The Smart Energy Home: Strategies to Transform the Region

October 2016

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About NEEP

NEEP was founded in 1996 as a non-profit whose mission is to serve the Northeast and Mid-Atlantic to accelerate energy efficiency as an essential part of demand-side solutions that enable a sustainable regional energy system. Our vision is that the region will fully embrace next generation energy efficiency as a core strategy to meet energy needs in a carbon-constrained world.

Disclaimer: NEEP verified the data used for this white paper to the best of our ability. This paper reflects the opinion and judgments of the NEEP staff and does not necessarily reflect those of NEEP Board members, NEEP Sponsors, or project participants and funders.

Executive Summary

Northeast Energy Efficiency Partnerships (NEEP), the regional energy efficiency organization for the Northeast and Mid-Atlantic, has been working to advance energy efficiency for decades. Since 2014, NEEP has been exploring and advancing the opportunities within Home Energy Management Systems (HEMS) to advance efficiency in the residential sector. In 2015, NEEP released a comprehensive report analyzing the various opportunities for HEMS.[1] This report found opportunities for HEMS through various technologies, delivery channels, types of homes, types of programs, and fuel types. While energy savings have been documented for many HEMS, some of the most promising opportunities from these devices and systems lie in other energy-related benefits. Building on that report, this report takes the research a step further to present market updates, a regional goal, and here-and-now strategies to drive market transformation and achieve the myriad benefits from HEMS.

First, NEEP establishes definitions and terminology within this space. While HEMS has had an official definition as established by the HEMS Working Group, NEEP identifies four key functionalities that we think are critical in order for a product or system to be considered "smart." Furthermore, we draw a distinction between "smart homes" - that have a great deal of connection components, and "smart energy homes" - that have some of the major energy end uses with the aforementioned smart functionality. These end uses include heating, ventilation, and air conditioning (HVAC); water heating; and plug loads, including both electronics and appliances.

When attempting to update the state of the HEMS market since the 2015 report, NEEP starts with a description of the technology, breaking up the major energy using systems into the incumbent technology, HEMS product category, and cost differentials between the two. Several important metrics and standards efforts have been underway in the past year, most notably ENERGY STAR's connected thermostat and other connected product specification efforts. Standby power, which has become a significant concern for some smart products such as smart lighting, is addressed. The energy costs of standby power must be outweighed by the range of benefits they provide in order for investments in any product to be recommended; as such, the net benefits for smart lighting, while looking promising, is yet to be determined and may hinge on the standby power levels.

The interest in and demand for smart products is growing amongst consumers. Of all trends that have taken off since the 2015 report, voice recognition devices, such as Amazon Echo, are perhaps most noteworthy. With other competitors such as Apple HomeKit with Siri and Google Home entering this market, the potential of voice control to integrate with efficiency and penetrate households is significant. Both online and brick-and-mortar retailers are ramping up investments in the smart home. Home security is also growing as a HEMS delivery channel, particularly for smart thermostats. Each of these present opportunities for increased focus on energy benefits and building partnerships to ensure mutual benefits.

Looking at various smart products and their potential for energy savings, demand response, load shifting, and integration with distributed energy resources, a few smart products rose to the surface. Smart thermostats,

[1] 2016, Northeast Energy Efficiency Partnerships, Opportunities for Home Energy Management Systems (HEMS) in Advancing Residential Energy Efficiency Programs, http://neep.org/opportunities-home-energy-management-systems-hems-advancing-residential-energy-efficiency-programs

smart water heating, some smart appliance, and smart plugs, outlets, or switches emerged as having the greatest opportunity for energy benefits. While other HEMS were found to be beneficial, those focused on the three major energy end uses (HVAC, water heating, and plug loads), were the smart devices with the most potential.

There are also several existing HEMS programs and efforts, including several smart thermostat promotions throughout the region. Additionally, there are policies supporting the development of the smart energy home in both California with AB 793, and within the Northeast with the New York REV proceeding.

Taking all of the market developments into account, NEEP analyzed the information to find the major barriers and opportunities to accelerated market adoption. The primary barriers identified are:

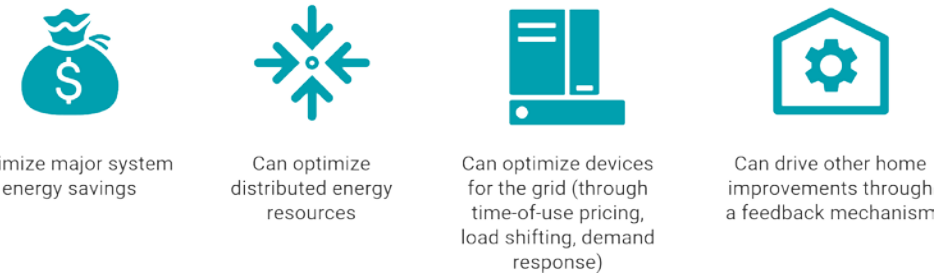
1. Energy Efficiency Program barriers: limited energy savings potential for all products except smart thermostat, evaluation difficulty of HEMS, and equity challenges (as these are expensive, non-critical devices).
2. Consumer barriers: low consumer awareness, security concerns, challenges with device set up/ease of use, and Wi-Fi (common protocol, but imperfect in application).
3. Technology barriers: primary focused on interoperability.
4. Grid barriers: particularly that Advanced Metering Infrastructure (AMI) is inconsistent throughout region.

While there may be many market barriers, there are also several HEMS market opportunities that can be exploited. These are outlined briefly below:

Program opportunities: primarily that program administrators already have product rebates in place, making it easier to expand promotion to smart products.
Customer opportunities: including increased interest in smart home technologies, especially voice-controlled interface devices (such as Amazon Echo), and home security as motivator for investment.
Technology opportunities: new smart products entering the market, many of which have or are close to having the desired functionalities to be considered “energy smart.”
Grid opportunities: specifically that there is an increased need to manage peak electricity use and also an increased appetite for distributed energy resources.

Given the barriers and opportunities, NEEP developed the following regional goal:

Regional Goal: **By 2030, more than 50% of total homes (75% of new construction) in the Northeast and Mid-Atlantic have at least two “energy smart” major systems (HVAC, water heating, plug load). This means they:**



In order to achieve this goal, NEEP put forward eight strategies for success:

1. **Leverage any HEMS infrastructure to drive home efficiency improvements.** Home performance program administrators can harness the user interface and other existing smart devices to get users hooked on home performance feedback and motivated to act.
2. **Smarten water heating**. Many stakeholders are needed to advance this, and success will result in the optimization of energy efficiency, demand responses, distributed energy resources, and variable use pricing for a major energy end use.
3. **Adjust savings expectations for smart thermostats, then put into permanent programs.** There are consistent demand response opportunities for smart thermostats, but program administrators and regulators should considered shifting to an aggregated savings approach across a service territory to realistically evaluate energy savings. Lean heavily on the ENERGY STAR process.
4. **Smart appliances, water heaters, and lighting should be promoted in existing products programs**. These smart products have smart energy home potential. Program administrators should not lose the opportunity to promote the smart versions of these products in existing programs. Look towards pilots to prove both energy and grid benefits.
5. **Develop strategies to seriously engage with service providers in the IoT space, especially home security.** These "nontraditional" market actors are moving a lot of products, and efficiency stakeholders need to strategically build partnerships with them, not try to complete.
6. **Program administrators diversify support of HEMS from strictly monetary incentives to other support features and role**s. As HEMS move from early adopters to the real world, there is a need to shift support away from only traditional monetary incentives to help build the penetration and user success of HEMS. Need to focus on building the complete turn-key customer service model. Smart Energy Audit: Helping with the installation, set up, ongoing energy advisor role for these products and systems.
7. **Investigate user friendly technologies, such as voice control.** Huge opportunity exist to increase persistence of scenes and energy efficient settings through more fool-proof technologies. Efficiency stakeholders should partner with players such as Amazon, Google, Apple.
8. **Promote dynamic energy pricing to help make all other strategies more impactful.** Dynamic pricing will amplify the return on investment for most HEMS, and policymakers, regulators, and utilities should work to promote the adoption on dynamic pricing rate structures.

Throughout our research and analysis in developing the most actionable strategies for "smart energy home" adoption in the Northeast and Mid-Atlantic region, NEEP narrowed in on the largest opportunities for impact to improve the energy benefits of HEMS. Through coordinated efforts such as the HEMS Working Group, co-convened by NEEP and the Home Performance Coalition, we anticipate that each of the eight strategies can be addressed. We also anticipate progress, though slow at first, will be made to push the smart energy home forward and advance towards our regional goal. NEEP is here to help as the residential sector transforms, and we look forward to working with a variety of partners to achieve our goals.

Introduction

As NEEP seeks to advance efficiency as a key piece of demand-side resource management, home energy management systems (HEMS) continue to present a unique opportunity and challenge. While energy savings have been documented for many HEMS, some of the most promising opportunities from these devices and systems can be found in other energy-related benefits. In 2015, NEEP released a report showcasing the various different opportunities for HEMS.[2] In this report, we take the research a step further to present market updates, a regional goal, and here-and-now strategies to drive market transformation and achieve the myriad benefits from HEMS.

Definitions in this space have evolved since 2015, and this report reflects that evolution. While an official definition of "Home Energy Management Systems" was adopted by the HEMS Working Group (see below), there is still no consensus on precisely which functionalities make a home energy management device "smart." Nor is there clarity on what could be considered a "smart home," and whether it necessarily takes into account the energy impacts of smart devices. Below, we map out what definitions have been established as well as proposed some new clarifying language.

"Home Energy Management Systems"

This phrase was defined by the HEMS Working Group to refer to: "any hardware and/or software system that can:

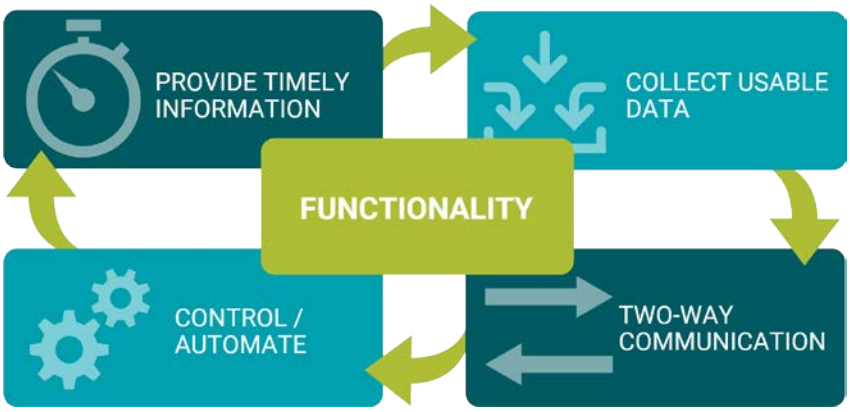
Monitor and provide feedback about a home's energy usage,

and/or

Enable advanced control of energy-using systems and devices in the home.

"Smart"

In this report, NEEP has sought to further define the space and proposes the following four key functionalities for individual devices or systems to be considered *smart* for efficiency and demand-side management purposes:



[2] http://neep.org/opportunities-home-energy-management-systems-hems-advancing-residential-energy-efficiency-programs

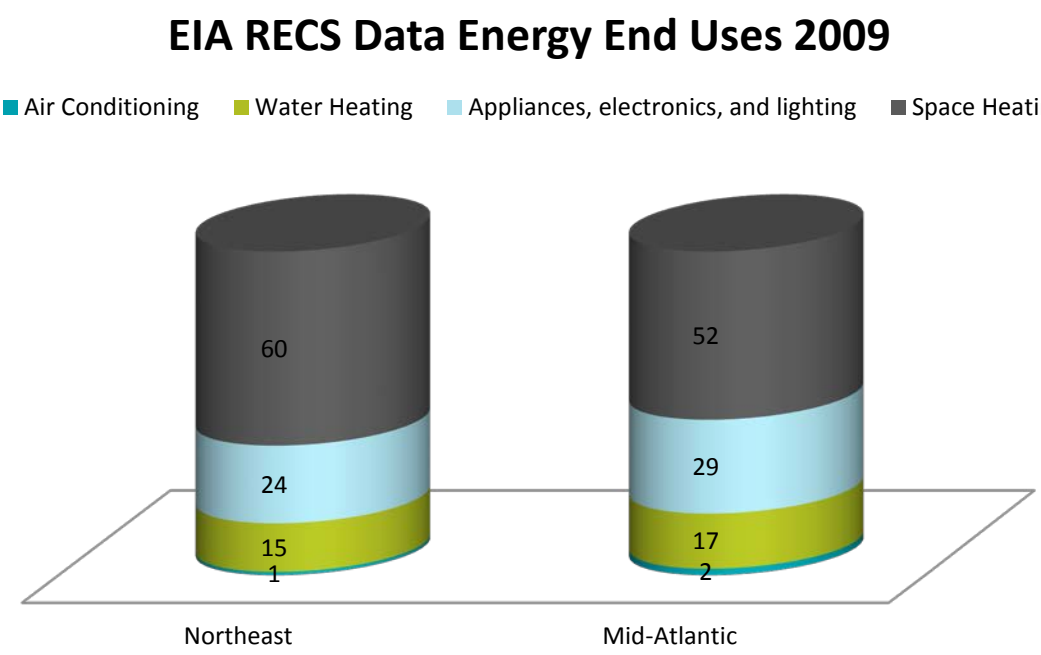
In order to be considered "smart," a device or system must:

1. *Provide Timely Information:* monitors energy usage and provides occupant-access to real-time (or near-real time) energy use of home, with breakouts for key end-uses and systems (including energy generation/storage data from PV/batteries)
2. *Collect Useable Data:* provides occupants with easy access to historical energy use data that it has collected, and when appropriate, provides a way for third-party access to these data.
3. *Control and/or Automation*: provides occupants the ability to control and/or automate operation of an end use (HVAC/water heating/appliances/EV charging) to optimize energy savings, demand savings, etc.
4. *Two-Way Communication*: has capability to facilitate communication between the grid and the end use operations for demand response or variable-use pricing optimization.

"Smart Home" vs "Smart Energy Home"

Finally, as NEEP is honing in on our regional goals and strategies, we are taking a step further to focus in on the major household systems that use and are projected to use the most energy in a home:[3] HVAC, water heating, and plug loads (including appliances and electronics), as demonstrated in Figure 1.

Figure 1: Residential Energy End Uses in Northeast and Mid-Atlantic, Energy Information Administration



While HEMS and smart products can be nearly any energy-using device in the home, as described as the Internet of Things (IoT), we have found the greatest opportunity for benefits lie in these larger areas of household consumption. Lighting, which has long been a focus of efficiency program efforts, has undertaken a major transformation as LED technology has gained traction in the market.[4] While smart lighting products do have some benefits, as described in *Strategy 4: Smart appliances, water heaters, and lighting should be promoted in*

[3] As identified in EIA RECS data, 2009 https://www.eia.gov/consumption/residential/
[4] http://www.neep.org/state-market-residential-lighting-brief

existing products programs, the energy use of residential lighting in general is on a trajectory to decrease, making the HVAC, water heating, and plug load categories even more important. As such, our discussion of "smart homes," which could be those with any smart devices from a smart toaster to a smart door lock, will focus in on the subset of smart homes that are "smart energy homes;" these homes are those that have smart products in place for the household systems that have the most significant energy implications.

Technology and Market Characterization

As described in detail in the 2015 HEMS Opportunities report,[5] HEMS have potential benefits in many different applications. In this section, we will walk through the technological elements, potential, market updates, adoption barriers, opportunities, and potential for market adoption. When appropriate, we will summarize information from the 2015 HEMS Opportunities report, but provide updates as they exist.

Technology Basics

HEMS and the smart technology space is complex. As Table 1 below demonstrates, in some cases there are one-for-one smart alternatives, and in other cases the HEMS or smart device is a new product that does not replace something existing. NEEP has leveraged the 2015 HEMS Opportunities report as well as pricing information from NEEP's 2016 Emerging Technologies Incremental Cost Study[6] to present average costs and calculated incremental cost where possible. For some categories, such as Smart TVs, that analysis has not been run, as their potential for impact is first being presented in this report in *Strategy 1: Leverage HEMS infrastructure to drive efficiency improvements*.

Table 1: Efficiency, Demand Response, and Distributed Energy Resource Potential of HEMS

Energy using system being Impacted	Incumbent Technology	HEMS Product Category	Average Smart Product Cost	Calculated Incremental Cost
General/ whole house	n/a	In-Home Display	$187	
	n/a	Energy Portal	$240	
	n/a	Smart Home Platform	$613	
HVAC	Non-connected Thermostat	Smart Thermostat	$196	$142
Lighting	Lighting	Smart Lighting	$31-$44	$24-$37
Plug load	Appliances	Smart Appliances	$1,778	$297
	Television	Smart TV		
	Surge Protector, standard outlet, standard wall-switch	Smart plug, outlet, or switch	$47	
	n/a	Smart Hub	$86	
General, esp. applicable for plug load	Electric meter, non-communicating electricity usage meter	Load Monitor	$48	
Water Heating	Water Heater	Smart Water heater (through retrofit adopter or built-in)	$1350	

[5] Ibid

[6] As established from NEEP's Emerging Technologies Incremental Measure Cost Study, 2016, http://www.neep.org/incremental-cost-emerging-technology-0

Metrics and Standards Efforts

There are several efforts currently underway to help simplify the metrics and standards in HEMS. As detailed in the 2015 Opportunities report[7] Section 4.1 Standards, Transparency, and Security, groups ranging from national labs to industry collaborations have been working on efforts to provide clarity. Since the publication of the 2015 report, ENERGY STAR has released several drafts of its Connected Thermostat specification. This specification aims to have a common baseline comparison of different connected thermostats based on their actual usage in different climate zones. Using a complex algorithm, EPA will take data from the thermostats and run it against a common baseline to establish a savings level. This level will not be the amount of energy actually saved, but rather a threshold against which various thermostats can be compared. In this way, this specification will be able to recognize the systems that show savings from the algorithm and develop a qualified products list of connected thermostats that are more likely to result in reliable savings. Since each home and each user is different, there is not one number that can be assumed for smart thermostat energy savings. The ENERGY STAR process, however, will go a long way to show which products, in aggregate, are likely to save energy.

ENERGY STAR also has put connected specification components into its lighting, clothes dryers, clothes washers, dishwashers, refrigerator-freezers, room air conditioning, and pool pump specifications. While these specifications are not designated solely for smart or connected products, they provide a pathway for smart and connected versions of existing efficient products to earn ENERGY STAR recognition. As described in *Strategy 4: Smart appliances, water heaters, and lighting should be promoted in existing products program*s, these efforts by ENERGY STAR are a significant step to help establish an installed base of smart devices throughout the region.

Additionally, the American Council for an Energy-Efficient Economy (ACEEE) has begun a labeling and EM&V protocol effort focused on “intelligent efficiency” opportunities. Not surprisingly, as the Intelligent Efficiency Labeling and Clean Power Plan Initiative looked to narrow its scope, HEMS rose to the surface. The goals of this effort are to promote the creation of EM&V protocols for intelligent efficiency applications in order to ultimately ensure the Clean Power Plan can appropriately account and give credit for these non-traditional efficiency measures. This is an early effort, but promising in its focus on the EM&V protocols and opportunities for claiming savings for HEMS and other products.

Furthermore, the Consortium for Energy Efficiency (CEE) has also been looking into the connected space, focusing its effort to date on establishing guidelines for communications protocols and connectivity. In 2016, CEE embarked on a communicating thermostat effort working to establish a communicating thermostat draft specification.

Standby Power

A key consideration for any connected and smart system is standby power consumption. Since these devices and systems need to communicate, they typically operate in an “always on” capacity, always ready to receive a signal when it comes. In some extreme cases, however, the standby power consumption could outweigh any moderate efficiency benefits of system smarts. While standby loads - typically in the .1-2W range for most products - may be negligible for large-end uses such as a water heater or a thermostat connected to an HVAC

[7] Ibid

system, standby power can start to tip the scales away from energy savings for smaller loads such as an LED bulb that might consume only 8-20W. As Table 2 demonstrates, recreated from NEEP's 2016 letter to the US Department of Energy (DOE) in regards to their General Service Lighting Standard Notice of Proposed Rulemaking,[8] it doesn't take much standby power for a small wattage lamp used only a few hours a day to become an energy pariah.

Table 2: Standby Power for Smart Lighting, Recreated from NEEP's 2016 DOE GSL Letter

Starting Lamp wattage	Standby power (in both on and off modes)	Annual kWh (at 3 hours of use/day + 21 hours/day in just standby mode)	% increase from no standby mode
8.5	0W (not connected)	9.3	
8.5	.2W	9.53 + 1.53 = 11.06	19%
8.5	.5W	9.86 + 3.83 = 13.69	47%
8.5	1W	10.40 + 7.66 = 18.06	94%
8.5	2W	11.50 + 15.32 = 26.82	188%

ENERGY STAR specifications have done a great job reigning in standby power, and most new smart devices are able to achieve relatively low standby power levels without significant financial burden.[9] As such, for stakeholders concerned about the potential negative impact of standby power for smart devices, it is critical to ensure that the benefits outweigh the costs. In the case of demand response (DR), when energy is at a major premium, the drawback of standby power may be outweighed by the DR benefits. The energy costs, however, of standby power must be outweighed by the range of benefits they provide in order for investments in that particular product to be recommended.

Market Analysis

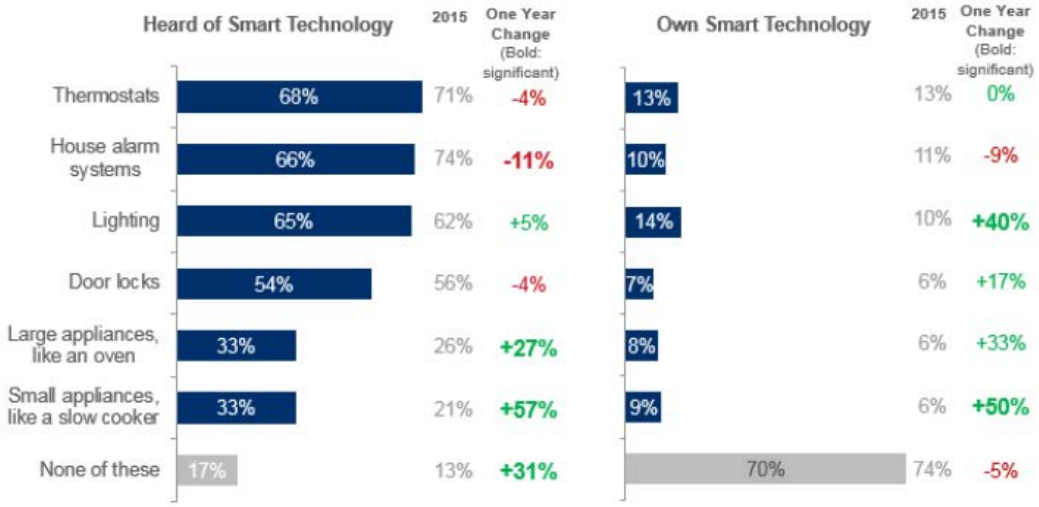
In the 2015 HEMS Opportunities report,[10] we described the HEMS landscape as "new and complex, HEMS have both big and small company investment. There has been considerable traction with smart thermostats deployed through US homes, but there is still a long way to go before HEMS are widely accepted by consumers." While many would consider this industry to still be in the "wild west," there have been significant momentum shifts in the past year that have started to offer some hints of stability in the market.

According to analysis from Zpryme,[11] 11.6% of Americans are likely to purchase a HEMS when asked in June 2016 (up 1% from a year before). Those likely to make a purchase are typically male and under 45. Interestingly, when asked in different regions, the Northeast "yes" levels were at 12.1%, much higher than the 7.8% in the Northeast a year before. HEMS purchasers are more likely to live in urban areas and have incomes greater than $100,000/year.

[8] http://www.neep.org/sites/default/files/resources/NEEPGSLNOPRCommentsFinal_2.pdf
[9] http://docketpublic.energy.ca.gov/PublicDocuments/15-AAER-06/TN208927_20160122T163706_Michael_McGaraghan_Comments_CA_IOU_Comments_on_LED_Lamps_and_Sm.pdf
[10] Ibid
[11] http://etsinsights.com/reports/dataset-u-s-consumer-energy-trends-technology-2013-2016/

In the 2016 Sylvania Socket Survey,[12] information on ownership rates and knowledge levels was gauged for a variety of smart products. As shown in Figure 2, awareness for smart thermostats and smart lighting is highest, while ownership rates are low across the board.

Figure 2: Sylvania Socket Survey Smart Product Ownership and Awareness



Of all trends that have taken off since the last report, voice recognition devices, such as Amazon Echo, are perhaps most noteworthy. "Digital assistants" were named as the #1 tech trend to watch by the Consumer Technologies Association,[13] and the Echo, introduced in 2015, has become one of the most successful smart home devices among consumers with three million units sold as reported in April, 2016.[14] Marketed as "a hands-free speaker you control with your voice…to play music, provide information, news, sports scores, weather, and more—instantly,"[15] these devices don't advertise energy management as a primary functionality. This device, which can pick up vocal commands from across a crowded room, has inspired smart home device manufacturers to forego their proprietary platforms and communications protocols in order to be available on the platform.[16] This convergence across vendors towards one platform may become a game changer in this industry that had been blossoming in dozens of different directions[17]. And with other juggernauts such as Apple HomeKit with Siri and Google Home beginning to enter this market,[18] the potential of voice control to increase penetration of smart devices in homes is significant, if this is indeed a lasting trend.

Other recent innovations in the smart home space include:

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[12] https://www.sylvania.com/en-us/tools-and-resources/surveys/Pages/socket-survey.aspx
[13] http://www.twice.com/news/cta/innovate-and-celebrate-cta-ids-5-tech-trends-watch/63029
[14] http://www.geekwire.com/2016/report-amazon-sold-3-million-echo-smart-speakers-awareness-grows/
[15] Description from: https://www.amazon.com/echo
[16] http://smarthome.reviewed.com/features/everything-that-works-with-amazon-echo-alexa
[17] http://www.neep.org/blog/neeps-listening-new-energy-efficiency-innovations
[18] http://appleinsider.com/articles/16/06/09/wwdc-2016-apples-siri-and-the-future-of-voice-vs-amazons-alexa-echo-google-now-microsoft-cortana

- Touch-control devices, such as LogiTech's Pop Home Switch,[19] that bring smart home controls from a potentially complex series of apps to a literal control bottom installed in a home.
- Li-fi,[20] which is sending internet signals through light fixtures, is presenting an opportunity for accessing the internet in a streamlined, and potentially more efficient, manner.
- Hub-less smart lightbulbs that can connect directly with a smart phone app. Several brands are detailed in NEEP's July 2016 Residential Lighting Brief[21] and recreated in Table 3.

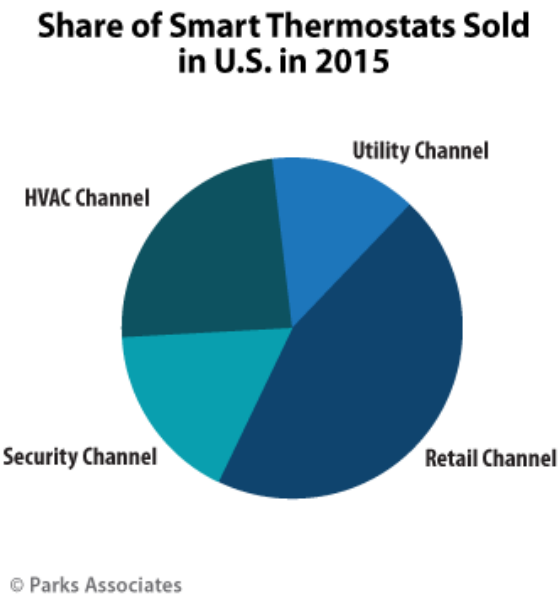
Table 3: Hub-Less Smart Bulbs, Recreated from 2016 NEEP Residential Lighting Brief

Brand	Product	Wattage equivalent	Color Tuning?	Standby Power	Efficacy	Cost
LIFX	White 800	60	White light color tunable	~.5-.7W	81lpw	$39.99
	Color 1000	75	RGB Color tunable	~.5-.7W	96lpw	$59.99
GE	C-Life	60	No, 2700K	~1W	73lpw	$70 for 4 bulb starter pack (2 C-Life, 2 C-Sleep)
	C-Sleep	60	3 settings: AM at 7000K, Daytime at 3000K, and PM at 2000K	~1W	77lpw	
Ilumi	Ilumi	60	RGB Color tunable	<1W	~80lpw	$99.99 for 2 pack

Not surprisingly, online vendors remain the primary mechanism for smart home product sales, especially for smaller and newer companies without an established sales channel. That being said, we are seeing increased offerings at brick-and-mortar retailers as well. Retailers from DIY giants such as Lowes and Home Depot are investing heavily in smart energy home displays and ecosystems, with others such as Sears, Target, and even Walmart stepping into this space.[22] Sears in particular, through its acquisition of the Wally Brand[23] and its desire to convert the Kenmore line of appliances to be smart,[24] is a retailer to watch in the coming years.

The home security channel, particularly focused on bundling existing offerings with a smart thermostat, has increased its impact in the market. A 2015 report from Parks Associates[25] showed the security channel selling more smart thermostats than the utility channel (Figure 3), and this is expected to continue to grow. Parks Associates projects "by the end of 2015, nearly six million professionally monitored homes will also have smart home control as part of their security

Figure 3: Parks Associate's Share of Smart Thermostats



[19] https://techcrunch.com/2016/08/11/logitech-pop/
[20] http://luxreview.com/article/2016/02/the-lux-explainer-li-fi
[21] http://www.neep.org/state-market-residential-lighting-brief
[22] http://sheltongrp.com/the-smart-home-is-here-because-retailers-are-going-all-in
[23] http://www.geekwire.com/2016/wallyhome/
[24] http://www.techhive.com/article/3084689/connected-home/sears-doubles-down-on-the-smart-home-with-new-kenmore-craftsman-and-diehard-products.html
[25] http://www.parksassociates.com/blog/article/pr0715-smart-thermostats

system."[26] While not every home has or will have a home security service, the potential for coordination with security providers is significant.

Potential for Energy Benefits

HEMS and smart products are beneficial not only for their energy savings. In several instances, energy savings from HEMS may be minimal, but other energy benefits, such as demand response (DR), behavioral demand response (BDR), integration with distributed energy resources (DERs), and load shifting ability are significant. In Table 4, we look at a wide range of smart products and rate them based on their potential for benefit across energy types and services.

Table 4: Energy Potential for HEMS

Smart Product	Fuel impacted	Energy savings potential	Demand response potential	Load shifting potential	DER integration potential
Smart Thermostat	Gas, Oil, Electricity, etc.	High	Medium: High for AC, Low-medium for winter heating	Medium	Medium-low
Smart Water Heating	Electricity, Gas, Oil	Medium-low for retrofit, high for replacement	Medium to High for electric	Very high for all fuels	Very high
Smart Appliances: Inflexible timing (refrigerators, stoves, ovens, small appliances)	Mostly Electric, Some Gas	Low	Low	Low	Low
Smart Appliances: Flexible timing (clothes dryers, clothes washers, dishwashers)	Mix of Electric and Gas	Low	Medium if peak and usage coincide	Medium	Low-Medium
Smart TV	Electric	Low	Low, but could be vehicle for BDR messages	Low	Low
Smart plug, outlet, or switch	Electric	Medium	Medium-low	Medium-low	Low
Smart Hub	Electric	Low	Medium-low	Low	Low
In-Home Display	Mostly Electric	Medium-low	Medium-low through BDR	Medium-low	Low
Energy Portal	Mostly Electric	Medium-low	Medium-low through BDR	Low	Low
Smart Home Platform	Mostly Electric	Medium-low	Medium-low through BDR	Medium	Medium
Smart Lighting	Electric	Low	Medium opportunity, Low per unit kW	Low	Low

[26] From Parks Associates 2016 biggest IOT trends, http://www.parksassociates.com/bento/shop/whitepapers/files/Parks%20Assoc%20-%20Top%202016%20Trends%20in%20IoT.pdf

In aggregate, a "smart energy" home has the ability to save energy, but even greater opportunities for demand savings. Furthermore, some smart technologies lend themselves well to load shifting, whereas others are better coupled with distributed energy resources such as solar PV, electric vehicle charging, and residential-sized energy storage. Some technologies, such as Smart TVs, are not necessarily "energy smart," though they lend themselves as a successful user interface for feedback and potentially to provide information for behavioral demand response (BDR); for some manufacturers, smart TVs may become more of a smart hub for the home.[27] With ownership rates of Smart TVs overtaking other smart home products by a longshot,[28] this is a smart technology that we want to keep an eye on.

Existing Efforts to Promote High Efficiency Options

Within the Northeast and Mid-Atlantic, there are several smart thermostat promotions currently in place. While many are in pilot phase, this has helped push the smart thermostat product category above and beyond the market penetration of nearly all other HEMS products. In Table 5, we summarize the types of thermostat programs (including both programmable and Wi-Fi enabled). Until the ENERGY STAR Connected Thermostat specification enters the market, there is a lack of consistency in programs around what is considered smart, connected, and programmable, and how much savings is being claimed for different types of thermostats. Note that not all thermostats currently promoted in the region meet the criteria NEEP set forward for smart functionality.

Table 5: Smart Thermostat Promotions in the Northeast and Mid-Atlantic

State	Details	Incentive Level
Connecticut	Pilot for demand response potential	TBD
District of Columbia	Offered for programmable thermostats	$25
Massachusetts	Offered for both programmable and Wi-Fi enabled thermostats	$25 for programmable $100 for Wi-Fi
New Hampshire	Wi-Fi thermostat as an add-on for Heat Pump rebates	$100
New York	Through REV marketplaces and utility programs	$25-$85
Rhode Island	Programmable Wi-Fi enabled Thermostats	$50
Vermont	Multi-year field study to evaluate the savings potential	TBD

In 2015, Efficiency Vermont focused on previously un-tested products and conducted a small pilot looking at smart lights, smart plugs, and HEMS hubs.[29] Through a 15 home pilot, it tested two ecosystems of smart lamps, hubs, and plugs to determine the user experience with these systems. Efficiency Vermont was testing the "out of the box" user experience; they mailed participants the products and left no instructions beyond product packaging for the participants to self-install and use, while Efficiency Vermont metered and recording what went

[27] http://blog.smartthings.com/tag/samsung-tv/
[28] http://www.broadcastingcable.com/news/technology/ihs-smart-tvs-taking-over/157697
[29] https://www.efficiencyvermont.com/news-blog/whitepapers/smart-lighting-smart-hub-diy-install-does-yield

on. The findings, while not statistically significant with such a small sample, suggested that through decreased hours of use and high use of dimming functionality, smart lighting might be an efficiency benefit. The dimming functionality also suggests opportunities for demand response deployment. Users generally were able to install the devices and the majority felt the products were worth their cost at the end of the pilot. These are promising first results from this product category.

Relevant HEMS Policies

In late 2015, California Governor Jerry Brown signed Assembly Bill (AB) 793 into law.[30] This bill is focused on promoting consumer access to energy management technologies. It requires utilities in California to do outreach to customers on how they can access real-time or near real-time energy data and promote home energy management technologies. The full impacts of this bills are yet to be realized, but its passage has cemented a connection between utilities and HEMS vendors and software.

Another important policy – this one within the NEEP region – is the developments of the Reforming the Energy Vision (REV) process in New York. In April, 2016, NYSERDA published a whitepaper[31] on rate designs that included a section on a "Smart Home Rate." In Table 38 of that whitepaper, recreated in Table 6, NYSERDA proposes cost savings from a flat rate, time-of-use, and dynamic pricing rate structures. Within this smart home rate, a very compelling case is made for either the time-of-use or dynamic pricing in yielding both better customer bills and lower costs of services.

Table 6: Customer bill and cost of service savings from smart home under three rate structures, Recreated from NYSERDA Table 38

Customer Bill / Cost of Service	Flat Rate	Time-of-use	Dynamic Pricing
Heat pump	$0 / $0	$2 / $0	$33 / $38
Air conditioner	$0 / $0	$80 / $22	$195 / $199
Heat pump hot water[87]	$0 / $0	$113 / $15	$200 / $35
Battery electric vehicle	$0 / $0	$143 / $50	$66 / $66
Home battery system	$0 / $0	$331 / $158	$401 / $431

These policies demonstrate increased potential of HEMS as well as evolving regulatory frameworks to help support the adoption and uptake of smart energy homes.

Key market barriers to accelerated adoption

While the vision of the smart home has been anticipated for decades, the market penetration of HEMS and smart energy systems is still very low. Several different types of barriers are contributing to that reality. In this section, we talk through several of the most pressing barriers to adoption.

[30] http://asmdc.org/members/a20/news-room/press-releases/governor-brown-signs-assembly-bill-793-promoting-consumer-access-to-energy-management-technologies
[31] http://on.ny.gov/1T3JPKi

1. Energy Efficiency Program barriers

    a. **Limited proven energy savings for all products except smart thermostat, which has un-reliable per-unit savings.** Smart products are not intrinsically more efficient than their counterparts. This means that the value proposition of a smart product alone can be challenging to prove. Smart thermostats have the longest track-record and largest body of evidence to show that they can provide energy savings because they optimize the use of a major system, HVAC, but while aggregated savings have been proven throughout evaluations, the individual household level savings is very hard to demonstrate. And the evaluations that do exist show many different savings numbers because of variation between methodology, baseline, etc.

    b. HEMS are difficult to evaluate. Many smart products are controlling something else, such as a smart thermostat or smart plug. As such, there is not a one-for-one "widget" comparison of the inefficient baseline product and the smart/efficient alternative. A deemed savings approach for any control technology is a fundamentally flawed approach and at best reflects an average across homes. The energy savings comes from the control of other energy using functions, and the calculation and tracking of that savings is an evaluation challenge.

    c. Equity challenges—these are expensive, non-critical devices. As opposed to more traditional efficiency measures, such as lighting, appliances, HVAC, or home performance upgrades, smart devices in many ways are not critical elements of a home. Many of the current owners of smart products are early adopters with disposable income to spend on devices that intrigue them. The perception around smart devices as luxury items has not yet been broken as these products have yet to go mainstream; while the payback period may be short, the upfront cost is still perceived to be high. If not all ratepayers have equal access or need for these products, then the justification for incentives that end up going to those who can afford it present both a moral and a free ridership challenge.

2. Consumer barriers

    a. Low consumer awareness. Contributing to the low penetration of smart products and systems is the lack of awareness and understanding of these products.[32] While smart thermostats have likely broken through to a larger audience, most other smart devices are still only known in small circles.[33] Even for those who are marginally aware of these products, the value proposition may not be clear.

    b. Security concerns. Consumers continue to be worried about bringing more products onto their home's network and the potential for compromising their home's vulnerability, either by hackers or others who would exploit the information from their smart devices. While there have

[32] http://www.mediapost.com/publications/article/278996/smart-home-products-only-30-of-consumers-even-kn.html
[33] "Less than 30% of U.S. broadband households familiar with where to buy smart home products and services": http://www.parksassociates.com/blog/article/pr-06242016

been next to no reported incidents of smart homes being targeted for malicious intent, the potential still exists, especially in the minds of wary would-be consumers.[34]

c. **Device set up and ease-of use may not be ready for the mainstream.** With start-ups and innovation come logistical challenges, and as the audience for HEMS moves from patient early adopters to the mainstream, the infrastructure to support the proper use and installation of products may not exist across HEMS vendors. As reported in Efficiency Vermont's Smart Lighting Pilot,[35] even self-described tech savvy homeowners had some trouble navigating set-up of smart home devices, though most were able to resolve any issues with the manufacturers' customer support tools. This will continue to be a challenge as those who are less tech-savvy or have less patience to call support lines begin to adopt these technologies.

d. **Wi-Fi is a common protocol, but imperfect in application.** A late 2015 report concluded that 81% of households have Wi-Fi at home,[36] leaving 19% of homes without. For those houses with Wi-Fi, the entire network can get bogged down as more devices are added, and as applications for HEMS increase, relying on Wi-Fi will continue to be a challenge. For those HEMS that use other communications protocols such as ZigBee, Z-Wave, or Bluetooth within the home, they still may ultimately rely on a Wi-Fi connection to send information to the cloud or to receive software update. For those without Wi-Fi, connecting to the cloud services or software updates may be out of reach.

3. Technology barriers

    a. **Interoperability.** Whether or not multiple smart products can work together on a common system continues to be problematic. Though market disruptors such as the Amazon Echo are breaking down this barrier by inspiring products to join their platform, a single "winning" communications protocols or proprietary platform has not emerged in the market. There are also an increasing number of multi-communication protocol hubs entering the market, reducing some of the concern for technical interoperability as long as there is corporate alignment. Convergence and partnerships are gaining ground, but we are still a long way before there is universal interoperability across platforms.

4. Grid barriers

    a. **Advanced metering infrastructure (AMI) is inconsistent throughout region**. This is a challenge as many of the benefits from smart energy home products and systems come in terms of optimization, and receiving grid signals and variable rate pricing can make the economics of a smart home device much more appealing to the masses. The inconsistency across the region also makes regional strategies challenging, as what may be very viable for one state or program may not be for the next.

[34] http://www.ifsecglobal.com/future-home-automation-debate-barriers-installers-cyber-threat/
[35] https://www.efficiencyvermont.com/news-blog/whitepapers/smart-lighting-smart-hub-diy-install-does-yield
[36] http://www.leichtmanresearch.com/press/120315release.html

Market opportunities to leverage

While there may be several market barriers, there are also many HEMS market opportunities that can be exploited. These are outlined briefly below:

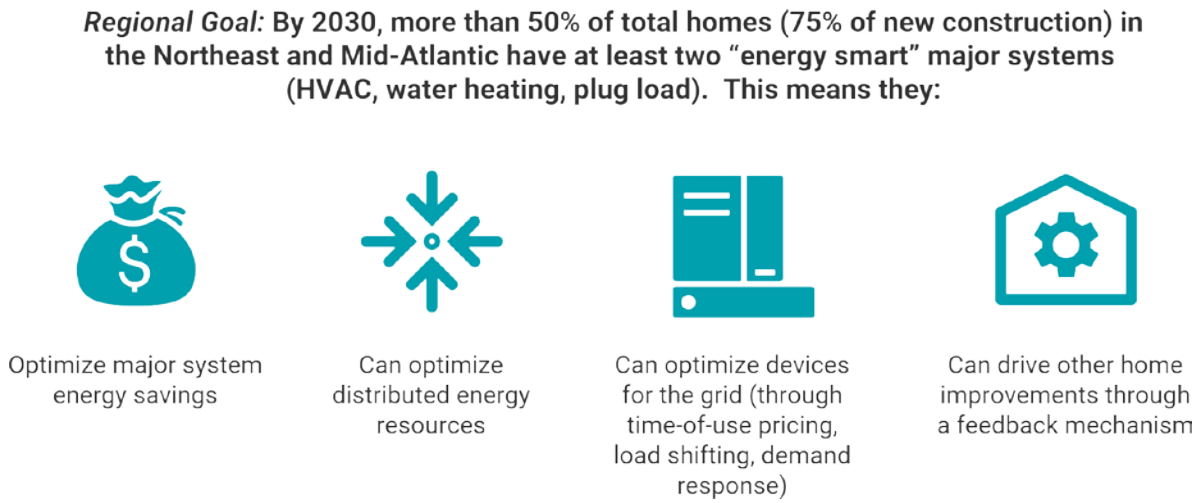
1. Program opportunities
    a. Program administrators (PAs) already have high efficiency HVAC, appliance, lighting, and water heater rebates in place, including the infrastructure, marketing, and industry relationships to support them.
2. Customer opportunities
    a. Interest in, and demand for, smart home technologies is increasing. Home security, comfort, and control continue to be the main motivators to purchase. While customers may not be buying smart devices for energy reasons, they are buying them and interacting with the user interface.
    b. Voice recognition and control devices are surging in popularity.
    c. Home security is motivator for investment in smart home devices. Many homeowners are taking advantage of the energy management services and capabilities offered by home security and telecomm businesses through bundled packages of services.
3. Technology opportunities
    a. Research and development for HEMS and smart energy devices is successfully turning out new and interesting products into the market, many of which have or are close to having the desired functionalities to be considered “energy smart.” Additionally, there are existing platforms and service providers that are pulling the technologies together and promoting them on the market. There is momentum building in the technology space.
4. Grid opportunities
    a. Regionally and nationally, there is an increased need to manage peak electricity use. This has led to increased interest in residential demand response and variable energy pricing.
    b. There is also an increased appetite for distributed energy resources such as roof-top solar, electric vehicles, and battery storage.

Long-Term Market Transformation Goal

In order to develop a regional HEMS market transformation goal for the Northeast and Mid-Atlantic, considerations must be grounded in realistic expectations and optimal benefit. After all, there is a large continuum between a complete smart energy home and a home with one or two smart devices. Truly smart homes will delight residents and optimize the energy components of a home, be they distributed energy resources, energy efficiency measures, interactions with the grid, or feedback mechanisms to drive investments in home performance.

Therefore, in order to truly appreciate the benefits from smart home devices and home energy management systems, we are pushing the region to achieve the goal that: **by 2030, more than 50% of total homes (with 75% of new construction) in the Northeast and Mid-Atlantic have at least two "energy smart" major systems (HVAC, water heating, plug loads). This means they:**

- optimize major system energy savings;
- can integrate with and optimize a variety of on-site distributed energy resources;
- can optimize devices for the grid (through time-of-use pricing, load shifting, demand response); and
- can drive other home improvements through a feedback mechanism.



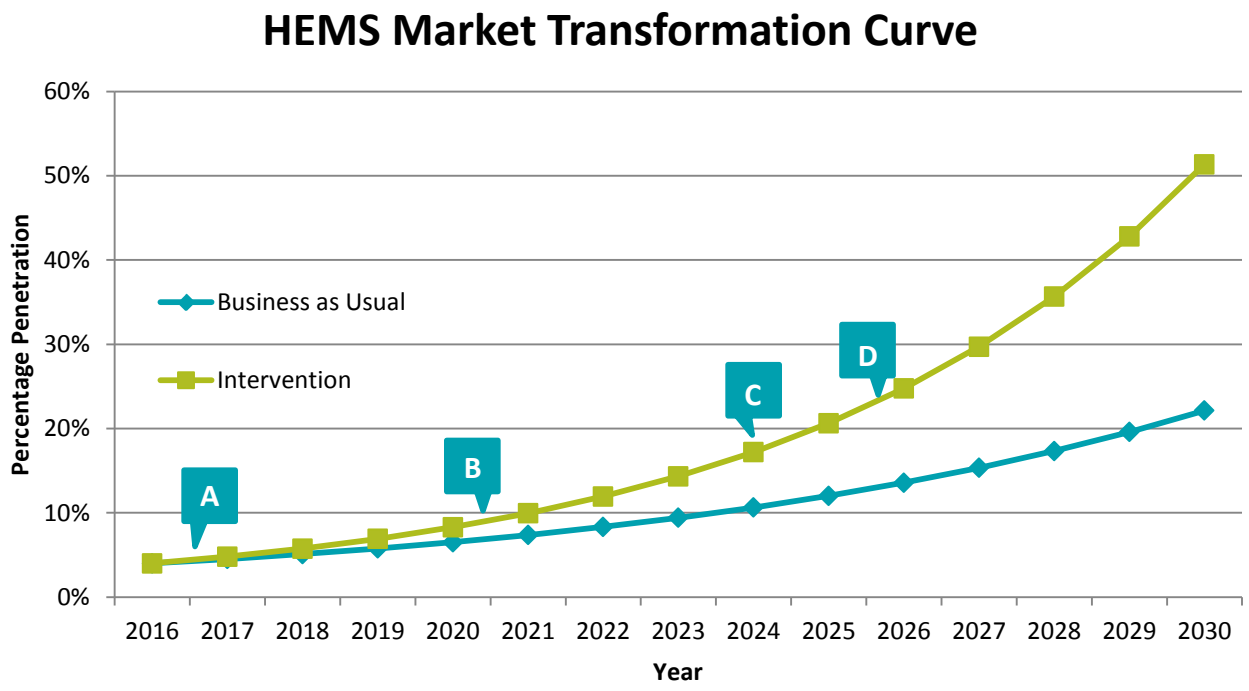
Theory of Change

In order to achieve this regional goal, there are several strategies and interventions that stakeholders must undertake. NEEP believes that by pursuing the outlined strategies, the region can overcome existing barriers, leverage market opportunities, and achieve the goal.

As Figure 4 demonstrates, the current market penetration of true HEMS is low. Because our regional goal includes at least two of three major energy-consuming systems must gain energy smarts, we are confident that the regional starting point is less than five percent. While smart thermostat penetration is projected to fall in the 10-15% range, smart water heating and smart plug load systems have almost negligible penetrations.

The strategies that NEEP recommends are largely concentrated in the next three to four years, a time during which adoption of smart energy systems will be increasing, as well as laying the foundation and aligning partnerships for success to really take off in the years to come. The business as usual case for this smart energy home that we've projected is steady growth. This is based both on the mixture of projections for the growth of this market (from incredibly large[37] to minimal growth[38]) and the fact that for water heating and plug load energy end uses, little market movement is pushing that adoption forward. The projection of business as usual to reach 20% by 2030 is largely driven by significant smart thermostat adoption and slow plug load adoption—without intervention, we are expecting smart water heating to have very minimal uptake.

Figure 4: HEMS Market Transformation Curve



Within the market transformation curve, we see four key inflection points occurring between 2016 and 2030. The first, **A**, takes place in the 2016-17 timeframe and reflects the beginning of strategies 1-8 outlined below. This is the most near-term element of the market transformation and demonstrates the first inflection point of the smart energy home developing more rapidly than the business as usual case.

The second key inflection point, **B**, occurs around 2020. This is a time in the market when we anticipate two major forces will come together. First, we expect to have firm, wide-spread partnership arrangements set up with security and service providers who are working in this space. This would start to rapidly increase the number of smart systems deployed because those channels would start to ramp up promotions. Second, we

[37] "While IoT may be a vague term now, according to research firm IDC, the global Internet of Things market will be worth $1.7 trillion in 2020, from: http://www.crn.com/news/mobility/300081116/samsung-sharpens-focus-on-internet-of-things-with-1-2-billion-u-s-bet-on-research-and-startups.htm."

[38] https://www.accenture.com/_acnmedia/PDF-3/Accenture-Igniting-Growth-in-Consumer-Technology.pdf

anticipate around 2020, the market will be converging around platforms such that the interoperability challenges we face now are minimized. These wheels are already in motion, and by 2020, we expect more clarity on ecosystems and interoperability.

At inflection point **C** in 2024, we anticipate a change in residential building energy codes and appliance standards that would be more supportive of these smart energy systems. This will be a long time in development with the objective of proposing smart energy components to the 2021 code design with the hope that by 2024, their adoption would occur. Considerations for standby power are already going into federal appliance standards, and by 2024 it is expected that several standards would help to support the adoption of smart energy systems.

In 2026, when we get to inflection point **D**, we anticipate all states in the Northeast would have adopted variable use energy pricing, thus enabling the major uptake in smart energy systems which would be better justified economically. This key occurrence, a long time in the making, would be the last major barrier need for widespread adoption.

Tracking of Market Transformation Progress

Because the HEMS space is complex and multi-faceted, we decided to take a creative approach towards measuring market traction towards our regional goal. This is a two-pronged approach outlined below:

- Product Development: Do the "energy smart" products on the market have the functionality that we outlined? Do they strive to work in the various applications related to the regional goal? Are we seeing more of these products available on the market?
- Regional HEMS Penetration: Are more home getting these smart systems? Do we see homes that have one system pursue a second? Do those homeowners pursue home performance improvements?

With these two pieces of data, coupled with any secondary research or evaluations from the NEEP region and beyond, we are confident that we will keep a firm grasp on the progress of this market over time.

Summary of Key Strategies and Interventions

As the Strategies for success to reach the regional goal section will detail, the following strategies are expected to overcome the primary barriers and exploit the key opportunities in order to help the region achieve its goal:

1. **Leverage any HEMS infrastructure to drive home efficiency improvements.** Home performance program administrators can harness the user interface and other existing smart devices to get users hooked on home performance feedback and motivated to act.
2. **Smarten water heating**. Many stakeholders are needed to advance this, and success will result in the optimization of energy efficiency, demand responses, distributed energy resources, and variable use pricing for a major energy end use.
3. **Adjust savings expectations for smart thermostats, then put into permanent programs.** There are consistent demand response opportunities for smart thermostats, but program administrators and regulators should considered shifting to an aggregated savings approach across a service territory to realistically evaluate energy savings. Lean heavily on the ENERGY STAR process.
4. **Smart appliances, water heaters, and lighting should be promoted in existing products programs**. These smart products have smart energy home potential. Program administrators should not lose the

opportunity to promote the smart versions of these products in existing programs. Look towards pilots to prove both energy and grid benefits.

5. **Develop strategies to seriously engage with service providers in the IoT space, especially home security.** These "nontraditional" market actors are moving a lot of products, and efficiency stakeholders need to strategically build partnerships with them, not try to complete.
6. **Program administrators diversify support of HEMS from strictly monetary incentives to other support features and role**s. As HEMS move from early adopters to the real world, there is a need to shift support away from only traditional monetary incentives to help build the penetration and user success of HEMS. Need to focus on building the complete turn-key customer service model. Smart Energy Audit: Helping with the installation, set up, ongoing energy advisor role for these products and systems.
7. **Investigate user friendly technologies, such as voice control.** Huge opportunity exist to increase persistence of scenes and energy efficient settings through more fool-proof technologies. Efficiency stakeholders should partner with players such as Amazon, Google, Apple.
8. **Promote dynamic energy pricing to help make all other strategies more impactful.** Dynamic pricing will amplify the return on investment for most HEMS, and policymakers, regulators, and utilities should work to promote the adoption on dynamic pricing rate structures.

Strategies for success to reach the regional goal

This section provides detail on the eight key strategies that NEEP has recommends for HEMS market transformation. Implementation of these strategies will set the region on a path to achieve the goal set forward in this report. The market actors and strategy components are detailed within each strategy area.

Strategy 1: Leverage HEMS infrastructure to drive efficiency improvements

Throughout this report, we have worked to highlight some of the benefits but also limitations of HEMS. One key limitation is that even the smartest home could be an energy hog if some basic home performance improvements are not done. While HEMS are the high-tech solutions for the "brains" of the home, basic improvements such as insulation and air sealing can have as much, if not more energy efficiency benefits on the "body" of the home.

As such, the first order strategy is for program administrators, especially those working in home performance programs, to leverage any and all HEMS infrastructure to drive home efficiency improvements. PAs should take advantage of the user interface (UI) and high levels of interaction individuals have with their smart devices to provide feedback and drive users towards home improvements. There are significant opportunities to leveraging users' attention to motivate them to take action that may not even directly be related to product at hand.

Within this recommendation comes the need for home performance contractors to become beacons for smart home technologies. These efficiency-focused allies are inside homes and can help boost the perceived benefits of their own work as well as help drive additional home improvements through education and feedback using HEMS. Some smart thermostats have contractor portals or functionalities that allow contractors access to some customer data to help diagnose or predict potential HVAC problems. This has the potential to help improve a contractor's relationship with their customer, though at present, few contractors are including any smart home products in their offerings, and those who are largely focused on smart thermostats.[39] The opportunities to leverage the home performance network for promotion of other smart energy systems such as plug load and water heating are significant.

While many of these opportunities will be built on relationships with HEMS vendors and service provides, some ideas and specific opportunities are outlined below:

- Work to leverage the user interface for any smart home app, smart TV[40], in-home-display, or other high-visibility function to include information about home performance offerings and upgrades. If possible, use comparative norms from one home to another with the intent of motivating action.
- There is a documented gender difference in those who invest in smart home technologies (men), and those who seek out home performance upgrades (women).[41] As such, it is less likely that someone who invests in HEMS would have also already invested in home performance upgrades. This finding provides justification to cross-market between programs and to target messaging to the decision maker.

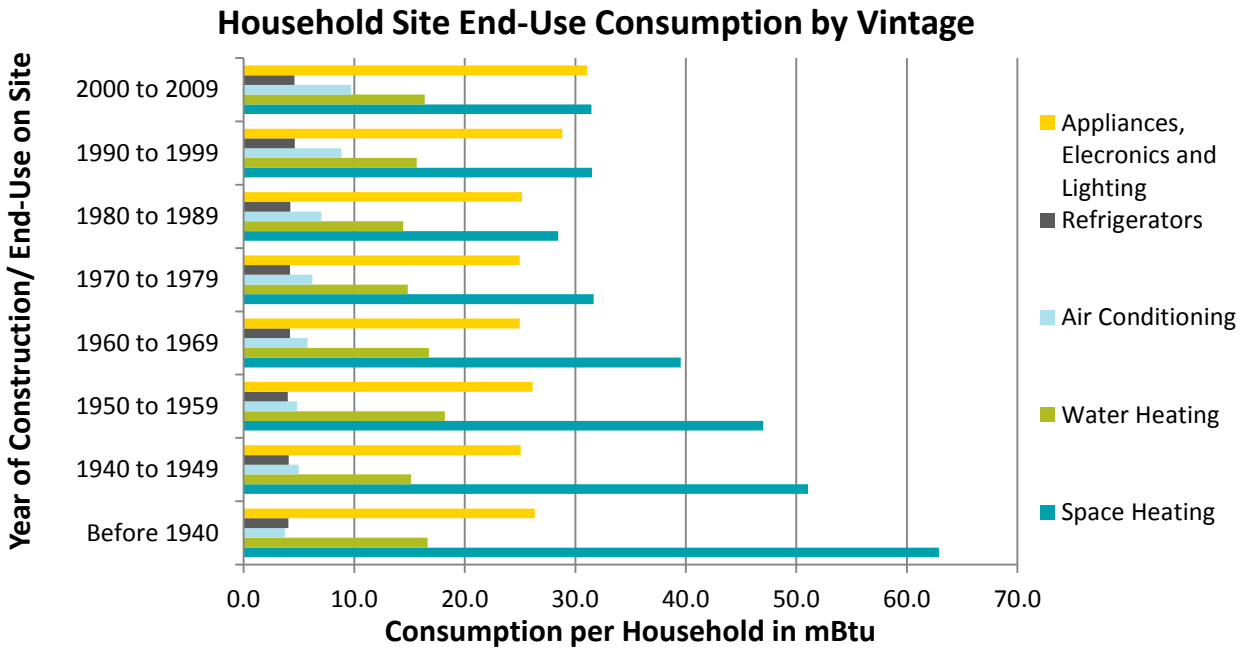
[39] NEEP 2016 NYSERDA Smart Thermostat Market Characterization, forthcoming at time of publication.
[40] http://www.broadcastingcable.com/news/technology/ihs-smart-tvs-taking-over/157697
[41] Shelton Group, The Smart Home Gender Gap, http://sheltongrp.com/lp/energy-pulse-2015-special-report/

- Home Energy Labeling, such as the DOE's Home Energy Score, is intended to motive low-scorers to invest in their home and achieve a higher score. Typically, however, the actual label (i.e. your home is a 4 out of 10) is provided at the end of an assessment and rarely highlighted by the homeowner. The user interface element of HEMS, however, provides an excellent platform to provide visibility and a reminder of the score. For example, if working with a smart home app, a program administrator could embed a small overlay in the top corner of the app UI that has the static score. Each time the user logged into that app, they would be reminded of their home's score and through that reminder, may be motived to invest in a retrofit and re-scoring to demonstrate improvement.

Strategy 2: All stakeholders work to smarten water heating

Water heaters are invisible to most consumers until they malfunction. While their product, hot water, is used and enjoyed every day, how, when, and to what temperature they heat that water are unknown and rarely even considered by the user. As reported in the 2015 HEMS Opportunities report.[42] smart water heaters provide opportunities for demand response savings as well as automated efficiency optimization. The ability of these appliances to shed load during peak times and shift usage to off-peak hours offers demand response capabilities that traditional appliances lack. Water heating is the second largest energy end-use - after space heating – with great potential for gas savings.

Figure 5: Household Site End-Use Consumption by House Vintage, Recreated from Table 27 in HEMS Opportunities Report



As explored in the 2015 HEMS Opportunities report,[43] the average household uses 17.7 mBtu on water heating in the Northeast. That number is larger for single-family homes, but is still significant for multi-family and mobile homes. As Figure 5 demonstrates, water heating energy use is quite consistent across all vintages of homes, as

[42] Ibid
[43] Ibid, 2015 HEMS Opportunities report, page 47, tables 27 and 28.

opposed to the stark contrast in space heating energy use for older and newer homes respectively. Additionally, water heating has an opportunity for energy savings across fuel types.

As it relates to HEMS, there are significant opportunities for smarter and grid-enabled water heaters to optimize and load shift water heating. Coupled with other HEMS products, the water heater could relatively easily learn the basics of a household schedule. Where present, variable use rates or rooftop solar would provide proper motivation to heat water at specific times and not at others, thus optimizing the energy impacts of water heating. Specific elements of a potential smart water heater strategy are detailed below:

- There are opportunities in relatively low-cost retrofits on existing water heaters to turn them into connected water heaters, capable of sending information and receiving commands. For program administrators running any retrofit or on-site visit program, this is a significant opportunity to add a measure and turn existing water heaters into demand response ready, connected water heaters.
- Furthermore, in addition to receiving demand response signals, retrofit smart water heaters have the potential to integrate with other HEMS to optimize performance. This includes having a HEMS send price signals or even just follow an expected demand curve to optimize the schedule for water heating. If carbon is a concern for a household, the water heater could be scheduled to kick on at times when the most renewables are on the grid (or kick off at more carbon intensive grid times). If a home has a HEMS or other smart device employing geofencing or other occupancy sensing, it could be possible to program some basic data point for hot water usage and couple that information with the occupancy data; in this case, the HEMS could ensure that the hot water is available when it is needed, and optimize the best time to heat it again based on expected use. This retrofit measure is a low-cost solution that could be bundled with a home audit or utility energy efficiency visit.
- There is also a significant opportunity for programs to support the integration of connected functionality into new water heating equipment, especially heat pump water heaters. In that way, all of the benefits could be achieved with a lower energy footprint.
- Beyond daily usage, there is an opportunity to use a retrofit or a new connected water heater to build relationships with home automation software and other HEMS which could include elements such as “vacation mode” for other HEMS and apps to push back water heater temperature during extended time away.

Strategy 3: Adjust savings expectations for smart thermostats, then put into permanent programs

Smart thermostats have, through dozens of pilots, whitepapers, and evaluations, demonstrated that they have the potential to save energy.[44] The amount and reliability of that energy savings, however, is hard to pin down. Across the nation, program administrators are taking different approaches to claim savings from smart thermostats, most of which are not held to the utmost scrutiny since many smart thermostat promotions are classified as “pilots.” In order to successfully move from pilots to full-fledged programs, we recommend that program administrators and regulators adjust their expectations for smart thermostats, moving from a per-widget expectation to an aggregated average savings across a service territory or region.

[44] NEEP HEMS Opportunities report, ibid, Table 4 and Appendix C

While the ENERGY STAR Connected Thermostat program is unlikely to provide sufficient granularity of savings for program administrators to the numbers from ENERGY STAR directly into their savings assumptions, the ENERGY STAR specification will narrow down the list of smart thermostats to those who are reliably achieving savings within a climate zone and those that are not. As such, it is strongly recommended that once the ENERGY STAR Connected Thermostat Specification is complete, programs only support thermostats that are on the qualified products list.

ENERGY STAR's process, however, does develop consistent methodology to compare apples-to-apples the savings from different products. In this recommendation, therefore, NEEP suggests program administrators work with smart thermostat vendors to get a state-level calculation of total savings using the same methodology for a given state as ENERGY STAR does for a climate zone. As such, a PA would not know the savings from any one house in a program, but would know the aggregated average savings for each smart thermostat vendor across the state. If, for example, Nest showed an 11% savings in New York, while ecobee showed a 12% savings using the ENERGY STAR methodology, programs and evaluators could work with those numbers to potentially discount or otherwise true-up the assumption, and then take the discounted number (let's say 8% and 9% respectively), and apply it to each of the Nests and ecobees supported through the program for that climate seasons. The average savings calculated for a given vendor would include thermostats that weren't sold just through a program, but the aggregated savings number would be pulling data from a larger pool, and therefore be more accurate and statistically significant. Evaluators would need to figure out how to appropriately discount those savings, but that discounted savings number would only be claimed on those homes that had purchased a product through the program. While at present, this is a lofty ask for thermostat vendors to provide this level of data, but once vendors are applying this methodology for ENERGY STAR certification, we do not believe it will be too onerous to provide a state-level subset of the data for program promotion purposes.

This is different than the deemed savings approach taken for most efficiency products, but is a more accurate and realistic way to claim savings on a product that gets energy savings from control rather than one-for-one replacement with an inefficient product. And since the data is submitted to ENERGY STAR every six months for the previous year's heating or cooling season, the number may change over time as different seasons occur differently. This is a good thing, as the actual data provided from the devices regularly will be much more accurate for lifetime savings than any deemed savings number developed at one time. As with any change, it will take time to adjust, and NEEP recommends regulators, evaluators, program administrators, and smart thermostat vendors begin these conversations immediately. Once a reliable savings calculation methodology is in place, smart thermostats are likely to pass most cost-effectiveness screenings and can then be moved in to programs on a permanent basis.

Strategy 4: Smart appliances, water heaters, and lighting should be promoted in existing products programs

The demand response, load shifting, and integration with distributed energy resources potential of smart appliances, smart water heaters, and smart lighting has been established through this report. In this chicken or egg situation, while a smart product installed in a home today without DER infrastructure may not provide immediate benefits over its efficient but non-smart alternative, in the future, the opportunities for benefits are abundant. As such, it is critical that program administrators don't lose the opportunity to integrate smart products into existing product programs to build the installed base of these devices. If a program already has a

mechanism to support appliances, lighting, or water heating, shifting focus to the smart (and still efficient) versions of these products will ensure the opportunity is not lost. ENERGY STAR makes this easy by offering a connected option for many products, and 3rd-party software companies such as Weatherbug Home or EnergyHub can integrate with the smart devices to pull them into the a demand response program once one exists. Once the infrastructure, such as demand response, solar, and time-of-use pricing are built out, there will already be a smart product installed that can take advantage.

Appliance rebate programs vary in cost-effectiveness, but the demand response potential alone for systems such as clothes washers, dryers, and dishwashers, may be able to help justify increased incentives based on incremental costs.[45] Currently, without much of a market asking for these, most manufactures include connected functionality only on their high-end models, but program administrator investment in this market segment could increase economies of scale and lower the future cost of smart appliances.

For lighting, Efficiency Vermont's recent smart lighting pilot concluded that smart lighting users were dimming their lights at high rates. While only 10% of residential lighting sockets are on dimmer switches, nearly all smart LEDs offer dimming through their user interface as an added functionality. Dimming light is a great way to reduce the energy consumption of a lamp, and furthermore, smart LEDs are highly efficient when compared to halogen or incandescent lamps. At present, however, smart LEDs have not proven themselves to be much more efficient than standard ENERGY STAR LEDs, and because of the near-constant standby power drawn by these lamps, in some cases they may be slightly less efficient than standard ENERGY STAR LEDs. Moving from passive to active savings, however, allows automation to potential maximize energy savings of smart lightbulbs. When dimmed, these bulbs draw less energy, and as more smart lamps fill existing sockets, there is an opportunity for demand response programs to harness smart bulbs during peak events. Dimming all the smart bulbs in a house during peak times, especially in winter in the Northeast when early sunset means lots of residential lighting use during peak times, could have a negligible impact on users but in aggregate, could amass to a significant benefit for the grid.

Furthermore, smart LEDs are one of the most popular smart home products installed, presumably in some part because of their relatively low price points. With simple smart LEDs costing as little as $20 (or less), this product category is financially more approachable than many other smart home products, and in some respects could be a "gateway" product to pique interest in other smart home investments. These benefits, coupled with existing residential lighting incentive programs, create opportunities for incentives to be provided to smart lamps for their demand response benefits, which in turn could help motivate consumers to invest in other smart home devices.

A key element to this strategy is to build upon existing relationships with retailers and manufacturers to demonstrate the interest in smart products. ENERGY STAR's connected functionality for many products provides a great pathway for appliance manufacturers to follow in order to become connected; the onus is on program administrators and efficiency stakeholders to build demand and motivation for further investment and ensuring the products are not just connected, but also smart. As such, taking advantage of exiting product programs to support the adoption of these devices is critical.

[45] http://www.neep.org/incremental-cost-emerging-technology-0

Strategy 5: Develop strategies to seriously engage with service providers in the IoT space, especially home security

Nontraditional efficiency market actors, such as home security and telecommunications providers, are becoming significant forces for how HEMS are getting into homes. In many situations, they are offering a bundling of security and home automation.[46] While these companies may be adding smart products onto their existing subscription services, there is no evidence that the energy optimization potential of smart energy products is being pursued. Rather, these smart products are seen as engagement tools to help service provides better connect with their customers. This report outlined many additional product functionalities and applications to go beyond a smart home and get to a "smart energy home." Unless a coordinated effort is made, devices installed through service provider channels may be missing this additional functionality and thus missing significant opportunities to save and optimize energy.

Utilities and other efficiency stakeholders need to develop a comprehensive strategy to seriously engage with service providers, especially security. These players are pushing HEMS products into the market, but at present do not understand the value proposition of partnering with utilities or pushing the energy benefits of the smart home. In a survey conducted for NYSERDA with nontraditional HEMS providers, most respondents indicated an interest in pursuing more energy benefits from their smart home solutions, but didn't see the value in engaging with utilities.

There is a clear need to put competition aside in favor of collaboration and building partnerships. NEEP's recommendation is that a common voice for the efficiency community, potentially through an existing vehicle like the HEMS Working Group, begins to engage and lay out the value proposition of partnership with representatives from home security and telecommunications. It is time for more active engagement to begin with these market actors and regional coordination is a great starting point.

Strategy 6: Program administrators diversify support of HEMS from strictly monetary incentives to other support features and roles.

As HEMS move from early adopters to the mass market, the needs of users change. There are barriers to the penetration and user success of HEMS beyond just first cost. Program administrators have the opportunity to focus on building a complete turn-key customer service model that not only will help with adoption, but also help ensure persistence and continued use of these devices.

There are several opportunities for program administrators to serve this role, including:

- Developing a Smart Energy Audit program. This would be an on-site visit to help with the installation and set-up of any hardware or software within the home. This could be coupled with any existing retrofit or direct install program. This could even include adding a smart energy home component to an existing audit program, which could include a walkthrough looking for specific smart opportunities. Looking at things such as: how can a home be optimized based on load profile, or specific end uses such as

[46] http://www.essence-grp.com/news-and-events/news/essence-partner-getsafe-wer-home-smart-living-solution

appliances or water heating that may need replacement, and replacing with an efficiency and smart new product.

- Programs playing the role of ongoing energy advisor for smart systems and HEMS. This could include having a call center to boost existing product customer support lines and to help increase education and awareness. If a call center was established, a program administrator could talk a customer through the various options within a smart home. Where smart meter date is available, potentially coupled with load disaggregation software, a program-supported call center may be able to determine some of the major end users of energy within a particular home and provide specific recommendations for smart products and upgrades.
- As referenced in other recommendations, program administrators and utilities have the opportunity to help push several elements of the smart home market. The potential for developing partnerships with retailers and HEMS vendors is significant, especially to help advance the development of some of the less obvious smart products, such as water heating and appliances. Shifting program intervention upstream may be a major way programs can influence the HEMS market.
- As is the case for many energy elements of a home, they are not currently adequately valued in a real estate transition. As partnerships have grown with realtors to emphasize the importance and increased value in an efficient home,[47] so too are there opportunities for program administrators to emphasis the smart components of a home in sale and purchase.
- Program administrators pilot new products and opportunities. The vision of a complete "smart energy home" will not happen organically, and utilities have the opportunity to pilot smart products such as water heaters, appliances, lighting, and providing home performance feedback through HEMS user interfaces. In this way, programs can help ensure these energy focused smart products are viable for customers and help ease introduction into the market.

Strategy 7: Investigate user friendly technologies, such as voice control

As outlined in the market update section, voice recognition and control devices such as Amazon Echo are becoming incredibly popular with consumers as well as driving innovations and partnerships amongst HEMS vendors.[48] This is exciting, as various vendors converging around a platform may diminish many of the interoperability concerns that have plagued this industry since the beginning. Furthermore, these voice control devices have the potential to be game changing in another way: their inherent ease of use.

While the search for a "killer app" to be the ultimate user interface and control all elements of a home continues, the simplicity in voicing a command within a home rather than clicking and scrolling through a phone's touchscreen is compelling. As outlined in a recent NEEP blog,[49] there is a significant potential opportunity to increase the persistence of energy-efficient settings and scenes through voice recognition devices. If a homeowner can easily vocalize the setting of distinct "away for work," "away for a few hours," and "away for vacation" modes for their home, for example, there is an increased likelihood that a user will continue

[47] One example of this is the Home Energy Labeling Information Exchange (HELIX) initiative: http://www.neep.org/initiatives/energy-efficient-buildings/green-real-estate-resources/helix
[48] http://www.greentechmedia.com/articles/read/Voice-Control-Emerges-as-a-Major-Theme-in-the-Smart-Home-at-CES-2016
[49] http://neep.org/blog/neeps-listening-new-energy-efficiency-innovations

to actually put the house into each of those modes through a vocalized command rather than have to toggle modes in one or more apps. While not necessarily onerous, if individual platforms are not able to mesh as well together as one voice control platform, then it is likely that users will continue to use voice commands where they might decrease use of multiple apps to serve the same function.

NEEP recommends that program administrators partner with industry actors such as Amazon, Apple, and Google to increase the availability of energy-efficient options in voice control system. Through partnerships comes the opportunity to increase energy savings by more successful use of scenes, moods, and settings.

Strategy 8: Promote dynamic energy pricing to help make all other strategies more impactful

Time of use and variable rate pricing are policy mechanisms to provide both the motivation and monetary compensation for much of the "smart" functionalities in HEMS. While some innovative products and manufacturers are developing smart products ready to be optimized based on price signals, the infrastructure does not yet exist in the Northeast to provide appropriate credit for that optimization. If utilities are able to move to a time of use or dynamic pricing scheme, HEMS and smart energy products would have the opportunity to flourish. Many of the potential benefits are not yet realized, and many potentially great products are not being enabled to respond to price signals because the demand is not yet there.

Many of the most impactful benefits of HEMS – be it load shifting, demand response, or integration with distributed energy resources – would be more cost-effective, and therefore prolific if the infrastructure for time of use or variable rate pricing existed. NEEP recommends that policymakers, regulators, and utilities review the information presented in this report soon to discuss the potential missed opportunities by not pursuing these pricing strategies. Any proposed new pricing strategy could first be piloted on a "smart energy home" to see the potential differences, though once dynamic pricing is in place, the smart home devices will start to capitalize on its benefits.

Conclusion

Throughout our research and analysis to develop the most actionable strategies for the Northeast and Mid-Atlantic to work towards a "smart energy home," NEEP has determined several things. First, HEMS and smart products do not provide energy savings alone. In fact, much of the benefit of most smart products stems from the other energy benefits that they can provide, such as demand response, load shifting, and integration with distributed energy resources. This is exciting in that there are so many benefits evident from these products and technologies. It is important to point out, however, that the traditional vehicles of efficiency programs will not be enough to build up the infrastructure of the smart energy home to achieve the regional goals outlined in this report. Coordination between departments and initiatives will be critical in order to build up the demand for and supply of several key smart home technologies.

Furthermore, through our analysis we found that even the smartest home could be inefficient. There is an acute need and opportunity to leverage the feedback, interface, and data from HEMS in order to drive home performance upgrade. While much of that work is invisible, HEMS have the opportunity to bring some of those improvements to life. Furthermore, if home performance and smart energy home technologies are coupled together, the on-display HEMS, such as a smart thermostat or an in-home display, can be that showcase piece to demonstrate and show off the home performance upgrades that had taken place.

Within this space, there is a both a push and a pull occurring. For some products and applications, efficiency stakeholders need to push in order to get these goals accomplished. Some smart energy home components do not have the natural market or demand, and may not be successful without a major efficiency effort. On the other hand, some products, service channels, and phenomena are occurring naturally and the onus is on the efficiency community to pull up to these opportunities and alter their course or work with them for the greater good. In some cases, this may be too challenging, and we may realize there is not a role for "smart energy" within a smart home product. In most cases, however, and with the strategies laid out in this report, the efficiency community has the opportunity to make a significant impact to improve the energy benefits of HEMS.

Through coordinated efforts such as the HEMS Working Group, co-convened by NEEP and the Home Performance Coalition, we anticipate that each of the eight strategies can be addressed. We anticipate progress, though slow at first, will be made to push the smart energy home forward and advance towards our regional goal. NEEP is here to help as the residential sector transforms, and we look forward to working with a variety of partners to achieve our goals.