPXML to ensure that the definitions of the measures allow states and programs to 'compare apples to apples' when looking at program successes and failures.

   Aside from increasing data access for customers and designated third-party providers, data sharing policies could help augment our understanding of energy use and grid dynamics more broadly. Additional research is needed into the performance of energy measures, and researcher access to data allows increased understanding of how we can leverage our nation's housing stock to support grid resiliency and reliability.

6. ***Develop replicable best practices for privacy and security.***

   The entire smart home industry—contractors, manufacturers, software developers, cloud service providers, and consumers—must be aware of and engage in best practices to maximize security and privacy. As this paper notes, many preliminary resources in this area have already been developed. These types of resources should be utilized and used to further define practices that will ensure privacy and security throughout the industry.

   While privacy and security are necessary to the success of smart technology, it is important not to allow privacy concerns to halt progress. Consumers have demonstrated that they are willing to trade privacy for convenience every day. A convenience value proposition still needs to be designed that will allow customers to make their own determination about comfort and security in the devices.

7. ***Focus on the consumer.***

   Focusing on consumers' values and concerns smart technologies' benefits and the consumer experience and ease of use will help pave the way for broader market adoption of smart home devices and services. Utilities and home performance professionals should avoid the one-size-fits-all approach and focus on the specific needs and goals (whether energy savings, comfort, safety, etc.) of each individual household.

   Bundling smart performance into a package of solutions offering a more comfortable, safe, and manageable home could help smart technology gain traction among more homeowners. Utilities and contractors alike should highlight the benefits smart home solutions can provide, rather than complex and potentially confusing technical features.

   Messaging to customers is key and some of the most effective messaging will be through stories. Consumers need to hear stories and anecdotes about how these new technologies can improve their comfort and safety while enhancing convenience. They need something to connect to, not just a widget or app to look at, if they are really going to buy into these new technologies.

8. ***Promote Contractor Certifications.***

   Contractor certification training recognizes contractors trained to provide advice on smart

technologies and is important to assist programs, contractors, and homeowners. HPC recommends that a "Smart on Smart" certification would support contractors interested in advancing their knowledge of HEMS and help them to engage with homeowners comfortably outside the smart thermostat. This certification should be a half-day workshop, annually updated with the new technologies in the marketplace and information regarding how they fit and address different residential buildings. Contractors will thus learn how to troubleshoot and recommend different technologies. A contractor who is "Smart on Smart" knows how smart technology can improve both energy performance and homeowner quality of life.

9. ***Implement Time of Use Pricing.***

Not every kilowatt hour is created equal—to the utility, to the environment, nor to the customer. While about 50 percent of U.S. residential customers have smart meters, which provide the granular data needed to separate the cost of the different kilowatt hours, only a fraction of homeowners are on pricing that allows customers to pay for a kilowatt according to its value. Dynamic time of use pricing helps convey the costs of using energy during peak hours—in terms of infrastructure and grid stress—and incentivizes customers to reduce energy consumption or shift to off-peak hours. By more directly connecting homeowners and their smart technology to their home's energy use via rates, these customers will be more aware of wasteful energy consumption and the value of energy efficiency. Importantly, the smart home technology can take advantage of that information to automatically shift load when convenient to take advantage of the price differential.

10. ***Pay attention to appliances.***

According to the Energy Information Administration, as of 2009, HVAC has dropped to less than 50 percent of an average home's energy use in the U.S. Space heating (41 percent) and cooling (6 percent) still represent a significant amount of a home's energy use, but appliances, lighting, and electronics—which together represent 35 percent of a home's energy use (according to 2009 data)—are quickly catching up.[134] Recent studies have shown, for example, "there are more than 50 electronic devices, appliances, and other miscellaneous electric loads plugged into the power outlets of the average California home [and] these devices are responsible for approximately two-thirds of a typical household's electric use."[135] Indeed, we are seeing a rise of appliances and electronics and the portion of energy they consume, and as such, need to ensure we do not just focus on HVAC system optimization.

134 U.S. Energy Information Administration, "Use of Energy in the United States Explained: Energy Use in Homes," 5 Feb-ruary 2013. Retrieved June 1, 2018, from https://www.eia.gov/energyexplained/index.php?page=us_energy_homes.

135 National Resources Defense Council, "Plug-In Equipment Efficiency: A Key Strategy to Help Achieve California's Carbon Reduction and Clean Energy Goals," April 2015. Retrieved June 16, 2018, from https://www.nrdc.org/sites/default/files/home-idle-load-plug-in-efficiency-IB.pdf.

Conclusions

As with many research areas, delving into the current state of the smart home market and policy landscape has uncovered many additional, related research areas that warrant exploration. These include the following:

- How emerging smart home technologies can be used to maximize program performance, auto measurement and verification, and auto quality control.
- Successes and failures of smart home- and smart technology-related pilot programs, and how they addressed or failed to overcome barriers.
- Energy impacts of data centers necessary to store all of the new data generated from smart homes and smart technologies.

Further research into the above-mentioned areas could help identify barriers and potential solutions, both market- and policy-based, and advance the overall evolution of smart homes. This evolution offers benefits to homeowners, industry, utilities, and our nation's electrical grid, and truly revolutionizes the home performance industry and home-to-grid connection.