



Automated Home Energy Management (AHEM)

Standing Technical Committee

Strategic Plan, v2011c – February 2012

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Prioritization of Gaps, Barriers and Needs

The following table lists a prioritization for the Gaps, Barriers and Needs included in the Building America AHEM STC Strategic Plan.

Table 1. Gaps and Barriers for AHEM STC.

Rank	Description
1	Energy Savings / ROI Insufficiently Quantified
2	Lack of Consumer Awareness of AHEM Products
3	Low Interest in Managing Energy Use
4	Complexity of AHEM Products

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Summary of AHEM STC Strategic Plan

The AHEM STC collectively identified numerous barriers to achieving widespread energy savings from AHEM technologies, as shown in Table 2. After barriers were identified by the group, we combined similar barriers together, discussed the barriers in a webinar, and prepared and posted on-line a Google form where each STC member could select the (up to) three barriers s(he) believes are most important. The STC selected the four top barriers shown in Table 2 as the priority barriers for inclusion in the Strategic Plan and further research. The remainder of this document focuses on the STC’s evaluation of the priority barriers. Table 2 ranks all the gaps and barriers included in the AHEM STC Strategic Plan.

Table 2. Voting results priority barriers selected by the AHEM STC for further evaluation

Rank	Description	Fraction of Voters [%]
1	Energy savings / ROI Insufficiently Quantified	50%
2	Lack of consumer awareness of AHEM systems	44%
3	Low interest in managing energy use	44%
4	Complexity of AHEM use and deployment	39%
5	Design, quality, functionality and individual preferences	28%
6	Lack of interoperability standards / different manufacturers for different appliances and controllers	22%
7	For Controllers, need to “smarten” existent appliances/outlets or purchase smart appliances	17%
8	Lack of dynamic electricity pricing (flat rate limits AHEM advantages for utilities)	17%
9	Potential conflict with utilities	17%
10	Information provided is not actionable	11%
11	Too many controls already in household - confusion, info overload	6%
12	For Controllers, only partial solutions (e.g., AHEM for lighting only) are available	6%

We present summaries of the four priority barriers, followed by a discussion of general themes to address these barriers.

1. *Energy Savings / ROI Insufficiently Quantified*: People can use AHEM to reduce energy consumption and costs, but need reasonably predictable energy cost savings to make a cost-benefit calculation; more rigorous assessments are required for utilities to incorporate AHEM into their energy efficiency programs. For many AHEM product classes, rigorous studies of their energy savings potential are lacking, particularly longer term studies that evaluate energy savings for more than just a few months.
2. *Lack of consumer awareness and interest in AHEM systems*: Most consumers are not aware that AHEM systems exist and even fewer people are aware of the full range of AHEM products available (see Appendix in October 2011 Draft of AHEM STC Strategic Plan). The relatively immature state of the AHEM market and relatively common “vaporware” create market confusion for interested consumers. The best way to address this barrier may be to resolve the other three barriers first, which will result in increased consumer awareness.
3. *Low interest in managing energy use*: A large portion of households have a very limited interest in managing their energy costs, even if they like the idea of reducing their energy use. This is a pervasive problem for Building America that is not restricted to AHEM. On the other hand, by making intangible home energy use data visible, AHEM technology has the potential to transform households’ awareness

of and interest in reducing energy costs and consumption. AHEM technology that provides relevant, personalized, and actionable information can help bridge this gap.

4. *Complexity of AHEM use and deployment:* The complexity of AHEM systems and/or their installation and use impedes their acceptance and effective use by consumers due to: 1) Deployment complexity, 2) Complexity of use, and 3) Complexity of information presented.

General Solutions

The STC has noted several common themes related to the type of research needed to increase uptake of AHEM products and systems. Solutions to address each of the four barriers are discussed in the barrier-specific sections that follow.

Field Studies to Evaluate Persistent Energy Savings: Rigorous field studies with sufficient sample sizes, including control groups, are essential to demonstrating the cost-effectiveness of AHEM products and systems. The question of persistence needs more thorough exploration in field studies to fully examine the question of cost effectiveness. Nearly everyone involved in the emerging AHEM market will benefit from field tests that can inform cost-effectiveness calculations. The results will help guide manufacturers and help them market their best products. Utilities need more reliable cost/benefit information to include AHEM devices in their energy efficiency programs. Building America will be able to focus their research on the most promising technologies and risk to homeowners will be reduced with better information available to them on what products they may want to invest in.

Consumer Engagement: AHEM has the potential to increase consumers' engagement with energy consumption and costs. Key opportunities include leveraging existing products valued by consumers (security systems, entertainment, life safety, communications) and enhancing user interface / design, ideally customized to individual households (see "Information Customization"). In particular, the STC notes smart phones as a promising medium, with the potential to leverage models used in other successful apps.

Information Customization: It appears that many households cannot effectively act upon information provided by AHEM because they either do not know what to do or are not motivated to act. Providing information, ideally specific and personalized actions that households can take to reduce energy costs has the potential to significantly increase realized energy savings and its persistence. In order to make this approach successful, the tailored recommendations should come with a realistic projection for energy cost savings. In addition to determining the best actions to recommend and how much energy the homeowner can expect to save, understanding what, how, and how often to communicate these recommendations will also be integral.

Automation versus Human-in-the-Loop: Typically, people need to feel in control of their homes, but often neglect to exploit energy saving opportunities due to a relative lack of interest in and inability to effectively manage energy costs. Automated controls have the potential to achieve significant energy cost savings for households, but must be executed in ways that do not inconvenience the inhabitants (e.g., inadvertently shutting down devices still in use, diagnosing false positives). Despite the complex technology this will require, automated home energy management products must still be cost effective. Combining AHEM functionality with other non-energy systems, like security systems, may help reduce costs and enable quicker adoption.

Dynamic Pricing: Dynamic electricity prices will likely be key to increasing the adoption of AHEM devices that help households take a more active role in managing their energy costs. If dynamic pricing forces homeowners to pay attention to their energy consumption throughout the day, they may be more likely to begin using AHEM products to manage the energy use of their HVAC systems and large appliances during periods of high electricity prices. While not very common now, dynamic pricing is expected to be prevalent as more and more utilities upgrade their meters to AMI or smart meters, which are needed to make dynamic pricing possible.

Interoperability Standards: Most whole-house home automation solutions depend upon information shared among devices from multiple vendors. To maximize the usefulness of all devices, interoperability standards will need to be developed for key AHEM components. Additionally, the communication protocol used to connect all AHEM devices should not interfere with other wireless signals around the house or in adjacent houses.

1: Energy Savings / ROI Insufficiently Quantified

Is this appropriate Building America research? Y: N: (please check all that apply)

BA Enclosures		BA Hot Water		BA Implementation	
Walls		Test Standards		Quality Control/Quality Assurance	
Roof/Ceiling		Distribution	X	Training	
Foundations		Condensing/Tankless		Documentation/Resources	
Moisture		Heat Pump Water Heater		Needs Evaluation/Identification	
Windows	X	Combined Space & DHW Heating	X	Other:	
Other:		Other:		House Type	
BA Space Conditioning		BA Miscellaneous Loads		New	X
Heating	X	Home Energy Management	X	Existing	X
Cooling	X	Lighting	X	Single-Family	X
Dehumidification	X	Large MELs (pools, etc.)	X	Multi-Family	X
Distribution	X	Small MELs (TVs, VCRs, etc.)	X	DOE Program Areas	
Ventilation	X	Other:		Emerging Technologies	
Other:	X	Analysis Methods/Tools		Deployment	
Testing Methods/Protocols		Validation and Testing		Codes and Standards	
House Simulation Protocol		Methods and Tools		Level of Effort (1 FTE = 1 person-year)	
Lab Test Methods		Field Data and Audits		Low-level (<0.25 FTE)	
Field Test Methods		House Simulation Protocol		Medium-level (0.25-1 FTE)	
Other:		Other:		High-level (>1 FTE)	
Key Stakeholders		Manufacturers	X	Designers	X
Builders / Remodelers/Trades	X	Utilities / Efficiency Programs	X	3 rd Party or Voluntary Programs	
Other:		Other:		Other:	
Applies to Climate Zone...		Cold/Very-Cold	X	Mixed-Humid	X
Hot-Humid	X	Hot-Dry/Mixed-Dry	X	Marine	X

Problem Statement:

The lack of reliable data on the cost/benefit ratio of AHEM systems and approaches is a significant barrier for widespread adoption of AHEM. Currently many business models for AHEM-related emerging technologies center around working with utility efficiency programs for pilot studies that lead to larger scale deployments. Without credible predictions of ROI, utilities cannot make these investments and be accountable to their investors (or ratepayers, in the case of municipalities). Builders and homeowners likewise need well-quantified energy savings predictions to minimize their investment risks.

Key difficulties in calculating reliable energy cost savings include:

1. Emerging technology makes it difficult to capture real-world usage data
2. Products are relatively new and untested; no long-term data on persistence of energy savings
3. Individual behaviors, preferences account for large noise in savings
4. When savings are achieved, difficult to attribute them to the particular AHEM device, as often controls are implemented on plug loads that are not discretely monitored (such as in the use of advanced power strips, for example).

Background Knowledge:

- Ehrhardt-Martinez et al. (2010): Meta review of energy savings from different types of feedback, finding a range of electricity consumption reductions of 4% to 12%, depending on sophistication.
- Parker et al. (2010): Two-year case study of 20 homes in FL using low-cost energy monitors. Initial savings of 7% through second year, then a follow-up 3 years later showed very little persistence

- O’Neil et al.: In-home field tests of advanced power strips (APS) suggested that behavior has a major impact on realized energy savings; significant savings variability due to consumer behavior and range of devices deployed.
- Dam et al. (2010): Field study found that initial energy savings from home energy displays of 7.8% after 4 months, not sustained after 15 months.
- Peffer et al. (2011): Summary of how thermostats are used.

System Considerations:

Different AHEM technologies can be used to reduce energy consumption by different end uses. One promising model for AHEM is for it primarily to be deployed to perform non-AHEM functions, i.e., the savings are an added bonus on top of what consumers are willing to pay for.

Planned or Ongoing Research:

- SMUD, TXU, and National Grid running smart thermostat projects.
- Fraunhofer team researching: 1) incremental energy savings from high-usability programmable thermostats relative to conventional programmable thermostats; 2) if high-usability energy displays show greater persistence in energy savings relative to conventional displays.
- PARR team researching potential ways to reduce natural gas consumption using feedback.
- NELC team researching ways to leverage HEM/smart grid for automated/assisted home energy audits.
- NREL currently conducting laboratory testing of Advanced Power Strips

“Closing the Gap”:

Neutral, third-party laboratory testing of many emerging AHEM technologies is needed first to assess basic functionality, reliability, interoperability, and ease of set-up/use. This information is crucial to making informed baseline estimates of achievable savings using various devices and combinations of devices.

Well-designed field studies with appropriate sample sizes, durations, and control groups are crucial to obtaining statistically significant datasets for computing real-world energy savings.

Coordination and Timeline:

Coordinate among BA teams and national labs to identify opportunities for field deployments (perhaps leveraging existing community-scale retrofit/construction opportunities).

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.

Draft - not to be cited

2. Lack of Consumer Awareness of AHEM Products

Is this appropriate Building America research? Y: N:

(please check all that apply)

BA Enclosures		BA Hot Water		BA Implementation	
Walls		Test Standards		Quality Control/Quality Assurance	
Roof/Ceiling		Distribution		Training	
Foundations		Condensing/Tankless		Documentation/Resources	
Moisture		Heat Pump Water Heater		Needs Evaluation/Identification	
Windows		Combined Space & DHW Heating		Other:	
Other:		Other:		House Type	
BA Space Conditioning		BA Miscellaneous Loads		New	X
Heating		Home Energy Management	X	Existing	X
Cooling		Lighting	X	Single-Family	X
Dehumidification		Large MELs (pools, etc.)	X	Multi-Family	X
Distribution		Small MELs (TVs, VCRs, etc.)	X	DOE Program Areas	
Ventilation		Other:		Emerging Technologies	
Other: Controls	X	Analysis Methods/Tools		Deployment	
Testing Methods/Protocols		Validation and Testing		Codes and Standards	
House Simulation Protocol		Methods and Tools		Level of Effort (1 FTE = 1 person-year)	
Lab Test Methods		Field Data and Audits		Low-level (<0.25 FTE)	
Field Test Methods		House Simulation Protocol		Medium-level (0.25-1 FTE)	
Other:		Other:		High-level (>1 FTE)	
Key Stakeholders		Manufacturers	X	Designers	X
Builders / Remodelers/Trades		Utilities / Efficiency Programs	X	3 rd Party or Voluntary Programs	
Other:		Other:		Other:	
Applies to Climate Zone...		Cold/Very-Cold		Mixed-Humid	
Hot-Humid		Hot-Dry/Mixed-Dry		Marine	

Problem Statement:

AHEM products have generally been marketed to utilities as accessories for the burgeoning smart grid. This approach means that few consumers know anything about AHEM products unless they are in the small minority of customers that have participated in utility programs involving AHEM devices. If consumers are unaware of AHEM products, there is little motivation for makers of AHEM devices to tailor their products to consumers. Lack of consumer awareness leads the development of AHEM devices to satisfy utility demands, rather than consumer demands. Ultimately, the lack of consumer awareness is caused by the fact that AHEM's place in the market has not yet been fully defined. Are these products for consumers or utilities? Until the market begins to cater to the consumers instead of the utilities, it may be difficult for HEM devices to gain much customer acceptance.

The largest problem associated with lack of consumer awareness is that consumer input is needed to guide the technology in the direction that will be most successful. Most new types of electronic gadgets are introduced to the market by several manufacturers with slightly different features. Early adopters help to guide the fledgling market towards products that have more mass appeal. That sort of initial vetting has not yet occurred with AHEM products and as a result, product development is still all over the map. It would be in the interest of the many companies developing AHEM products to push for more consumer awareness to help guide their product development.

Background Knowledge: None known.

System Considerations:

Lack of consumer awareness hinders the growth of the industry, which may be the root cause for some of the other barriers identified here, namely the complexity of the products and lack of information related to ROI. Time and maturity should help to remedy all three barriers.

Planned or Ongoing Research:

Utility pilots of AHEM technology have the potential to increase awareness of AHEM devices, although the STC is not aware of general efforts made to quantify this awareness.

Probably the best way for consumers to learn more about AHEM devices is through traditional advertising. Best Buy has just launched a Home Energy Management store on line and in a few larger stores. This could help give tech-savvy consumers more exposure to the products.

“Closing the Gap”:

A strong potential exists to increase awareness by incorporating AHEM functionality into other systems that homeowners are already willing to pay for, such as smart phones, security, life safety, entertainment. This could help address the ultimate problem with lack of awareness, namely getting AHEM products into homes, without necessarily addressing the lack of awareness. However, if homeowners get used to having more control over the energy use in their homes, the concept of AHEM may become familiar, which could improve awareness of the products.

Coordination & Timeline:

This barrier to AHEM adoption will not be overcome through Building America work. Most likely, as smart grid projects become more ubiquitous, so will AHEM products. Also, as larger companies jump into the AHEM space, more traditional advertising will reach consumers. We already see this happening with Best Buy creating a space to sell AHEM products.

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.

Draft - not to be cited

3. Low Interest in Managing Energy Use

Is this appropriate Building America research? Y: N: (please check all that apply)

BA Enclosures		BA Hot Water		BA Implementation	
Walls		Test Standards		Quality Control/Quality Assurance	
Roof/Ceiling		Distribution		Training	
Foundations		Condensing/Tankless		Documentation/Resources	
Moisture		Heat Pump Water Heater		Needs Evaluation/Identification	
Windows		Combined Space & DHW Heating		Other:	
Other:		Other:		House Type	
BA Space Conditioning		BA Miscellaneous Loads		New	X
Heating		Home Energy Management	X	Existing	X
Cooling		Lighting	X	Single-Family	X
Dehumidification		Large MELs (pools, etc.)	X	Multi-Family	X
Distribution		Small MELs (TVs, VCRs, etc.)	X	DOE Program Areas	
Ventilation		Other:		Emerging Technologies	
Other: Controls	X	Analysis Methods/Tools		Deployment	
Testing Methods/Protocols		Validation and Testing		Codes and Standards	
House Simulation Protocol		Methods and Tools		Level of Effort (1 FTE = 1 person-year)	
Lab Test Methods		Field Data and Audits		Low-level (<0.25 FTE)	
Field Test Methods		House Simulation Protocol		Medium-level (0.25-1 FTE)	
Other:		Other:		High-level (>1 FTE)	
Key Stakeholders		Manufacturers	X	Designers	X
Builders / Remodelers/Trades		Utilities / Efficiency Programs	X	3 rd Party or Voluntary Programs	
Other:		Other:		Other:	
Applies to Climate Zone...		Cold/Very-Cold		Mixed-Humid	
Hot-Humid		Hot-Dry/Mixed-Dry		Marine	

Problem Statement:

Improving energy efficiency in the home is a goal that a large majority of Americans regard positively but rarely act upon. This disparity between sentiment and action is a problem in all areas for residential energy use and is not restricted to AHEM products. However, unlike some other home improvement actions like replacing an inefficient appliance or installing additional attic insulation, many AHEM products rely on the behavior of the household to produce energy savings. Products like In-Home Displays (IHDs) give consumers feedback on their energy use as way to increase awareness and motivate action. However, devices that give homeowners feedback on their energy use, especially those with targeted feedback, could motivate people to make energy efficient improvements that would decrease energy use without requiring persistent behavior changes.

The attitude that people want to save energy as long as they do not have to change their habits or do anything to affect change is one reason that some products in the AHEM space are moving away from relying on the behavior of the homeowners and towards automated control. If AHEM devices are smart enough to make good decisions about energy use in the home without impacting the comfort of the homeowners, this barrier will largely be bridged.

The problem of persistent AHEM energy savings, also may be related to the lack of interest in working for energy savings. An IHD may be a fun toy when first installed but maintaining a strict long-term regimen to save energy is hard work. Some innovative programs, like OPower's utility bill feedback that compares the household to others in the neighborhood, play on people's competitive nature to keep their attention. There are also a number of companies that are linking social networking and energy efficiency, creating a community for people to share their actions and successes and hopefully, spur more action among the participants. There are a number of strategies to incentivize action for saving energy but there are still many lingering questions

about their effectiveness. Like other feedback-related products, the question of persistence is yet unanswered for these social and marketing-based approaches.

Background Knowledge:

- Ehrhardt-Martinez, K. (2009): Discussion on public sentiment on energy efficiency and past behavior change studies.
- Dam et al. (2010): Field study found that initial energy savings from home energy displays of 7.8% after 4 months not sustained after 15 months. Lack of persistence in energy savings attributed to lack of persistence in households' interest in engaging with display.

System Considerations:

This barrier is related to Barriers 1 (Unclear Savings/ROI) and 2 (Lack of Consumer Awareness).

It may be possible to increase interest from incorporating HEM functionality into other systems that homeowners are already willing to pay for, such as security, life safety, entertainment, communications. This may be a way to bring more automated controls into the house without having to sell the consumers on energy saving alone.

Planned or Ongoing Research: None known.

“Closing the Gap”:

Just as there a number of strategies for keeping people interested and acting on energy efficiency, there are number of ways this gap can be addressed. On the technology development side, there are on-going efforts to create products that do not rely on interaction from the homeowner to save energy. The Nest Learning Thermostat is a good example of this approach. This programmable communicating thermostat learns the patterns of households and automatically adjusts the schedule to both keep the residents comfortable and save maximum energy. Efforts on the technology development side will obviously be spearheaded by companies developing products in the AHEM space.

Another approach involves behavioral studies to determine what may keep people engaged enough with their AHEM products to keep action, and thus energy savings, persistent. This may involve creating a system for personalized, actionable feedback based on each home's energy use. That strategy will require more research on accurately predicting energy savings for different actions and how to present these recommendations to homeowners in a way that will be well-received. Research to better predict energy savings associated with retrofits is currently ongoing at NREL. This research is essential to all facets of Building America work with retrofits, but would equally applicable here. The behavioral component to this strategy is needed to understand how to present recommendations to homeowners.

Leveraging interaction with other products, like security systems, is another of strategy to keep the homeowners engaged. If the controls for a home security system were combined with an IHD, homeowners would have to look at their energy use every day. Some IHDs include Internet connections for access to local weather information and email in an attempt to further engage the homeowners.

Coordination & Timeline:

There is a small amount of overlap in efforts to close this gap and other Building America research, namely the research required to determine the appropriate feedback to homeowners and the expected energy savings. This work is currently ongoing with the BEopt development team at NREL in conjunction with the Building America teams. Otherwise, this barrier will largely be addressed on the technology side or with behavior research. Any of the final products, whether they are actual devices or messaging strategies, could be tested in a Building America study to validate the claims by different companies. However, the timeframe and actual action to address this barrier will largely be up to the independent companies working in the AHEM space.

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome: *Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

Draft - not to be cited

4: Complexity of AHEM Products

Is this appropriate Building America research? Y: N: (please check all that apply)

BA Enclosures		BA Hot Water		BA Implementation	
Walls		Test Standards		Quality Control/Quality Assurance	
Roof/Ceiling		Distribution		Training	
Foundations		Condensing/Tankless		Documentation/Resources	
Moisture		Heat Pump Water Heater		Needs Evaluation/Identification	
Windows		Combined Space & DHW Heating		Other:	
Other:		Other:		House Type	
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Heating		Home Energy Management	X	Existing	X
Cooling		Lighting	X	Single-Family	X
Dehumidification		Large MELs (pools, etc.)	X	Multi-Family	X
Distribution		Small MELs (TVs, VCRs, etc.)	X	DOE Program Areas	
Ventilation		Other:		Emerging Technologies	X
Other: Controls	X	Analysis Methods/Tools		Deployment	X
Testing Methods/Protocols		Validation and Testing		Codes and Standards	
House Simulation Protocol		Methods and Tools		Level of Effort (1 FTE = 1 person-year)	
Lab Test Methods		Field Data and Audits		Low-level (<0.25 FTE)	
Field Test Methods		House Simulation Protocol		Medium-level (0.25-1 FTE)	
Other:		Other:		High-level (>1 FTE)	
Key Stakeholders		Manufacturers	X	Designers	X
Builders / Remodelers/Trades		Utilities / Efficiency Programs	X	3 rd Party or Voluntary Programs	
Other:		Other:		Other:	
Applies to Climate Zone...		Cold/Very-Cold	X	Mixed-Humid	X
Hot-Humid	X	Hot-Dry/Mixed-Dry	X	Marine	X

Problem Statement:

The complexity of AHEM systems themselves and/or their installation and use impedes their acceptance and effective use by consumers in multiple ways:

1. Deployment complexity. Some AHEM systems, particularly home automation systems, require professional installation, increasing cost.
2. Complexity of set-up/use. Centralized AHEM systems and many individual devices such as thermostats require programming.
3. Complexity of information presented. IHD's may present extraneous information that confuses some consumers instead of enabling consumers.

An overarching question related to complexity of use and information presented is the role of automation in AHEM. To what extent should occupants be involved in AHEM? Minimizing households' interaction with or involvement in AHEM could greatly reduce these factors as barriers by automating energy savings.

Background Knowledge:

- Perry et al. (2011): Usability metrics for thermostats.
- Zeifman and Roth (2011): Summary of non-intrusive load monitoring research (NILM) to obtain device-specific energy consumption data that could be used to provide enhanced feedback to residents.

System Considerations:

This barrier is related to Barrier 1, Energy Savings/ROI Insufficiently Quantified. Savings that depend on residents' actions can be thwarted by complexity, costs increased for professional deployment (e.g., electrician).

Planned or Ongoing Research:

Some companies, e.g., Tendril, have started offering home energy information systems that leverage smart meters to present more context-specific, actionable information, although it is not clear how effective it is. Multiple thermostat manufacturers have or are planning to launch products to simplify thermostats with greater functionality.¹

Several organizations are performing NILM research and development, working to commercialize NILM. Fraunhofer is researching: 1) incremental energy savings from high-usability programmable thermostats relative to conventional programmable thermostats; 2) if high-usability energy displays show greater persistence in energy savings relative to conventional displays.

“Closing the Gap”:

Device-specific research recommendations include:

In-Home Displays (IHD):

1. Development of IHDs that do not require professional installation (i.e., no electrician) or significant user effort (e.g., turning on-off devices for NILM set-up)
2. Evaluation of what displays and display attributes are meaningful and actionable to technology-naive users, leading to specifications (e.g., for ENERGY STAR, utility energy efficiency programs)
3. Evaluation of the incremental, persistent energy savings from providing customized recommendations to residents based on their home, personal, and energy consumption characteristics: Field testing of savings based on development of relevant segmentation of residents. Related to #3 below.

Controllable AHEM Systems:

1. Field evaluation of installations that can be done by naïve users (“plug and play”) and automatic control of appliances with optional manual intervention to understand if this yields greater acceptance and effective use (i.e., real-world energy savings).
2. How can the smart meter infrastructure installed for demand response and/or real-time pricing be readily leveraged for in-home control (centralized, device, or on-board)? Technology assessment, field tests of systems based on smart meter infrastructure.

Field evaluation of effectiveness of NILM products/systems that can be used to provide context-specific information and recommendations to households; research to evaluate the degree of human-in-the-loop preferred by occupants and its impact on the cost effectiveness and realized energy savings of controllable AHEM systems.

Coordination & Timeline:

TBD

¹ See: <http://www.greentechmedia.com/articles/read/energyhub-teams-up-with-radio-thermostat-of-america/>,
<http://www.greentechmedia.com/articles/read/ecofactor-cuts-house-power-by-17-percent-ibm-launches-its-buildings-effort/>.

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.

Draft - not to be cited

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Appendix A: Change Log

Record of additions and modifications to the summary sheets.

Date	Version of Plan (updated version #)	Title of Gap/Barrier/Need	Description of Change
10/5/2011	Strategic Plan, v2011b	All	All gap/barrier/needs updated
01/31/12	Strategic Plan, v2011c	All	All gaps revised by Earle, L. and Sparn, B.

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Appendix B: Past Research – Resolved Gaps, Barriers and Needs

When gaps or barriers are resolved, a brief summary is appended to the strategic planning document as a running record of Building America achievements.

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Appendix C: Contributors

The following people participated actively in STC discussions, contributed input to the STC, and/or were on the STC mailing list.

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