



Opportunities for Home Energy Management Systems (HEMS) in Advancing Residential Energy Efficiency Programs

August 2015



Executive Summary

Home Energy Management Systems (HEMS) are an invention of the internet age; they are a 21st-century byproduct of the idea that utility smart meters can enable two-way communication with homeowners while smart consumer products can allow greater connectivity, control, and ultimately a better living. Since the earliest documented implementations of smart meters in the mid-2000's, program administrators around the world have looked for ways to use the energy information provided at the whole home level to enhance residential energy efficiency and conservation programs. In certain parts of the United States, changes in utility regulation, such as the decoupling of sales from profits, have paved the way for alternate residential program mechanisms that utilize technology to deliver more energy savings and enhance customer satisfaction. These are some of the earliest instances of programs that used home energy consumption information with the goal of influencing energy savings, a concept which evolved into what is now referred to throughout the energy efficiency industry under the umbrella term of "HEMS."

A 2010 ACEEE report¹ began to quantify the opportunities presented by feedback initiatives, many of which utilized nascent HEMS devices and technology. The paper published results showing reduced household electricity consumption of 4 percent to 12 percent on average; these results demonstrated that feedback was an effective behavioral tactic in getting customers to save energy, and the more accurate and timely the feedback, the better. This study and its findings formed the basis for an accelerated interest in energy efficiency programs that used direct feedback as a savings mechanism, often with a connected, communication-capable device at the heart of the strategy. In the years since the ACEEE report, the market for technology and consumer products has changed dramatically. Major corporations have entered, and exited, the energy efficiency market, with early incarnations of consumer-facing dashboards such as Microsoft Hohm and Google PowerMeter later giving way to a plethora of products, platforms, and dashboards that offer expanded capabilities to both end-users and program administrators. These products range from pieces of hardware that monitor and control single energy end-use systems; to whole-home monitoring devices that track multiple fuel sources or that use disaggregation algorithms to parse out electric loads; to platforms that use no in-home hardware at all, but use consumer data, building characteristic information, and geographic location to conduct sophisticated data analysis and yield reasonable portfolio-level estimates.

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The definition of what constitutes a "home energy management system" has evolved, too, from once denoting only a monitoring system to today's more widely accepted view of HEMS as an umbrella acronym for a variety of home energy management *solutions*, which can involve stand-alone or combined versions of the aforementioned products and dashboards. As dynamic as the market for HEMS products has become, however, the lack of independently verified empirical data on HEMS-provided savings impacts, as well as the lag in development of standards and communication protocols, has created what some would argue is market

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¹ <http://aceee.org/research-report/e105>.



confusion for consumers and participants in energy efficiency programs. Nevertheless, the HEMS space continues to evolve, with manufacturers and program administrators acting to address barriers to consumer uptake in the hopes of fulfilling the promise of deeper savings.

NEEP, through its work on business and consumer electronics, identified HEMS as an emerging area for programs and developed a research scope to synthesize much of the findings and results from the past several years of HEMS evolution into a discussion of opportunities for HEMS in energy efficiency programs, particularly those in the Northeast and Mid-Atlantic. The purpose of this report is to demonstrate the potential for HEMS as an evolving avenue to deeper residential energy savings, and it explains, in detail, the variations and characteristics of HEMS; what the market is and who the major market players are; what the major barriers to implementation look like; and finally, it attempts to outline potential program solutions with HEMS at the core of the strategy. NEEP contracted CLEAResult to lead the HEMS research and investigation. This report is intended to evaluate the opportunity of HEMS, NEEP is committed to continuing tracking and engagement efforts in this space and to, fueled by the research and analysis in this report, develop regional strategies to transform the HEMS market in the years to come. This report includes the following sections:

Technology Assessment. Working off of a comprehensive technology assessment put together for the Pacific Gas & Electric Company (PG&E) 2015 HEMS Market Characterization, the research team used the PG&E report's taxonomy to break HEMS into information-based and control-based products; these two functionalities include sub-categories of devices into which nearly every known HEMS device and platform can be assigned. Information-based systems refer to the direct feedback platforms envisioned in the 2010 ACEEE report, while control-based systems use programming and sophisticated technology to insert more automation into a product and remove the variability caused by human behavior. The technology assessment provided the research team several lenses through which potential opportunities for HEMS in programs were identified.

Program Activity Assessment. In support of future opportunities for HEMS in programs, the research team sought out the objectives, parameters, and any available results from completed or in-process programs that have utilized or are using HEMS. With the added benefit of the categorization laid out in the Technology

Assessment, the landscape for HEMS pilots, projects, and programs expanded considerably; any programs discovered were organized into the more precise information-based and control-based device categories, which allowed for easier comparisons amongst goals and significant results. This work began to bring estimates of savings potential for HEMS-enabled programs into sharper focus, and set up the additional analysis conducted in the Opportunity Assessment.

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Policy Opportunities and Recommendations. The opportunities for HEMS adoption in the Northeast and Mid-Atlantic, as well as nationally, are enhanced by legislative action at the federal and state level, standards and protocol development by nationally recognized entities such as ENERGY STAR®, and efforts to revisit cost-effectiveness calculation methodologies. In this section, the NEEP HEMS research team reviewed and summarized these efforts with respect to their impact on opportunities for HEMS in energy efficiency programs. The most prominent advocacy efforts are currently helmed by Efficiency First and the Home Performance



Coalition, who recognize the value of incorporating smart home technology into residential energy efficiency programs and have directed their focus accordingly. Although initial efforts around standards and protocols in the HEMS space stalled, ENERGY STAR and the Pacific Northwest National Lab (PNNL), amongst others, have renewed discussions around testing devices and establishing protocols to support manufacturers in this market. In this section, the research team addresses several HEMS barriers and challenges put forth in the Technology Assessment and recommends policy drivers to help solve these issues going forward.

Potential of HEMS as a Measurement and Verification (M&V) Tool. In the earliest deployments of smart meters, program administrators envisioned that interval data could provide value to programs through a utility's advanced metering infrastructure (AMI). Independent of AMI, some HEMS have the capability to collect interval level data. Leveraging recent work from a May 2015 NEEA report, this section analyzes the potential opportunity to use HEMS as an M&V tool to measure and verify savings from energy efficiency measures in a home. The research team also reviewed new and ongoing efforts and potential products or systems that may unlock previously unattainable data sets for the purposes of more rigorous and quicker program M&V.

Opportunity Assessment. Through the examination of HEMS technology options available, HEMS program activities, policy drivers, and M&V considerations, the opportunities for HEMS begin to present themselves. The remaining pieces of the puzzle are those critical programmatic considerations that may be taken for granted in traditional residential energy efficiency programs, but which deserve fresh attention with the new perspective granted by the capabilities inherent in HEMS. The research team examined many variables and leveraged new HEMS-specific learnings into the opportunities and recommendations described in this paper, and found that although every program is different, the Opportunity Assessment provided strong guidance as to the direction that programs can take; following are summaries of the recommendations that have emerged from this extensive analysis.

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- **Energy End-Use:** Focus on space heating and cooling end-uses for the most savings potential, especially when non-electric fuels are a priority. Continue to monitor the growth of plug loads and consumer electronics, and plan for HEMS-based strategies that can facilitate electricity savings.
- **Region / Territory:** Within the Northeast region, smart thermostats and associated smart climate controls hold the most immediate promise for HEMS-enabled programs, especially when bundled with existing retrofit measures for efficient equipment upgrades. In some Northeast and Mid-Atlantic program territories, smart climate controls should offer energy and demand savings capabilities in order to take advantage of future HEMS product advancements.
- **Channel:** The DIY / self-install channel, and to a lesser degree, the qualified installer channel, are currently the paths of least resistance through which most vendors and manufacturers are moving their products. Programs should leverage these channels for cost-effective delivery while exploring other potential avenues for encouraging HEMS and connected device uptake.
- **Dwelling Type:** HEMS hold promise for nearly every dwelling type, but the nature of the systems available and desires vary widely by vintage, building type, and occupant income level. Existing homes



are the biggest opportunity by sheer volume, but the multifamily market is growing quickly in many metropolitan areas throughout the country and should be examined for new program opportunities. Additionally, using the direct install channel strategically in low income properties, manufactured homes, and in existing multifamily structures is highly recommended for any programs looking to bring HEMS into those building types.

- **Energy, Demand, and Other Resources:** The capabilities of HEMS are such that program administrators who wish deliver energy savings now and other, additional resource savings at a later time should be able to do so through product updates and add-ons. Demand response capabilities of HEMS should be available for any program that is forecasting peak load issues, whether in summer or in winter. Energy and thermal storage as well as energy balancing abilities inherent in HEMS will be critical aspects of grid resilience planning; and, to the extent possible, energy programs should begin exploring opportunities to claim savings for water and greenhouse gas emissions where these benefits can be accounted for.
- **Customer Engagement Planning:** Conduct proactive customer segmentation and employ the basic behavioral strategies when designing a program that utilizes information-based HEMS.
- **Designing Programs with M&V:** Strive for using interval data in HEMS program M&V, for both rigor and timeliness; settle on data collection protocols that allow this capability before programs are launched.

HEMS may make it possible to deliver whole-home energy usage information, long-term customer engagement, demand response savings, direct load control, more data and transparency for M&V, and ultimately more cost-effective energy savings. With the analysis conducted in this report among others, the research team concluded that program administrators should have confidence that HEMS can deliver energy and other resource savings,

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as well as enhanced customer satisfaction, as long as the appropriate program design considerations are taken.

With the assumptions from this report in hand, programs in the Northeast, Mid-Atlantic, and beyond, could achieve space heating and cooling savings of up to 17 percent from a whole-home baseline, or smaller increments of savings across a wide variety of end uses, by pulling the appropriate program levers. The opportunity also exists for programs and regulators to reconsider the way that

programs are evaluated at a portfolio level in order to encourage adoption of HEMS products that can conserve resources while providing non-energy benefits to users such as enhanced safety, health, and security.

Recommendations. This section includes specific recommendations around:

- Best practices for using HEMS in customer engagement and program evaluation planning
- Estimated savings and discussion of cost-effectiveness variables for resource planning
- A HEMS program design framework
- Recommendations for further research and new program strategies

NEEP and the research team hope that this report will be a resource to ensure programs are better equipped to select vendors, manufacturers, and third-party service providers to deliver an advanced HEMS platform to program administrator clients. Homes will, at some point in the not-too-distant future, be filled with smart



technology. With HEMS, programs have a golden opportunity to leverage the power of smart technology to accelerate progress towards sustainability goals, while engaging customers with relevant, useful, even delightful enhancements to their living environments.