Smart Technologies and Connected Products: Early Adopter Toys or Gateways to Energy Savings?

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ABSTRACT

Appliance and heating, ventilation, and air conditioning (HVAC) manufacturers, security and telecom companies, and various service providers have promised a future where occupants can monitor and control every product from their smartphones, while these products also monitor and control equipment and communicate with each other. This functionality can automate mundane tasks, potentially enhancing comfort, convenience, and energy efficiency. Companies offer smart lighting that automatically adjusts according to occupancy and personal preference, smart outlets that turn off appliances overnight, and coffee pots that begin brewing based on your smartphone's alarm clock. But will such smart home technologies really save energy?

This paper investigates the potential energy and cost savings of a variety of smart home technologies, including lighting, HVAC, appliances and home energy management systems. We discuss the results of our modeling of the benefits and cost-effectiveness of smart home technologies relative to conventional renewable energy and energy efficiency measures. The paper also analyzes key trends and drivers in the smart home market, and potential energy impacts relevant to homeowners, manufacturers, and utilities.

Introduction

The explosion of wireless communication technologies and high-speed internet connectivity has transformed our lives. Today, many capabilities that would have seemed alien in 1990 are commonplace just a few years after initial introduction. Information technology has forever changed how people communicate with friends, read the news, hail a taxi, watch their favorite TV shows, find driving directions, and pay for groceries.

These new technologies improve upon earlier designs by leveraging powerful off-device computing and storage systems ("the cloud"), inexpensive compact sensors, and cheaper batteries. Leveraging the cloud allows devices to use less storage, processing, and other computing assets, thus reducing the size, cost, power consumption, and weight of these devices. For many activities, small sensors embedded in a mobile phone, wearable device, or home appliance can monitor their environment and relay data to cloud computing and storage facilities via wireless internet connections. The cloud then processes the data using algorithms, stores the data in a database for future use, and communicates updates back to the device. This computing model is often hidden from users; while they look at the data on their screens, a robust cloud infrastructure powers these amazing devices. For example, a marathon runner using the powerful data and communication capabilities of their fitness tracker can benchmark their training sessions and improve their performance.

In the smart home, connected products' goals are very similar to the marathon runner – monitor, benchmark, connect, and improve. In theory, the ability to monitor the status of everything in the home, track activities, and identify trends should lead to improved performance. Who wouldn't want the ability to control temperature, lighting levels, lawn sprinkler schedule, and oven timer remotely from their smartphone? But what are the tradeoffs and limitations of these emerging technologies? Could adding dozens of sensors and communication points within the home actually increase energy consumption?

Homeowners, manufacturers, utilities, and regulators should consider the potential impacts of these technologies. In this study, we characterize a wide range of internet-of-things (IoT) and connected home products and investigate their potential to provide energy and cost savings. We summarize available information on product capabilities and claims from device manufacturers and service providers and highlight recent research showing the potential side-effects of these new technologies in practice. We then model the benefits and cost-effectiveness of smart home technologies, including lighting, heating, ventilation, and air conditioning (HVAC) systems, and home energy management systems (HEMS) relative to conventional renewable energy and energy efficiency measures.

The Promise of Connected Home Technologies

As these technologies enable new and unique features for historically "unconnected" devices, traditional players such as manufacturers of HVAC equipment, appliances, and controls, as well as new players such as security providers and telecommunication giants, are racing to provide customers with novel, compelling, and beneficial products. Figure 1 highlights connected home technologies that promise a compelling future with a wide range of energy and non-energy benefits.

Figure 1. The Connected home of the future *Source*: Navigant.

The non-energy benefits typically focus on enhanced convenience, security, comfort, and peace of mind. Example products include:

- Connected LEDs that can synchronize with your smoke alarm system to alert you to a fire or follow an operating schedule to simulate occupancy while you are on vacation.

- Connected thermostats that can alert residents if the set point falls too low and pipes are at risk of freezing or that can send signals to other energy consuming products based on occupancy.
- Connected HVAC equipment that use fault detection and diagnostic alerts to warn of potential failures.
- Connected major appliances that can alert users when consumable supplies (e.g. filters, detergent, etc.) are running low and automatically order replenishments.

In addition to the non-energy benefits, these technologies are laying the groundwork for inexpensive long-term energy savings. Example products include:

- Plug load controllers (i.e., "smart plugs") with app-powered remote access that allow homeowners to turn off energy consuming products when they are away from home.
- Connected HVAC systems that use internet connectivity to change operations based on weather and other previously inaccessible data, such as a homeowner's proximity to home through their mobile phone's GPS.
- Connected appliances that can serve as dispatchable assets for utility demand response (DR) programs by curtailing load during major consumption peaks according to price signals or alerts from the smart grid infrastructure.
- Home energy networks that communicate with all of the home's IoT products and services to "turn the house off": causing the refrigerator to extend defrost cycles, storage water heater to lower temperature, lights to turn off, security cameras to turn on, and thermostat to adjust set points.

Perhaps the most notable promise of these new connected technologies is their relentless rate of improvement. Unlike more brute force energy efficiency approaches (e.g., larger heat exchangers), these technologies follow the continually advancing wave of software development and decreased computing costs. Additionally, the benefits of connected home technologies will continue to multiply as these products continue to integrate with each other. For example, on movie night, a single user interaction can "set the scene": your smart outlet will start your popcorn-maker, your connected fireplace sparks to life, your audio-visual systems switch to theater mode, and lights dim and change color based on personalized preferences.

Table 1 outlines the typical features for connected products as well as vendor claims for energy savings, non-energy benefits, and demand response capabilities. However, while most of these products claim energy savings potential, few quantify savings. Nevertheless, connected home products offer the opportunity to monitor, benchmark, and control the numerous individual plug loads that account for an increasingly large share of the home's energy consumption. Today, there is limited opportunity to reduce plug load consumption through normal efficiency standards or utility incentive processes, so new approaches will be needed to reduce their impact on overall home energy consumption and integrate these strategies into energy efficiency programs.

Table 1. Emerging connected products and vendor-claimed energy savings and other benefits

Product	Features and operating example	Claimed energy savings	Non-energy benefits
Lighting & controls	Features: Remote monitoring and control; scheduling; custom colors; personalization; integration Example: Scheduling connected lighting to fade on/off with sunrise/sunset	80-85% [1]	Convenience; experience; security; peace of mind
Smart thermostat	Features: Remote monitoring and control; adaptive scheduling; occupancy sensing; DR capable; fault alerts Example: Lowering set point based on occupancy	10-25%	Convenience; automation; comfort
Central HVAC & room AC	Features: Remote monitoring, control; scheduling; fault detection and diagnostics; DR capable; maintenance alerts; advanced zoning Example: Alerting users to unexpected operating conditions, equipment faults	Up to 30%	Convenience; comfort
Plug load controller (i.e., ”smart plugs”	Features: Remote monitoring and control; scheduling; energy measurement Example: Turning a conventional appliance into a smart one with remote on/off capabilities	Not quantified	Convenience, comfort; safety
Major residential appliances	Features: Remote monitoring and control; fault alerts; DR delay; energy monitoring; energy saver mode; automatic replenishment Example: Remotely extending drying time to prevent clothing wrinkles	Not well quantified; 30-50% claimed by some[2]	Convenience; performance; peace of mind
Integrated smart home platforms & security systems	Features: Remote monitoring and control; alerts; video recording; automation; DR capable Example: Vacation mode adjusts the thermostat, lighting, and security system	Not quantified	Peace of mind; convenience; safety; automation

Source: Navigant review of representative vendor claims in product literature.

Limitations of Smart Home Technologies

Connected home technologies often appear very attractive for their lifestyle benefits, but the realized energy savings are often underwhelming as these technologies pose unintended tradeoffs. Below, we highlight three common connected home technologies: programmable/ smart thermostats, connected lighting systems, and connected home platforms. While the connected home industry is still in its infancy and product developers can drastically improve the next wave of connected products, these current issues may temper the enthusiasm of homeowners purchasing the devices and other stakeholders promoting the systems for energy efficiency and other benefits.

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[1] Navigant assumes vendor claims for LED savings assume an incandescent baseline. This comparison may be true from a consumer perspective, but is not accurate relative to higher efficacy lighting options on the market today. Most vendors do not distinguish savings associated with the control capabilities with those from the LED bulbs.
[2] Few vendors quantify the energy savings from connected appliances, but the 30-50% estimate is based on vendor claims for several features on dishwashers and clothes washers.

Programmable Thermostats

HVAC systems (i.e. air conditioning and space heating) account for up to 47% of U.S. home energy consumption, so it's easy to see the value in control technologies that reduce HVAC energy consumption by even modest amounts (EIA 2013). Thermostats maintain indoor comfort for the homeowner by automatically controlling the HVAC system operation to maintain an indoor temperature set-point. However, because most homeowners do not change their thermostat settings regularly (i.e., turning set-points down when they leave the home, and back up when they return), HVAC energy is wasted by operating during unoccupied times or overnight. Programmable thermostats reduce energy consumption by changing the set-point temperatures for the HVAC system (+/- 5-6 °F) when homeowners are away from the house or sleeping. Modern programmable thermostats first debuted in U.S. homes in the 1980s, and HVAC manufacturers, utility energy efficiency programs, and other efficiency advocates promoted the technology as a way to reduce HVAC consumption by 5-15% (DOE 2016).

In theory, programmable thermostats should save energy for the majority of homeowners, and in many cases are very effective, but the widespread real-world energy savings do not match advertised figures. Studies examining programmable thermostats have revealed that the actual performance of current designs often fails to deliver their predicted energy savings for many users for the following reasons: auxiliary heating for heat pumps, proper usage of existing manual thermostats, poor initial scheduling and incorrect operation, and low customer awareness of energy-saving settings (Nevius and Pigg 2000; Plourde 2003; Combe et al. 2011).

In light of the technical shortcomings and over-predicted savings of traditional programmable thermostats, several manufacturers have developed the next generation of smart thermostats that attempt to resolve these issues using advanced features and control strategies. As noted above in Table 1, these smart thermostats include features such as easy and intuitive web scheduling, adaptive learning, occupancy and proximity sensing, optimized start-up and recovery, and homeowner feedback. Some products provide additional capabilities for a variety of utility demand response and other demand-side-management programs. Nevertheless, the most important goal of these next generation thermostats is facilitating the scheduling of temperature setback by minimizing the burden on the homeowner through increased usability and automation. For a homeowner, these thermostats would primarily offer the same unit energy savings of a well-maintained programmable thermostat (between 0-20%), but with some added features (Churchwell and Sullivan 2014; Nest Labs 2015).

Connected Lighting Systems

Connected lighting systems provide homeowners with several new capabilities. As smartphones become the primary computing interface for most consumers, centralized control is an attractive proposition relative to traditional light switches, dimmers, and occupancy sensors. Connected lighting systems usually involve a collection of LED bulbs with specialty bases that connect the bulb to the network, enabling users to control light levels (i.e., dimming), color changes, preprogrammed settings (e.g., movie setting), and other features. The systems can even automatically turn off when no one is home or have an "off" switch on a smartphone to simplify the act of turning every light switch off.

While the convenience benefits of this technology are clear, the energy savings of connected lighting systems are highly uncertain. Table 1 highlights manufacturer claims of 80-85% savings, but these numbers require careful consideration of the baseline. Connected LED lightbulbs can offer significant energy savings over incandescents and CFLs (e.g. 85% and 30% respectively) due to their core lighting technology, but LED bulbs do not need wireless connectivity to be efficient. With decreasing prices and wider availability in recent years, LED bulbs could be considered the new baseline, with connectivity considered a premium feature.

Several European studies have shown that current connected lighting products may actually increase, rather than decrease, home energy consumption, due to substantial standby mode operation. Traditional switches disconnect the flow of electricity to a lighting fixture, so bulbs draw zero standby power. Connected lighting products must always be listening for an "on" signal, so the bulb has a small, but meaningful, power draw (0.4-0.6 W) for all hours of the year (8,760 hours), leading to modest additional energy consumption (3.5-5.3 kWh/year). Most bulbs operate for only a fraction of the day (e.g. 2 hours), and because LED bulbs are so efficient (6.1 W), the actual annual consumption is small (4.5 kWh/year).[3] One study found that many connected lighting systems consume more than 50% of their annual energy in standby mode (Kofod 2015). When compared to a basic LED bulb, this represents a 50% increase in annual energy consumption unless the connected lighting system contributes additional energy saving benefits. By comparison, the connected lighting system would need to reduce operating times by 1.5 hours per day, or roughly 75% per year, to offset this increased consumption.

Connected Home Platforms

Many connected home product developers envision a future where every appliance and sensor is networked so that each point can share data, coordinate activities, and respond holistically to homeowner needs. For example, the occupancy sensing feature of one device can relay occupancy information to the security system, lighting system, and other devices. While this interconnectedness will provide convenience and other benefits, the products that power this functionality may also pay a significant standby or operational energy consumption penalty. For example, a smart plug consumes standby power while it is listening for an "on/off" command, and the plug also consumes electricity during operation to measure the consumption of the plugged-in device. Compared to conventional plug loads, the combined consumption these two operating modes across several dozen devices can add up to a significant plug load for the home. Figure 2 highlights the differences between standby and active mode for an analog and smart home. Compared to the on/off operation of the analog home, the smart home can save energy during active mode, but may consume additional energy during standby mode. The exact impacts of this standby/active mode tradeoff are difficult to predict even for a homeowner who fully understands their occupancy and consumption schedules.

[3] Navigant estimates for daily lightbulb use are based on two hour a day for average lightbulb from Gifford et. al. (2012). Consumption values were estimated from vendor literature and Kofod (2015).

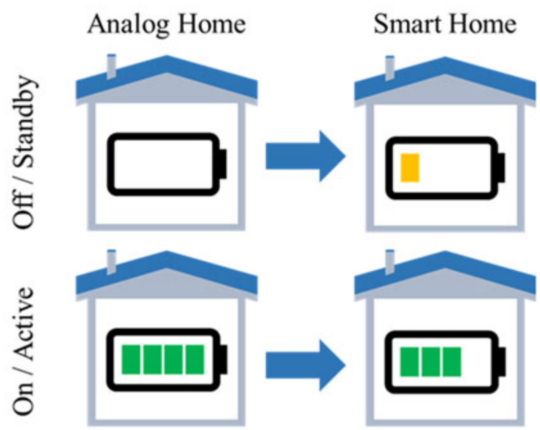

Figure 2. Mixed energy benefits of smart home of the future Source: Navigant.

Table 2 outlines the energy consumption for several lighting and plug loads in a typical home and projects the standby and operational consumption for the associated connected products. Without any additional energy savings opportunities, these connected products increase consumption by >800 kWh, which is the equivalent of adding nine 40 inch Energy Star TVs to the typical American household (EPA 2016). In the future, this issue should become less significant as the connected products of tomorrow should have lower standby consumption due to the natural product development lifecycle. The typical product development process for high-technology products includes a nascent period where developers unveil new features while accepting other drawbacks, which are addressed over time.

Table 2. Standby mode calculations

Product	Number	On mode unit consumption (W)	Standby unit consumption (W)	Collective standby consumption (kWh)	Notes / Assumptions
Smart light bulbs	67	12	1.00	536	8,000 hours standby, same active mode consumption as basic LED bulb
Smart plugs	25	1	0.25	107	6,000 hours standby, 2,760 active
Connected home hub	2	36	1.50	217	6,000 hours standby, 2,760 active
Total	94	-	-	859	-

Source: Average number of light bulbs per home from Gifford et. al. (2012). Power consumption information and number of smart plugs and connected home hubs based on vendor literature and Navigant judgment. Smart light bulb standby consumption can vary substantially from 0.2-2.0 W and greater (Kofod 2015).

Energy Modeling Study

In order to compare the energy benefits and potential penalties associated with these connected products, Navigant conducted a building simulation study to evaluate the energy savings for a range of energy efficiency technologies. We used the software program BEopt[4] to

[4] The U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) developed BEopt with the purpose of analyzing Zero Net Energy (ZNE) home designs (NREL 2016).

evaluate quickly the energy and utility cost savings of different technology combinations. The software performs an hourly simulation for each building end-use (e.g., lighting, water heating, etc.) and fuel type (e.g., electricity, natural gas, solar photovoltaic [PV]) using each combination of building features, time-of-use utility rates, and other parameters the user selects. Table 3 outlines the traditional and connected home technologies included in this analysis. We modeled the technologies according to a Building America benchmark home meeting baseline building energy codes for several climate zones (e.g., Chicago, Phoenix, Seattle, Atlanta). This includes standard assumptions for occupancy and non-weather-sensitive building loads (e.g., cooking, laundry, plug loads) for a 3 person, 2 bath, 2 story, 2400 sq. ft. home, and calculates HVAC energy consumption using TMY-3 weather data. The home uses natural gas appliances for cooking, water heating, space heating, and electricity for other end-use loads.

Table 3. Conventional and connected technology characteristics

Technology	Improvement over baseline	Technology characteristics and energy benefits
Air conditioner (AC)	SEER 16 vs. SEER 13	• Higher efficiency AC system reduces electricity consumption during the cooling season. • Savings will vary by climate with hotter climates (Phoenix) seeing greater savings than milder climates.
Furnace	95% AFUE vs. 80% AFUE	• Higher efficiency gas-fired furnace reduces natural gas consumption during the heating season. • Savings will vary by climate with colder climates (Chicago) seeing greater savings than milder climates
Solar PV	5 kW vs. no system	• Solar PV system generates on-site electricity to offset the home's electricity consumption and exports excess generation to the local electrical grid through net metering. • Savings vary by location, with greater savings in sunnier locations (Phoenix) than more cloudy locations (Seattle).
Connected thermostat	Daily setback vs. single setpoint temperature schedule	• WiFi or connected thermostats function similarly to a standard programmable thermostat, but have higher likelihood of initial setup and proper operation of setback, and potential for additional setback. • For this study, we evaluated two scenarios: 1) daily setback vs. a single setpoint temperature, and 2) an additional +/- 3 °F setback vs. daily setback.
Connected lighting	100% LED vs. 34% CFL, 66% incandescent baseline	• WiFi or connected lighting systems function similarly to traditional light bulbs, but have additional capabilities to turn off when occupants are away. • For this study, we evaluated two scenarios: 1) basic LED vs. a baseline of 34% CFL, 66% incandescent, and 2) connected LED vs. basic LED.
Smart plugs	25% reduction over baseline plug loads	• WiFi or connected plugs function similarly to standard electrical outlets but provide tracking capabilities and remote shutoff. • These features provide energy savings by turning off seldom used devices overnight or overtime, and altering consumer behavior when occupants see their consumption.

Table 4 highlights the energy and utility cost savings percentages from different traditional and connected home technologies. Both sets of technologies provide energy savings, but vary based on the climate region and assumptions for baseline technologies. The energy savings of traditional technologies are largely dependent on climate region, whereas many connected products focus on plug load applications, which do not vary substantially with climate. Connected home technologies can provide savings over an inefficient baseline, but savings decrease compared to newer homes and products that already incorporate non-connected energy efficiency features.

Table 4. Energy and utility savings results

Technology		Energy savings % (Source MMBtu) - location		Utility cost savings % - location	
		Low	High	Low	High
High efficiency AC		1% - SEA	7% - PHX	1% - SEA	7% - PHX
High efficiency furnace		1% - PHX	9% - CHI	1% - PHX	6% - CHI
Solar PV system		31% - CHI	49% - ATL	29% - SEA	67% - PHX
Smart thermostat	vs. no setback	4% - All sites	4% - All sites	3% - CHI	5% - PHX
	vs. basic setback	1% - All sites	1% - All sites	1% - CHI	3% - PHX
Smart lighting	vs. baseline	3% - CHI	7% - PHX	3% - SEA	5% - PHX
	vs. LEDs	-1% - CHI	-2% - PHX	-1% - All sites	-1% - All sites
Smart plugs		2% - CHI	5% - PHX	2% - SEA	4% - PHX

Table 5 highlights the initial cost, incremental cost and simple payback period of various traditional and connected home technologies. The traditional technologies have significantly higher upfront costs than the connected home technologies. Traditional equipment serves a core function of the home, and even baseline equipment has a significant capital outlay. Connected home technologies have lower initial and incremental costs and are attractive "add-on" technologies for existing buildings. These connected home technologies are relatively inexpensive today and will continue to decrease in cost as adoption moves beyond early adopters. Traditional technologies, besides solar PV, have limited opportunities to rapidly reduce costs going forward. The payback periods for both traditional and connected home products exceed the often quoted 3-5 year reasonable payback window, which is why utility incentive programs regularly offer rebates to lower the payback period. For connected home technologies, stakeholders should recognize the products' non-energy benefits rather than energy savings, because comfort, convenience, and other factors are the primary drivers for their adoption.

Table 5. Initial cost, incremental cost and simple payback results

Technology		Initial cost (whole home)	Incremental cost (whole home)	Simple payback (years) - location	
				Low	High
High efficiency AC		$5,788	$582	4 - PHX	65 - SEA
High efficiency furnace		$3,713	$960	8 - CHI	49 - PHX
Solar PV system		$22,848	$22,848	16 - PHX	52 - SEA
Smart thermostat	vs. no setback	$250	$250	1 - PHX	2 - PHX
	vs. basic setback	$250	$150	3 - PHX	19 - PHX
Smart lighting	vs. baseline	$799	$727	2 - PHX	3 - PHX
	vs. LEDs	$799	$727	Negative	
Smart plugs		$1,000	$1,000	14 - PHX	31 - SEA

Note: Technology costs provided by BEopt v2.6 (NREL 2016) Lighting costs reflect 2012 LED costs (10x over base), which are significantly higher than today's costs for individual bulbs, but are still relevant for connected products. Solar PV costs reflect $3.67/W-DC for panel and $4.57/W-DC for full install w/ inverter, but will vary by location.

Summary

This study characterized and evaluated several important connected home technologies on the basis of energy savings and other benefits. The simulation and standby analysis identified areas where connected home technologies have potential energy consumption deficiencies, especially relative to traditional energy efficiency measures. Currently available connected home technologies, which are sometimes marketed for their energy efficiency benefits, may offer negligible energy savings. In some cases, the products may even increase the home's energy consumption and utility costs. Nevertheless, these systems are attractive to homeowners due to their significant non-energy benefits, while manufacturers, utilities, and other stakeholders are interested in greater customer engagement opportunities. In the future, connected product developers will reduce standby consumption, improve the interconnectivity of their devices, and enhance their capabilities to provide aggregated services to utilities through greater customer engagement, behavioral energy efficiency, demand response, and other grid services.

Conclusions and Recommendations

The results of this study suggest that energy savings are not currently the key driver for further adoption of most connected technologies. Even where energy savings exist, consumers will purchase these products primarily for the comfort, convenience, and peace of mind benefits. Furthermore, while these products are in their infancy, many early adopters purchase these products for novel recreational use. Product designers and early adopters are recognizing the significant benefits in providing a more seamless experience for entertainment, security, lighting, and comfort systems. Just as early car owners rejoiced when simple keys replaced their engine crank, so too next generation homeowners are enthralled by a future where the tap of a finger replaces manually controlling all of the light switches in their home. While the current state of the connected home should be viewed as progress compared to the analog home of today, continual technology development over the next few years will bring the market closer to realizing the connected home vision.

Although the study did not find large energy savings for any single connected product, there are other energy benefits that may be attractive to stakeholders. Manufacturers, utilities, service providers, and policymakers should leverage the capabilities of connected products that customers are installing in their homes, in order to enable greater aggregated impacts. As the connected home enables easier consumer-utility communication, energy service providers can enable greater penetration of DR programs in homes. Improved sensing and communication capabilities allows contractors to more closely monitor their customers' HVAC systems to benchmark performance and identify faults in need of repair. Utility customer engagement programs can identify the operating profiles for more devices within the home and provide more specific recommendations to reduce a customer's energy consumption.

The next several years will see a wide range of stakeholders looking to enter the connected home market. Start-ups and emerging players will test business models that create entirely new services, while existing players may incorporate connected products and services incrementally as a premium service offerings. Potential participation in utility energy efficiency and demand-side management programs will require new program designs and evaluation methods, especially for behavioral and plug-load efficiency programs. Ultimately, consumers' thirst for non-energy benefits will create market pull, but manufacturers, service providers, utilities, policymakers may also push the market to help achieve their objectives.

As the market for connected products continues to grow, stakeholders must collaborate, recognizing and addressing each other's needs, priorities, and goals. Cooperation on research and development (R&D) activities can further reduce the cost and complexity for connected home technologies and improve their capabilities. Further modeling studies and field trials can better quantify the benefits that different energy savings, DR, and grid service opportunities from connected home products. These cooperative activities can reduce the cost and complexity for connected home technologies and help unlock their potential to deliver beneficial services to homeowners and the utility grid. Table 6 outlines specific recommendations for manufacturers, service providers, utilities, and policy makers.

Table 6. Recommendations by stakeholder

Stakeholder	Recommendation	Benefits/Impacts
Manufacturers	• Partner with independent third parties to standardize and validate energy savings and DR capabilities • Target enhanced comfort, convenience, and performance attributes in product development and marketing • Leverage existing connected home platforms when entering the connected space	• Increases credibility with consumers, utilities, and policy makers • Creates opportunities for greater customer engagement to sell premium products and services and develop recurring revenue streams
Service Providers	• Target largest savings opportunities first, but look to aggregate the large number of individual plug loads in the home • Accelerate open communication protocol development for cross-compatibility of products, platforms, and services	• Increases brand awareness and the variety of services the company can provide to customers and utilities • Enables greater competition among individual vendors, which improves the cost and capabilities of individual products
Utilities	• Conduct pilots to understand benefits, especially around plug load controls • Perform rigorous evaluations (e.g., randomized control trials) of energy savings of new products before providing incentives • Design, implement, evaluate, and report on connected home energy savings programs to further validate technology potential	• Improves customer engagement and insight to tailor energy savings opportunities for each home • Identifies promising strategies to incorporate more home appliances and plug loads into efficiency and DR programs
Policy Makers	• Conduct modeling and field studies to understand the capabilities of connected home products to provide aggregated demand savings and behavioral savings • Provide R&D support for technology developers to develop and demonstrate their new connected products and services • Investigate the impacts of connected product features on minimum appliance efficiency standards and voluntary specifications to prevent unintended efficiency losses. • Support policies and standards that ensure privacy, security, interoperability, and transparency for connected products	• Provides independent and credible information to consumers, utilities, and other stakeholders • Maintains the energy savings benefits of appliance efficiency standards and voluntary programs while supporting innovation and economic development

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