ENERGY STAR® Smart Home Energy Management Systems
2018 Work Group Summary
February 2019

On June 26, 2018, the Environmental Protection Agency (EPA) released a discussion guide announcing a new initiative to explore ENERGY STAR recognition of Smart Home Energy Management Systems (SHEMS). At the 2018 ENERGY STAR Products Partner meeting, EPA announced the creation of stakeholder work groups focused on key topics to explore to inform a Draft 1 performance specification. Each work group was co-chaired by EPA and a stakeholder. Participants in the four work groups that ultimately went forward met via conference call about twice a month through the end of 2018. Below are the work group focus areas and the key question they were tasked with addressing:

1. **Characterizing an "away" hour:** co-chair from National Renewable Energy Laboratory (NREL)
    - What is a simple and practical way to characterize an hour with effective energy optimization?
2. **Miscellaneous energy loads:** co-chairs from Argonne National Laboratory (ANL) and Consumer Technology Association (CTA)
    - How important is managing MELS with occupancy information and what strategies would lead to the most energy savings?
3. **Occupancy detection methods:** co-chair from Alarm.com
    - Which occupancy detection methods (or features) would be sufficient for this type of program?
4. **Demand Response (DR) & Distributed Energy Resources (DERs):** co-chair from Northeast Energy Efficiency Partnerships (NEEP)
    - How might integration with demand response and distributed energy resources work to help mitigate demand issues and unintended consequences?

The opportunity to participate in the work groups was made available to a broad range of stakeholders. The size of each work group ranged from 55-95 members with varying backgrounds, including utility energy efficiency and demand response program managers, academic researchers, national labs, device manufacturers, and service providers. Following is a summary of the vision informed by the work groups and individual discussion summaries from each work group. Questions regarding this effort can be sent to smarthomesystems@energystar.gov.

Next Steps: EPA hopes to release a Draft 1 ENERGY STAR specification and evaluation method by the end of the first quarter of 2019. Stakeholder engagement following the release of Draft 1 is encouraged; follow the development process at www.energystar.gov/shems.

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Vision

Based on the excitement and diverse contributions in the work groups, stakeholders share a vision of SHEMS that realize the full potential of integrating whole-home connected technology. While it was also clear that this potential cannot be realized immediately, stakeholders agreed that the ENERGY STAR program is uniquely positioned to work towards it.

In the long term, the work groups envision a SHEMS capable of measuring and controlling the primary flows of energy in the home including major loads, energy storage, and energy production assets. These would include space heating and cooling, dehumidification, water heating, electric vehicle charging, pool filtration pumps, battery storage, and on-site power generation. Ideally all connected devices could communicate to the SHEMS "brain" about energy use and receive a signal when the SHEMS indicates an opportunity for energy management that benefits the user.

The SHEMS could further deliver value for load flexibility by seamlessly coordinating the response of the whole home to grid conditions, so that customers are minimally affected, and the utility or aggregator has only a single entity per home to contract and communicate with. That communication could allow utilities to easily access the entire home's load balancing capability. In a situation with varying electricity price, the SHEMS could be capable of optimizing the home's energy use to keep bills as low as possible.

The nearer term vision is a SHEMS than can be used with devices that are commonly connected today and capable of supporting those that will be connected in the near future. SHEMS would drive energy savings by leveraging occupancy information, user-friendly energy management, and convenience. An ideal SHEMS would rely on various occupancy detection tactics to identify opportunities for energy optimization and seamlessly align the response of the home to the users' needs and, potentially, to grid conditions. Consumer burden associated with energy management would be reduced by providing simplified system control and autonomous operation without sacrificing comfort and user experience. At the same time, all systems would allow for ultimate consumer control or override. To support that vision, interoperability amongst all connected devices in a home would allow systems to easily communicate and expand.

EPA looks forward to working with stakeholders to craft a first of its kind ENERGY STAR program that builds toward this vision. Our goal is a program that:

- accounts for current market realities
- provides flexibility for a growing market
- provides a range of options for consumers
- delivers a meaningful way for service providers to differentiate their products
- realizes energy savings and promotes energy management solutions that benefit consumers and the environment.
- provides incentives for systems to evolve toward the shared vision of SHEMS that realize their full potential.

Away/Device Mode Workgroup

The "Away" (later renamed "Device Mode") work group met four times via Skype. More than fifty stakeholders signed up for this work group and roughly twenty attended each call. The group focused on identifying "away" mode SHEMS features that are critical to facilitating energy savings, primarily by leveraging occupancy (or vacancy) information.

The work group focused on a subset of household end uses deemed most suitable for facilitating energy savings in response to an "away" signal. An "away" signal could come from any component SHEMS device, such as a thermostat, or from another source of occupancy information in the home. The group assumed that an ENERGY STAR certified SHEMS would include an ENERGY STAR certified smart thermostat, thereby addressing the critical elements of home comfort and energy savings. The service provider stakeholders confirmed that integration with smart thermostats is currently common practice and that, while not yet common, further integration with the other critical devices such as water heaters has been developed by certain providers and is on the horizon for the broader SHEMS market.

Having identified key devices and assessed the state of the market, the group considered definitions to characterize different types of "away" modes and the practical limitations around how devices could respond to an "away" signal. Encouraging SHEMS to go beyond scheduled events to capture savings during unscheduled vacancy without negatively impacting the end user experience was a main focus of these discussions. Service providers are well equipped to develop strategies (such as intake surveys to customize preferences) to ensure a positive user experience, which in turn would maximize the likelihood that users would keep the energy management features of the SHEMS activated.

The group then sought to identify ways in which an ENERGY STAR specification could address the effectiveness of a SHEMS against two different metrics: energy savings and consumer satisfaction. Though this conversation was productive, the group struggled to identify concrete specification and data requirements.

Definitions

The work group proposed and discussed the following definitions.

"Away" Certainty: Different categories of the "away" state that would impact device mode responses were identified as follows: Scheduled, Certain (detected and confirmed by the user), Detected High Confidence, Detected Medium Confidence, Detected Low Confidence.

"Away" Duration: Duration categories of "Away" status were identified as follows:

Short Term	Medium Term	Long Term
Gone for lunch 1-2 hours; gone for workday 8-10 hours	24-72 hours	> 72 hours

Device control

Providers of SHEMS have only so much control over the devices that are connected, their capabilities and their controls. Some devices may be managed by simply powering them off while others may need to be put into a lower power or sleep mode, depending on their function and the length of time people are away. For some products, allowing a certain degree of control, such as setting upper and lower limits, to be left to the device manufacturer would help ensure a positive user experience. For devices such as a smart thermostat, the SHEMS could simply convey the occupancy information for the device to make its own best decision for operation.

Away Conditions and Operating Modes

Create a table for each end use that lists operating modes / actions specific to that end use and that are based on the type and length of Away period

The sample tables below may have too many columns and too many rows for most end uses, but is meant to provide a general illustration of possible details

Various classifications for devices may be helpful, e.g. devices that require long lead up times before occupant can access primary function like a water heater (long recovery devices (hours) vs short recovery (minutes))

example: thermostat controlling heat	This example of a thermostat may actually provide far more flexibility in operating modes other end uses			
	Length of Away Time			
Away source/certainty	**Short (<1 day)**	**Medium (1-2 day)**	**Long**	**Unknown**
Scheduled	set back 4F, recover for ETA	set back 6F, recover for ETA	setback 10F, recover for ETA	
Certain: e.g., detected and confirmed via notification, active trigger	same as scheduled			same as scheduled short term
Detected - high confidence	If there is an inferred ETA, then use that for planned recovery but limit setback to Short Away (4F) in case of error in ETA or keep setback so that recovery time is <1 hour			setback so that recovery can be
Detected - medium confidence				setback so that recovery can be
Detected - low confidence				

GAS OR ELECTRIC RESISTANCE WATER HEATERS	Length of Away Time			
Away source/certainty	**Short (<1 day)**	**Medium (1-2 day)**	**Long**	**Unknown**
Scheduled	no action	set back 10F/120F or adjust stratification for less hot water, recover for ETA	turn to vacation mode (lower temp), recover for ETA	
Certain: e.g., detected and confirmed via notification, active trigger	same as scheduled			same as scheduled short term
Detected - high confidence	If there is an inferred ETA, then use scheduled actions for length of Away, but keep setback to no more than Medium Away in case of error in ETA			no action
Detected - medium confidence				no action
Detected - low confidence				no action

Specification and Data Elements

The work group discussed control strategies for electric resistance water heaters and lighting. The water heater discussion was based on the experience of one hot water heater controller manufacturer and revealed that additional follow up would be needed to address heat pump water heaters and lessons learned from existing water heater control programs. The group agreed that a potential data reporting requirement for SHEMS to demonstrate energy savings could include time spent in specific modes (as applicable).

Miscellaneous Electrical Loads (MELs)/Plug-Load Workgroup

The MELs work group met five times over the phone. The discussions initially focused on what defines a miscellaneous electric load (which led the group to using plug-load terminology instead) and which plug loads could be realistically impacted by solutions such as smart plugs, smart strips, and home energy submetering systems.

Once the group agreed upon scope and basic definitions, the discussion moved to what aspects of these devices could realistically be controlled and/or measured. The group overwhelmingly felt that, as part of a SHEMS, these devices must be able to provide remote on/off control, either through user-input or through control by the SHEMS system itself. In this group, the desire to know *what* is plugged into each of these receptacles was not as strong as the desire to know how much energy was being drawn from them and to have the ability to control those loads as appropriate.

With an idea of what it wanted from these devices, the group focused discussion on ensuring the smart plugs and strips not add notable additional energy load. Data collected from several stakeholders and public data sheets available on manufacturer websites revealed that most of these products (for which data are available) use around 1 watt or less in standby mode. A small number of poorly performing products were shown to be consuming as much as 5 watts in standby, with no discernable additional features compared to the rest of the market. A majority of the group felt it is important to constrain standby energy use, as a single 5-watt equivalent continuous standby draw equates to nearly the annual energy consumed by a typical notebook computer[1].

While current smart plug and power strip technology is straightforward in operation, there is a desire in the future for better communication between the plug load and the SHEMS system. Certain products, mostly electronics, can respond poorly to loss of power without a shutdown sequence. If communication protocols can advance to allow a SHEMS system to directly control the operational modes/states of plug load devices with a SHEMS system setting, user experience can be maintained while allowing the possibility of additional energy savings. This type of communication may also lead to additional flexibility in transferring energy use data from the edge product to the SHEMS system to inform the end-user and/or be collected by the service provider for utility or other purposes.

Definitions

The following definitions were used by the workgroup:

Smart Plug: A 120/240 Volt wall outlet or device which is placed between a standard outlet and a device's power plug. This device offers the ability to be controlled by a wireless remote or app using Wi-Fi, Bluetooth, or other wireless communications protocols. Most advanced smart plugs offer the ability for preset timed events, surge protection, and current draw feedback.

Smart Power Strip: A device placed between a power outlet and more than one edge device's power plugs, which provides functionality like a group of smart plugs defined above.

Specification and Data Elements

The work group discussed potential specification requirements and data reporting elements that would help support meaningful plug load solutions in a SHEMS package and would deliver data helpful to evaluating system performance. Those discussed included:

1. **A SHEMS package could include at least one of the options listed below. Multiples of the same device could be acceptable.**
   a) At least one smart power strip
   b) At least two smart plugs
   c) At least one home energy sub metering system

2. **Smart plugs and power strips could be held to the following criteria to be eligible for inclusion into the SHEMS package:**
   a) able to communicate with the SHEMS system. Cannot only operate as a stand-alone device.
   b) capable of turning controlled devices on and off remotely via the SHEMS based on occupancy or homeowner control (e.g. remote control, phone app).
   c) not consume more than 1 watt in standby mode

   Suggested Data to collect:

   Plug Control Data for qualified product exchange (used for certification and web listings):
   - type(s)

[1] https://www.cta.tech/CTA/media/policyImages/Energy-Savings-from-Five-Home-Automation-Technologies.pdf

- brand and model name(s)
- communication method (Wi-Fi, Z-Wave, ZigBee, Bluetooth, wired, etc.)
- standby energy consumption
- special features (scheduling, Alexa/Google assistant compatibility, occupancy, display vs. control of energy use)

Field Data from Service Provider Installments:

- number of smart plugs/strips connected per installation
- percentage of plugs installed that report energy consumption of controlled device
- types of connected loads (pick list, provided by homeowner, provided by some products)
- what rooms are these devices installed in? (installer verified, homeowner survey)
- distance from uncontrolled to controlled outlets

Occupancy Workgroup

The occupancy work group discussions initially focused on the sensitivity, reliability, and effectiveness of occupancy detection and how use of that information would impact the people and pets in a home. The work group explored different characteristics and desirable features of various occupancy detection methods and developed vocabulary about how a SHEMS would use occupancy information to trigger energy management events. The group explored a variety of use cases to think through how different systems could support different user needs and preferences and determined in the end that much of the customization and customer support should be managed by service providers. The work group shifted then to discuss the core tenets and definitions needed to establish requirements for occupancy detection that would make SHEMS valuable in delivering energy savings and energy management services.

The group discussed how reliable and accurate occupancy detection was key to ensuring a positive consumer experience and how users needed to be able to override events or actions when the system got it wrong. We group also discussed what would be helpful to evaluate how well different approaches to occupancy detection are performing in terms of optimizing unoccupied spaces or dwellings.

Definitions

In addition to leveraging definitions from the discussion guide, this work group developed provisional definitions for the following terms to aid in discussions.

Occupancy scope-humans, pets, and level of activity are important for determining sleep mode and pet mode. Occupancy may thus include assessment of the presence, quantity, and level of activity of humans and animals at the room, space, floor or dwelling level. All inclusive of a variety of methods of detecting dwelling and space level occupancy with examples.
Persistent Occupancy Device: A device that detects room, space or dwelling level occupancy that is always present in home. This could be a sensor integrated into another product or a standalone sensor or mechanism that can detect and communicate dwelling or space occupancy.
Transient Occupancy Device: A device that detects room, space or dwelling level occupancy that is not always present in home, this could be a sensor integrated into another product or a standalone device like a garage door opener or mobile phone that can detect and communicate dwelling or space occupancy.
Explicit/User generated events a.k.a. Hard trigger – initiated by a user (lead user) as an active and explicit input -e.g. setting up a schedule (home, away, vacation, sleep) or action through an app,

commanding a voice assistant or arming a security system or actively pressing a button on a physical thing in the home. (Excludes confirmation from a soft trigger notification).

Implicit/System generated events a.k.a. Soft trigger – passive and inferred at the dwelling level where system acts based on occupancy information alone without user input. E.g. Arm stay + sensor activity = passive – some people leave but don't arm their security systems. Must include the ability for user(s) to override (option to ignore or undo each event). Suggestion to use layering of multiple indicators for this but likely only one method would be required. (System generated events)

Suggested trigger: Combination of System + User Generated Events a.k.a. Opt-in events – notification to user(s) of optimization event based on occupancy info (machine learning, AI etc) + requires user to confirm in order for action to take place.

Specification and Data Elements

The work group discussed the following potential specification requirements and data elements that would support effective SHEMS occupancy detection and be helpful in terms of evaluating systems:

1) **System capability to automatically understand vacancy or occupancy in a home without active user input**. **Suggested requirements:**
    a) Package could include at least one line-voltage powered persistent device that detects occupancy or vacancy or more than one device (if battery powered) for soft triggered events.
    b) SHEMS could be able to receive a minimum set of occupancy data, act on it, and then transmit it to products connected to the system.
    c) SHEMS could communicate occupancy information through a central control point that can share that information with all connected devices.
    d) Minimum occupancy data would be transferable among devices with/without aid of cloud connection (additional information can be communicated via cloud). System should be able to communicate occupancy information to trigger designated away modes for energy management. Note there was disagreement among group members on reliance on the cloud.
    e) SHEMS should be able to send return occupancy signal to connected devices without cloud communication.
    f) **Suggested Data to collect:**
        i) core system means for detecting and communicating occupancy
        ii) methods deployed per installation
        iii) means for validating that occupancy information is collected and shared

2) **Reliable persistent occupancy is important** How might we ensure that occupancy detection persists? Require line voltage or redundant devices as suggested above? Alerts to user and service provider when system is not fully functional e.g. Battery, loss of connectivity, loss of efficacy, obscured, blocked?
    a) **Proposed requirement:** System would have a resolution and notification process when occupancy detection is not working properly.
    b) **Suggested Data to collect:** Description of that process.

3) **System should have flexibility in how occupancy information is used. Proposed requirements:**
    a) SHEMS should be capable of producing events by explicit, implicit and suggested triggers.
    b) SHEMS should indicate whether it has capability for demand response events from device or utility.
    c) System should include a method for allowing a user to configure sensitivity or preferences to adjust how responsive the system is to inputs of occupancy.

d) System should have capability to capture quickly why a suggested event is declined and report that data.
e) **Suggested Data to collect:**
   i) x hours away trigger by x, + x devices participating in given event.
   ii) Average number of suggested events that are enabled.
   iii) Average number of suggested events that are declined and reasons why.
   iv) Average number of times a user overrides an implicit soft trigger within 20 minutes of trigger - this means that a user actively counters an implicitly triggered event by interacting with their system within 20 minutes of the event being triggered.

Demand Response/Distributed Energy Resources Workgroup

The workgroup had strong agreement on a shared vision of what would make a SHEMS most valuable for DR/DERs (reflected in the overall vision above). However, it was clear from the discussions of the DR/DER Workgroup that most of the smart home products that are immediate candidates for the SHEMS program focus on providing customer amenity, rather than robust energy or demand management. Given this, we focused us on how we might facilitate progress towards that vision by encouraging SHEMS to include constructive building blocks. We talked about potential specification requirements and some data collection that would be helpful to encourage those building blocks.

Building Blocks

The most important building blocks we identified are:
1) Components attached to the SHEMS (e.g. smart plugs) would be able to estimate or meter energy consumption and communicate it to the SHEMS in a standard way.
2) SHEMS would be able to aggregate energy use information from disparate sources into a coherent picture. (Note that thermostats generally only know run time of equipment, not energy, so this will not be immediately deliverable for all devices.)
3) Feedback about how the home responds to grid signals is useful in aggregate and per home. Which devices turned off or turned down? Was the response overridden? Etc.

Requirements and Data Elements

The work group discussed the following potential specification requirements and data elements:
1) Smart plugs would be of value if they provide an estimate of power flowing through them.
2) Capability to notify residents about upcoming DR events, allow overrides before and during events, and include data on the percent of DR events that were overridden.

Other issues discussed without reaching consensus

There were several topics the group discussed without coming to agreement. We present some of these topics here, with the thought it could be helpful to others.

Smart home architecture: The group discussed the variety of architectures for smart homes, including those without hubs, where device integration happens in the cloud and the central control point is an app or something similar. We concluded that these variations on the architecture are not immediately relevant to the SHEMS effort.

How smart plugs are used in the home: Surprisingly, 240V devices like electric resistance water heaters and simple EV chargers may be connected through smart plugs, at least in one vendor's system. The group discussed whether it would be possible to know what kinds of loads are connected to the SHEMS, without coming to a clear conclusion. It was clear that whatever energy data is available through the SHEMS, the real customer value comes when it's converted to actionable information.

Pay for performance and SHEMS data: The group discussed the value of the SHEMS to report the response of devices in the home to DR requests, as part of a pay for performance program model. The group generally agreed that this was not yet an important feature due to limited time of use pricing models nationwide. Data from thermostats has been integrated into such programs only after showing correlation with smart meter measurements. A similar process could be used for SHEMS device data, but the question is vastly more complicated – for instance, a load connected to the SHEMS could be reduced, at the cost of a larger load in the home that isn't connected to the SHEMS. However, while it could be some time before this data is useful for pay for performance, it is immediately useful for program targeting, considered in aggregate. For instance, do the homes with dryers communicating with the SHEMS tend to show more robust DR response?

Use cases: Many thought it would be helpful to have a matrix of use cases mixing grid needs and conditions with DERs available in the home, to be able to explore energy management capabilities. It was suggested that a recent SEPA report contained something similar, but we were not able to find it spelled out, nor did the group have time to work this out.

Enrollment: How a household with a SHEMS is enrolled in a DER or DR program is clearly important. There was some concern that households might end up in a "bad" DR program and have an experience which biases them against such programs in general. There was some discussion of potential guidance for programs. The idea was also raised of making sure SHEMS provide a channel to notify customers that they are in fact enrolled in such a program.

Total opt-out vs. reduced response: There are many cases where there may be an option for a reduced response to a DR request, instead of opting out completely. For instance, a household could set up their thermostat two degrees instead of four. We did not have time to explore this idea further.