ARICENT®

Home Energy Management – Beyond the Numbers

Table of Contents

Introduction

Home energy management (HEM) is a hot topic for several good reasons: 1) In a time of increasing energy bills and shrinking income, consumers want to reduce the amount they spend each month on electricity; 2) Utilities need to switch from a model of getting people to consume more to consuming less (for capital cost and regulatory reasons); and 3) Societies around the world need to put the brakes on unsustainably escalating use of fossil fuels, much of which go to generating electricity.

HEM systems are appearing that attempt to satisfy these challenges. They are part of a broad trend of turning previously "dumb" products into "smart" ones that are connected to a network, aware of how they are being used, able to inform the user about their status, and can be controlled in new ways such as with a smartphone. We are entering the "post-PC" era that will be defined by machine-to-machine communications (M2M) without user intervention (for example, a clothes dryer can autonomously determine when the cheapest time is to run and start itself). In the next 5-10 years of this "Internet of things", virtually any device over $20 will be connected to a network of some sort.

Smart homes, Home Area Networks (HANs) and HEM systems will be both enablers and results of these emerging technologies. In smart homes, almost all aspects of the living space—temperature, entertainment, lighting, communication—are connected to each other and the wider world, intelligent to one degree or another, and able to be queried and controlled by the home owner remotely. HANs provide the connected platform (typically wireless of some sort) that enables a smart home to work and—with a gateway—connect to the outside world and cloud-based capabilities. HEM systems are a specific element of smart homes that allow homeowners, utilities and others to monitor, manage, and conserve energy.

In combination with the coming Smart Grid (a revamped, more intelligent, and capable electrical distribution grid) and the in-progress rollout of Smart Meters (which provide more accurate and up-to-the-minute consumption information), HEM systems have the potential to drastically change how we think about and use electricity. For these reasons, established technology companies such as Microsoft, Google, Cisco and GE, as well as a crop of new start-ups are jumping into the market.

We will focus here in particular on home energy management but also look more broadly at implications for the future of smart homes. We will look behind the numbers to provide directions on how to avoid the pitfalls and be successful in the HEM market.

- What's the real revenue potential of the HEM market?
- How many households will have functioning HEM systems?
- What home infrastructure is required to make it useful to consumers and companies?
- What sort of energy savings will result from consumers being more aware of their usage?
- What paybacks will consumers see from installing HEM systems?

Research Approach

This paper draws on the expertise and know-how of the many Aricent and frog designers, technologists, strategists, and engineers who make up our Energy Practice. This team is engaged on a daily basis in designing and building the products, services, and experiences, which will be part of our energy-efficient future. The paper builds on interviews conducted with more than 40 experts, ranging from companies making smart grid and connected home products to the venture capitalists investing in them; utilities and service providers who are considering their deployment; and industry analysts and pundits who cover them. This paper also references secondary research reports from syndicated research firms, whitepapers from academics, and news reports from blogs and journals covering the energy sector. We feel privileged to be part of this vibrant smart energy community. Our intent with this paper is to use our practitioner's perspective to foster critical discussion of the conventional wisdom in the HEM category.

A Look at the Market

$3 Billion Global Revenues in 2014

Forecasts for HEM systems and devices seem to paint a rosy picture about how quickly they will get adapted and the size of the opportunities ahead for system manufacturers, installers, and utilities. But this is only one side of the story. It's easy to get mesmerized by the big numbers thrown around, and fail to perceive the underlying issues and constraints that trouble manufacturers and providers later in the development lifecycle.

Our research indicates that some of these predictions may be overly optimistic. There are a few revenue paths to hit the $3 billion figure, and some significant hurdles to growth.

> In 2014, global revenues for energy-related HAN products and services could reach $3.3 billion.
>
> On World report, 2010
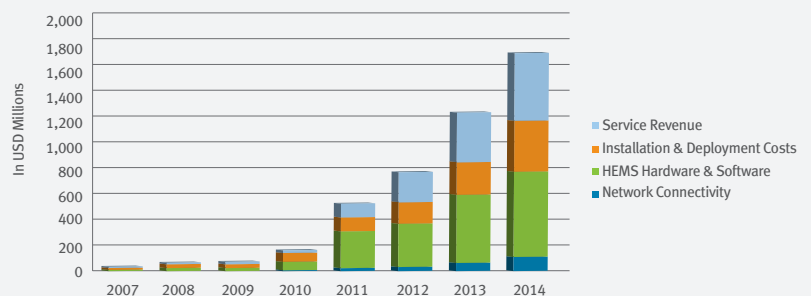
What are the Implications?

Given that HEM technology is getting embedded into familiar—and often low-cost—devices, there are two primary paths to revenue for HEM systems—fees from network connectivity services, and fees from installation and ongoing support.

Even if we assume that consumers won't run their HEM systems through their existing home broadband and Internet, and will use a HEM system-dedicated network connection, the revenue from this is miniscule compared to the larger market.

Revenue from deployment (installation and support) is significantly higher, although steep up-front costs and the possible need to hire professional help are inhibitors for many consumers. Without a clear value proposition, if installation services are not bundled for free (as they are for cable television or home phone installation, for example), and if installation of HEM systems is beyond the do-it-yourself capabilities of most consumers, then adoption will be severely impeded.

Revenue forecast for selected products and services

It's also important to understand the deployment hurdles and stakeholders. In many urban areas, rentals in multi-unit buildings is the predominant model for housing, and there is less incentive for a rental household to take on the cost and effort of installing the necessary smart home infrastructure to support home energy management. Therefore, getting the property owners and apartment-owner associations on-board is key so that they can offer HEM systems as a selling point to prospective tenants ("we've done the investment so you can achieve lower utility bills"). This can be done with ecosystem approaches involving utility companies, telcos, local councils, and potentially banks, to offer turn-key and cost-effective deployment, as well as attractive financing to apartment owners.

A Tough Nut to Crack
The company that cracks the code on self provisioning will be the winner. Without it, adoption will be slow. Currently we have not seen much evidence that systems meeting the other criteria outlined in this paper can be deployed without professional help.

A Look at the Market

28M Households in 2015

A report from Pike Research forecasts that there will be over 28 million users of HEM systems worldwide by 2015. But this does not necessarily mean that an equivalent number of home area networks and gateways will be installed. While a HEM system can be used in conjunction with a smart meter lacking a HAN gateway, the full benefits of HEM systems don't come into play. The gateway allows connectivity with the wider world, taking advantage of utility integration and cloud-based capabilities. As we shall see below, connectivity to outside the home is also essential for behavior changes that truly move the needle on reducing energy consumption. It, therefore, makes sense to add HAN gateways when installing smart meters, and in fact almost half of the 100 million smart meters planned worldwide in the next five years will have HAN gateways.

However, our research indicates that only approximately 6 million US households will have HEM systems by 2013, even though tens of millions of new smart meters are planned to be installed in the next five years in the US. So a considerable capability at the meter will go unused since there will be no HEM system to connect it to.

> Driven by consumer demand and a strong push from electric utilities, there is a substantial market for HEM systems and energy information displays (EIDs), which is predicted to reach 28.1 million users worldwide by 2015.
>
> - Pike Research, Dec 2009

What are the Implications?

We believe that the future of the (smart) home should not be overly dependent upon the smart meter market. Many utilities are wary of getting too close to the consumer and are slow at innovating their existing products and services. More opportunities for autonomous growth will be possible when working in parallel with smart meter installation.

If you are independent of the utility and smart metering market, then focus your attention on providing benefits to consumers, and look at benefits that go beyond simple energy conservation. However, if you are going after the smart metering market, then you need to focus your benefits on the utilities themselves, as they will govern rollout rates.

> In-home display devices will comprise the largest EID category, with 14.4 million units shipped by 2015. Web-based dashboards will be the next major category with 11.1 million users, followed by mobile phone energy applications with 2.6 million users.
>
> - Pike Research, Dec 2009

A Look at the Market

3.7% of Average US Household Income Spent on Energy

The ideal market for HEM systems is where large amounts in absolute spend and percentage of income are devoted to energy. An added driver exists in markets that have moved static power pricing to real time pricing, allowing prominent display of current pricing and consumption information to home occupants.

Spend on Energy
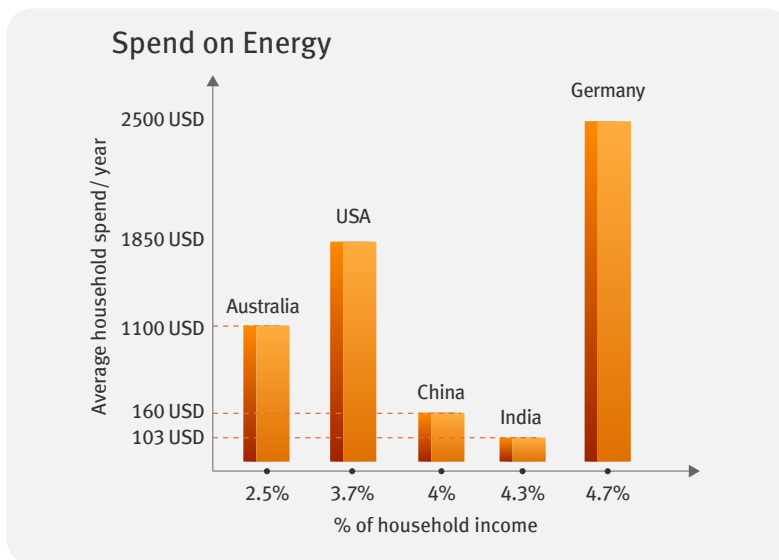
What are the Implications?

As is evident from the graph, Europe and North America are currently the most attractive markets for HEM systems and products. Given the large public spending being earmarked for smart grid and smart home initiatives in these regions, the market for HEM systems will continue to remain largely Europe- and North America-centric (despite the fact that the US largely uses fixed-pricing). While India and China may represent burgeoning energy markets, energy is so heavily subsidized in these countries that there is little consumer incentive to invest in expensive technology to marginally reduce power consumption.

It is becoming increasingly evident that a "One-size-fits-all" approach will not work for the Europe- and North-American markets. Especially in the current economy, customers are wary of investing money today for uncertain benefits tomorrow, so manufacturers and providers will need to address basic needs first, followed by advanced systems that are fully integrated into the home environment.

A Look at the Consumer

15% Savings From Displaying Energy Consumption Information

Most people have no idea how electricity is made or how it gets to their homes. Though vital to modern life, electricity is invisible and intangible. Most people aren't even sure how they use it, aside from turning on a light switch. Say "kilowatt" and eyes glaze over instantly. If home energy management is to be successful, electricity needs to be made obvious, tangible, and meaningful.

A widely cited study by Oxford University Environmental Change Institute's Sarah Darby shows that simply displaying information (providing direct feedback to the consumer) only reduces power consumption by 5-15%. Though better than the 0-10% reduction prompted by simply looking at a utility bill, on the face of it, this indicates that people will get relatively little benefit out of simple consumption status information.
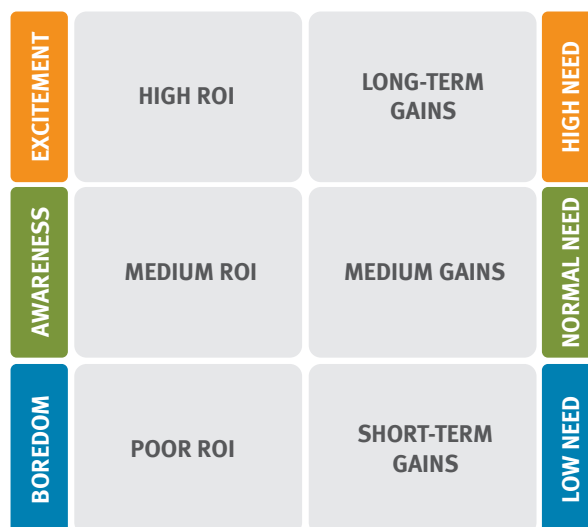
> Energy savings from direct feedback (from the meter or an associated display monitor) ranges from 5% to 15%.
> - Sarah Darby,
> Environmental Change Institute,
> Oxford University

What are the Implications?

It is going to be vital to inform, educate, and engage people to bring about beneficial behavior change. Charts and information devoid of rich context do little to motivate behavior change. It's the difference between filling out a jogging mileage log and using Nike+, or between balancing your checkbook and tracking your spending over time and comparing it to other people like you on Mint.com. The Toyota Prius turned "hyper-miling" into a game where people were given a chance to outdo themselves and others on each trip by using as little fuel as possible. Similar approaches of turning energy consumption into fun contests, engaging social networks, and providing "compared to others…" feedback will all have a role to play in encouraging behavior change.

Most people find shifting their behavior patterns and habits novel at first, but over time tend to stop looking at the information, which in turn leads to a regression in behavior.

EXCITEMENT	HIGH ROI	LONG-TERM GAINS	HIGH NEED
AWARENESS	MEDIUM ROI	MEDIUM GAINS	NORMAL NEED
BOREDOM	POOR ROI	SHORT-TERM GAINS	LOW NEED

A Look at the Consumer

30+ Sensors Required to Make a HEM System Meaningful

Because relevance is paramount for creating sustained behavior change, HEM and HAN systems need to be architected to deliver meaning, not just data. Studies have shown that over 30 sensors are required for an average North American home to make a HEM system comprehensively meaningful to occupants. Without sensors, there is no rich data. Just feeding information from a smart meter to the HEM system is neither meaningful nor interesting enough to consumers since it simply shows people the sum total of what they are being charged for, but not the details of what is causing the power to be used or how to more effectively manage it. Without an effective sensor network in the home to provide the detailed per-device/appliance insight, a HEM system is quite limited in its ability to help beneficial behavior change.

What are the Implications?

Availability of sensors is a critical enabling factor in the success of HEM systems. Smart appliances, which incorporate sensors to provide detailed feedback of real-time energy usage and some remote control of their activity (from elsewhere in the house or outside the house), are on major manufacturer roadmaps for 2013. However, with a 7+ year replacement cycle for major appliances, it will be a while before they become the norm.
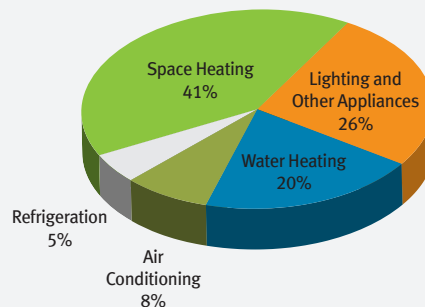
A Look at the Consumer

A fully automated (instrumented) home down the road will have:

- Sensors at the meter monitoring the total energy consumption for the home
- Temperature/humidity/light sensors in every room/zone of the house and outside the home
- Smart plugs for all the regularly used appliances that would either measure the load or actuate when the mode is changed
- Heavy duty load controllers for your pool pump, HVAC, heat pump, etc.
- ZigBee switches and dimmers (built into the wall, not plugged in)
- A host of smart appliances

In the meantime, suppliers of HEM systems will need to supply sensors to build the network ecosystem. Manufacturers like Control4, Digi, SHN, Tendril, Watteco, Jennic, Rain Forest Automation and others supply plugs, sensors, programmable communication thermostats (PCTs), but this is still a nascent market and the participants are working out the gaps.

How Energy is Used in US Homes (2005)

Space Heating 41%
Lighting and Other Appliances 26%
Water Heating 20%
Air Conditioning 8%
Refrigeration 5%

Source: U S Energy Information Administration, Residential Energy Consumption Survey 2005.

While a holistic solution would require an extensive network of sensors within the home, an interim solution could be to focus on the "Big Four" energy consumers. In American homes these are: HVAC, Lighting, Heat Pumps, and Pool Pumps. It is not uncommon for a pool pump to be 50% of the household energy bill, and HVAC 40%. If manufacturers and providers of smart energy solutions focus primarily on sensors and related smart systems for heating and cooling, this alone may significantly improve the energy consumption of consumers. However, even this incremental approach faces the same challenges of installation and equipment costs, and long payback periods. The key innovation required in this space is figuring out how to monitor and control these systems at low cost.

A Look at the Consumer

2.5 Years Payback for Home Energy Products and Systems

Due to the complexity of creating a sensor-laden smart home, the average cost of building the basic sensor network within the home is high. As of Fall 2010, the napkin math says that approximately $3,000 worth of equipment is needed for it. With the average US household energy spending currently in the $2000 range, the high cost of building smart home networks will further inhibit adoption by consumers. Most studies indicate that a payback of three years or less on the cost of lighting upgrades is a rule of thumb that people apply in decision-making. With solar power, the high installation costs and long payoff periods have meant slow uptake for residences. Even humble fluorescent light bulbs have faced the near-term-cost/long-term-benefit psychology barrier.

What are the Implications?

The obvious inference from the above is that energy management systems need to move beyond pricing. Although price is a significant factor in determining payback period and consequently the pace of adoption, providers and manufacturers need to keep in mind several considerations.

SENSORS
~$70USD X ~ 11 = 700USD
SMART PLUG
~$85 USD X ~15 = 1275 USD
HEAVY DUTY LOAD CONTROLLERS
~$250 X ~4 = 1000 USD

TOTAL   ~3000 USD

- $5000 systems won't sell, and neither will ones that provide low savings (e.g. 5%).

- B2B2C and alternative paths to monetization might be a way around this. We can envisage residential energy management firms cropping up, offering to take on consumer energy supply for a fixed annual fee, and then installing energy-efficient appliances and HEM systems to provide the contracted lumens of light and guaranteed temperature.

- For those attacking the market directly, it makes sense to keep costs as low as possible by leveraging existing consumer platforms (e.g. apps for mobile phones or tablets) to keep user interfaces simple, accessible, upgradeable, and low-cost.

Any energy-efficiency measure that produces an ROI of 25% or more is considered an attractive use of money. Returns on lighting efficiency have been shown to be in the range of 30-50%. Charles Zimmerman, a vice president at Wal-Mart, has said, "Energy efficiency is one of the best investments we can make."

4 Potential Routes to Market

We've outlined here some of the primary routes to market for proving HEM products and services to consumers, but there may be more. Each strategy has significant implications for product design and development for manufacturers and providers.

Route to Market	Target	USP
The Utility-Centric Route	• Shave peak loads with Demand Response (DR) • Promote energy efficiency • Gain greater visibility into the consumer end-points to the utility network • Improve communication with the household residents	• Low cost • Easy to deploy • Secure • Clearly positioned in the market
Non-Utility Service Provider Route	• Healthcare for independent living • Energy management firms engaged in demand dispatch • Home security firms offering digital security • Carriers and cable companies offering multi-play	• Service specific functions • Provide high computational capability • Easy to use
Home Builder/Home Automation Route	• Evolution of high-end home automation markets • Integrated with a wide array of devices and tools including HVAC, lighting, entertainment, pumps, and security systems	• High degree of functionality • Drive innovation and value through integrated systems and controls • Superior (and customized) user experience
Direct-to-Consumer Route	• Primary function is energy management • Economies of scale for deployment and support • Remote management capabilities	• Self-provisioning systems • Easy to use

- **The Utility-Centric Route –** In this route, the objective is to shave peak loads with Demand Response (DR), promote energy efficiency, gain greater visibility into the consumer end-points to the utility network, and improve communication with the household residents. This model is characterized with products and services that are low cost, easy to deploy, secure, and clearly positioned in the market.

- **Non-Utility Service Provider Route –** This route is characterized with products and services that serve specific functions, provide high computational capability, and are easy to use. It is well-suited for markets such as healthcare for independent living; energy management firms engaged in demand dispatch; home security firms offering digital security; or carriers and cable companies offering multi-play.

- **Home Builder/Home Automation Route –** Many firms choosing this route come from high-end home automation markets (for example, 4Home and iControl). This approach is characterized with products and services that have a high degree of functionality, and are integrated with a wide array of devices and tools including HVAC, lighting, entertainment, pumps, and security systems.

- **Direct-to-Consumer Route –** Here the primary function is energy management and using it as a stepping-stone into broader smart home capabilities. Products and services that are self-provisioning and simple to use characterize this approach. If consumers can install themselves, then the deployment economics improve dramatically. Indeed, this is where much of the early action is—self-contained kits like The Energy Detective, PowerCost Monitor, and Efergy are appealing to the eco-pioneers. (However, eco-pioneers are just a small portion of the overall population—about 7% in the U.S. for example—and what is also needed are solutions that will appeal to the broader mainstream.) An alternative direct-to-consumer approach is being taken by retailers like Best Buy that are adding home service capabilities (Geek Squad in their case), and are in a strong position to offer turn-key solutions for home energy management.

> Best Buy is working with home automation companies to develop networked energy management systems that will allow residents to see the actual energy use of connected devices, and to control their operation to save energy and reduce peak loads. These services could be bundled with other options including home security and entertainment, and with utility load management programs, to provide greater total customer value.

Summary

HEM systems and the broader smart home market are indeed filled with opportunity, and the excitement around them at the moment is valid. However, as we have seen in this paper there are some significant hurdles to overcome before HEM systems, in particular, hit a mainstream growth pattern:

Cost: The up-front costs (equipment and installation), uncertain revenue streams for providers of HEM systems, the many players involved in deploying HEM systems (each of whom wants a cut of the revenue), and the uncertainty in consumers' minds about savings in utility bills from investing in HEM systems, all point to a challenging cost equation.

Complexity: Because today's HEM systems are starting from scratch, they are complex to build out in a home in a comprehensive manner. Many elements—sensors, wireless, interface devices, backend infrastructure integration, cloud services, interoperability standards, and others—must all be in place for HEM systems to reach their full potential. Starting incrementally to gain some (relatively) quick wins will be vital.

Behavior: Patterns of energy usage are deeply ingrained and, despite cost incentives, can be difficult to change. Inciting behavior change by engaging emotions as well as rational facts will be essential to the success of HEM systems in reducing energy consumption. This will require systems that are engaging for consumers to use and have easy-to-use—even enjoyable-to-use—interfaces that provide meaning as well as data. Understanding emerging and dynamic consumer behaviors and perceptions at the front end of strategy will be vital. Also, monitoring how they change over time to continuously inform product development.

Bridging the Innovation Gap for HEM Solutions

At Aricent, we create great user experiences by understanding unmet user needs and working in all layers of the device/ecosystem stack. And we prevent innovation erosion with a process covering all stages.

Aricent offers a portfolio of "Innovative" products and services that help to transform "Devices, Machines, and Homes" into "Smart, Connected, and Automated" entities. Aricent has significant expertise in helping customers' transform complex technologies into simple, intuitive, and distinct user experiences while offering a repeatable, high-value process to create and maintain high innovation velocity, and at the same time seamlessly manage the transitioning strategy across phases.
 A few examples of our work include:

Designing and Developing a Superior User Experience for Smart Meter Management: A leading utility provider wanted to enhance its customer's user experience by transferring its recognizable brand experience from print and TV to the digital world. Aricent helped the customer create a digital design system that not only mapped out the look and feel of how the customers interacted via web, desktop, and mobile, but also transformed the animations and feel of the digital world.

Developing a HEM System: Aricent worked with a leading Tier-1 manufacturer of HEM systems as an end-to-end system integrator on the UX design, embedded architecture, and ODM management to provide a production-ready and field-tested solution. Customer support services and assistance for future releases were also provided. Our solution helped the customer achieve accelerated time-to-market while maximizing R&D investment.

Development of Digital Programmable Thermostats: With heating and cooling systems accounting for as much as 75% of an average household electricity bill in the US, programmable thermostats are becoming increasingly popular to reduce energy consumption. With support for multiple "modes" and built-in PID controllers, programmable thermostats are paving the way for the next-generation climate control systems.

Developing LCD-Based Room Sensors for a Building Automation OEM: How can manufacturers build cost-effective sensors without compromising on quality? A leading US building automation OEM wanted to develop a wall-mounted temperature-monitoring system for large buildings. By implementing an LCD-based user interface, and using communications device drivers and modules to implement temperature control, the manufacturer was quickly able to deploy a cost-effective, efficient solution.

Industry Credentials

We bring **decades of experience** in developing breakthrough products and services.
We have won **more than 200 industry awards** (CES Innovation, IDEA, and others).
Our software powers more than 500,000,000 connected devices.
Our clients include:

- 8 of Interbrand's Top 10 Best Global Brands
- 7 of the top 10 telecom service providers
- 8 of the top 10 mobile device makers
- 9 of the top 10 network equipment manufacturers

To learn more about Home Energy Management, contact your Aricent's local sales representative. For more information, please visit www.aricent.com/smarthomes.

CORPORATE OFFICE: 1, Town Center, East Brunswick, NJ 08816
 www.aricent.com