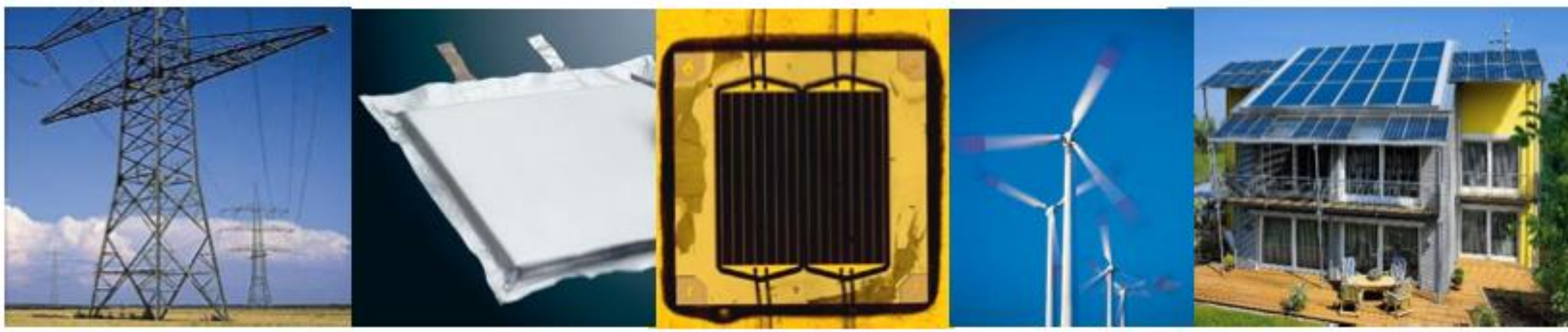
Home Energy Management: Products and Trends



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Home Energy Management

- Home Energy Management (HEM): A class of technologies including sensors, control systems, and feedback devices to manage residential energy consumption
  - Energy savings potential of up to 22%
- Ongoing technology trends increase HEM market viability:
  - Pervasive in-home communication
  - More "smarts" in devices / Rollout of smart meters
  - Low-cost sensors
  - Interest in electrical demand response

Reference: Ehrhardt-Martinez et al. (2010)

Outline

- HEM Taxonomy
- General Trends
- Subgroup Product Classes
- Subgroup Discussions

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HEM Taxonomy

- We devised the following classification system for all types of HEM products available in the residential market
  - Enabling Technologies
  - User Interfaces
  - Control Devices
- These categories are meant to capture key aspects of typical HEM devices and are not mutually exclusive
- List of products in LaMarche et al. (2012) – *not exhaustive, products come and go*

Category 1: Enabling Technologies

- The underlying framework supporting obtaining, processing, and communicating information about energy usage
  - *Sensing*: Acquisition of dynamic variables within the home environment
    - Smart meters, temperature sensors, occupancy sensors
  - *Communications*: Physical devices to support the network
    - Gateways, range extenders, routers, modems, local area networks
  - *Communications Protocols*: Standards for communication
    - ZigBee, X10, UPB, Insteon, Z-wave

Category 2: User Interfaces

- Provide either *raw* (kWh, $/hr, watts) or *processed* (comparisons, budgets, tips, etc.) energy feedback to consumers via display
  - Wide range of media and designs
    - Home Energy Display (HED)
    - Web portal
    - Smartphone application
    - Other (e.g., TV)
- Unless a consumer has a smart meter, many software approaches require hardware that must first be installed

Category 3: Control Devices

- Allow the consumer or utility to actively control energy use, with varying degrees of automation/human-in-the-loop
  - *Centralized*: Multiple devices managed from a single location
    - Home automation systems, lighting control systems
  - *Device-Level*: Single device or function with standalone control
    - Lighting control by sensor/remote, thermostats, smart plugs
  - *On-Board*: Control functionality is integrated into the device
    - Smart appliances, computer power management

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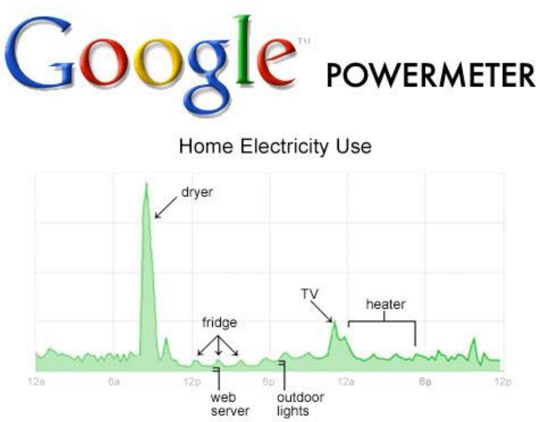
General Trends – Nascent Market

- Despite this potential, the HEM market has very limited uptake
- Products frequently announced, come to market, leave
  - Much innovation and product diversity – “killer app” not yet found
  - Significant players shifted focus – lack of consumer interest, scalability



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Several Barriers to HEM Adoption

- Consumer awareness of HEM products is low
- Cost considerable, unpredictable return
- Often limited or negligible HEM non-energy benefits
- Consumers must learn how to find and navigate current products that are:
  - Complex in terms of installation or setup
  - Confusing in terms of pricing, home requirements
  - Ephemeral (vaporware)

These factors limit the demand for HEM technology among the general population

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Product Classes

- Home Energy Displays (HEDs)
- **Device-level Power Management**
- **Advanced Power Strips**
- **Lighting Controls**
- **Programmable Thermostats**
- **Centralized Home Automation Systems**

Home Energy Displays

- Raw and processed information
- Large energy savings potential – 4-12% of *whole-house* energy – but persistence!
- Field effectiveness variable
- Consumer attention and interest very limited
  - <1 minute/day typical
- People want access via multiple media
- Emerging trends
  - Make “big data actionable”
    - Tips and alerts – e.g., My Eragy, Tendril
    - Disaggregation?
  - Social media integration – e.g., People Power
  - Games – e.g., Simple Energy, Joulebug,
  - Incentives – e.g., Efficiency 2.0

Image Credits: Energy Inc., Powerhouse Dynamics

References: Erhardt-Martinez et al. (2010), LaMarche et al. (2012)

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Device-level Power Management

- "Smart" Appliances – networked
  - Automated DR
  - Track appliance energy consumption
  - Potential to enhance convenience
  - Vendor lock-in?
- Plug-level solutions
  - Lower cost (e.g., ~$50) – may enable users to transition into a home automation lifestyle
  - Select on/off schedules, track power
  - Best for loads with higher electricity consumption: Window AC, entertainment center, commercial

Image Credits: Plugwise, ThinkEco, Whirlpool

Advanced Power Strips (APS)

- Can address Miscellaneous and Electronic Loads
  - Master-slave control, remote control, occupancy control, scheduling
  - Some monitor power draw
  - Savings: ~100-625kWh/year (entertainment, IT)
- Many products are available
  - Most APS work as intended except USB
  - Market issues: ~75% never heard of this product class, poor marketing, confusion w/ basic units
  - Costs typically $30-70 – more than basic units
- Actual savings depend greatly upon effective user behavior
  - Unclear real-world residential savings

Image Credits: Belkin, Visible Energy

References: Earle and Sparn (2012), Ecos (2009), Fraunhofer (2011) , Ryan and Grant (2012)

Lighting Controls

- Lighting ~14% of residential electricity consumption
- Timers, occupancy sensors
  - Plug-level controls can also perform this function
  - Central control systems

- Challenges
  - Energy savings potential not understood – how much “waste” exists?
  - Limited potential non-energy benefits that save energy
    - Ambience, security, convenience

Reference: DOE/EIA (2011)

Programmable Thermostats (1 of 3)

- Heating and cooling comprise 42% of total source residential energy
- Rule of thumb: 2 to 3% reduction in heating energy consumption per 1^{o}F reduction in setpoint temperature
- Most U.S. households own either a programmable (37%) or manual (48%) thermostat (if they know what that means)
- Large energy saving opportunity – *BUT:*
  - Unclear if programmable thermostats reliably save energy relative to manual thermostats!
  - LBNL and EPA Thesis:
    - Significant in-lab variations in thermostat usability
    - Higher thermostat usability will lead to greater real-world use of energy-saving features and energy savings

References: Sachs et al. (2012); DOE/EIA (2011); Meier et al. (2011).

Programmable Thermostats (2 of 3)

- Fraunhofer Field Study – 63 affordable housing units
- Installed new thermostats as part of weatherization
- Randomly gave units high and low usability thermostats
- Evaluated nighttime setbacks using indoor temperature and furnace state monitors

$118

$17

- Findings:
  - **Negligible** use of nighttime setback – both groups
  - **Comfort trumps energy**
  - Need to increase **motivation** and **trigger action**

Reference: Sachs et al. (2012)

Image Credits: Fraunhofer CSE, Honeywell/Amazon.com

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Programmable Thermostats (3 of 3)

- Newer "smart" thermostats beginning to address challenges identified
  - People prioritize comfort
  - Lack of understanding how thermostats work
- Smart thermostats are gaining traction
  - Learning through interaction and occupancy sensing, e.g., NEST
  - HVAC feedback, e.g., OPOWER + Honeywell
  - Wireless communications
- Challenges
  - Real-world energy savings data???
  - Price – $249 for a thermostat?!?

Image Credits: Cnet.com, Nest.

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Centralized Home Automation Systems (1 of 2)

- Currently costly, labor intensive and complex
  - Limits widespread adoption
- Integrating HEM with existing home systems
  - Existing home automation players, e.g., Control4, offers home theatre, video, and security in addition to lighting controls
  - Verizon, Comcast, etc. offering subscription services for energy management, security
    - Cost: Verizon ~ $250-300 + ~$10/month

Image Credits: Control4 , HAI

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Centralized Home Automation Systems (2 of 2)

- Modular, customizable systems
  - e.g., Intel, Microsoft prototype consoles, customizable for each users' home devices through app, store
  - Potential to provide non-energy benefits – Health, security, entertainment
  - Could increase engagement
- Non-energy benefits like health, comfort, entertainment, and security may to appeal to a wider audience.
  - e.g., Lowe's + AlertMe cloud-based management system "Alerts you when your child arrives home from school"
  - Control of home electronics, lights, thermostat

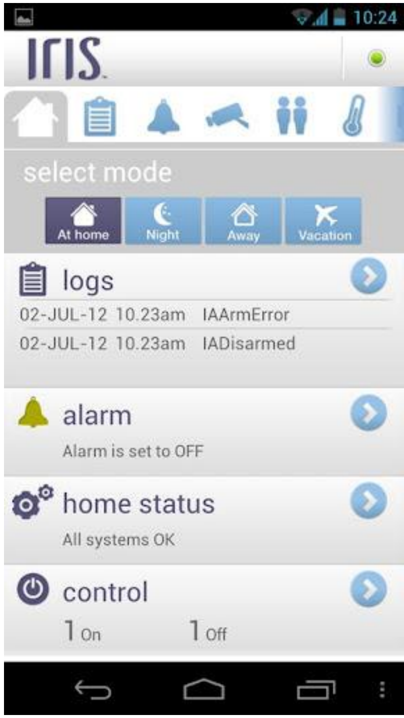

Image Credits: Microsoft, Lowe's.

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Image Credits: eGauge, Eragy, LaMarche et al. (2012).

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HEM Taxonomy (LaMarche et al. 2012)

Category		Description	Examples
Control Devices Actively control energy use; varying degrees of automation/ human-in-the-loop.	Centralized Control	Manages multiple control devices from a single location	Whole home automation or lighting controls
	Device-Level Control	User controls a single device or function, standalone control	Thermostats; smart plugs; power strips
	On-Board Control	Control functionality integrated in the device	Smart appliances; IT power management
User Interfaces (UI) Provide energy feedback to consumers, display both raw and processed data.	Home Energy Display (HED)	Stand-alone in-home display; often portable	
	Web Dashboard/ Portal	Online interface accessible from Internet-enabled device	Many HEDs can integrate with multiple media.
	Smartphone Application	Device-specific interfaces for iPhones, Android phones, etc.	
Enabling Technologies Support *obtaining, processing,* and *communicating* energy usage information.	Sensing	Acquisition of dynamic variables within the home environment	Temperature sensor, smart meter
	Communications	Physical devices supporting network	Gateways, LAN, wireless routers, modems
	Communication Protocols	Standards allow networked nodes to communicate	X10, UPB, Insteon, Z-wave, ZigBee

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