Normalized Metered Energy Consumption Workshop 1/17/16

HEA Response to Questions

HEA respectfully submits our responses based on our company's experience using AMI data to categorize residential energy consumption to both educate residents and track their energy consumption. We have pioneered algorithms that set an energy baseline by analyzing the energy consumed in the year prior to analysis and then tracking energy changes going forward. By disaggregating electricity and natural gas consumption into five main categories – two that are weather dependent (heating & cooling) and three others that are not (always on, recurring and variable) – we can accurately identify energy consumption changes in each category and normalize them as appropriate.

We realize we have a unique perspective based on our experience and do not claim our comments will address all aspects of the questions. We do believe our comments will provide a unique and valuable contribution since they are based on real world experience and actual data from over 4,500 California homes.

Panel 1: State of current research

- How has the analysis method been used in program development (customer, sector, etc.)?

HEA software has been used in residential EE programs administered by:

- The cities of Atherton, Claremont, Los Altos, Los Altos Hills, Monte Sereno, Mountain View, Portola Valley, San Jose and Woodside;
- Stop Waste of Alameda County;
- The City of Fresno in support of their Central Valley Home Energy Tune-up program funded by PG&E.

More than 4,500 households have used HEA software to analyze and track their energy use. We divide electricity and natural gas use into 8 categories as shown in the following table.

Energy Category	Nat. Gas	Electricity	Consists of….
Winter Heating	✓	✓	Energy use that correlates with lower temperatures, including gas furnaces, electric space heaters, heated floors, electric blankets, etc.
Summer Cooling		✓	Energy use that correlates with higher temperatures, including fans, air conditioning, etc.
Variable	✓	✓	Behavioral energy use that is unpredictable: lights, washing machines, dishwashers, microwaves, stoves, cook tops, entertainment systems when they are on, computers when they are turned during a portion of the day, etc.
Recurring		✓	Energy used consistently at the same time every day: pool or spa pumps, outdoor lighting, coffee pots on timers, etc. These loads can be controlled by timers but can also include consistent behavioral patterns (i.e. easily recognized by residents).

Energy Category	Nat. Gas	Electricity	Consists of….
Base	✓	✓	Continuous energy use (meaning consistent across specified time intervals) caused by devices that draw power in a predictable manner: refrigerators, natural gas water heating, desktop computers in sleep mode, game consoles in sleep mode, DVRs, whole house audio systems in standby, surround sound systems, wifi routers, powered phones, clocks, etc.

When a user engages with HEA software they give permission to automatically retrieve and continue retrieving energy data from their IOU account. An energy baseline in each category is established for the household based on the prior year's energy use. The user learns about how energy in their home fits into the 8 categories (5 electric and 3 natural gas) and receives targeted recommendations based on their unique consumption patterns. Going forward HEA software automatically tracks energy changes in each of these 8 categories. Heating and cooling energy is normalized using publically available weather data; other categories are not normalized but are compared to other homes with comparable characteristics (e.g. variable/behavioral loads are compared across homes with the same number of occupants). We believe this measurement method provides an inexpensive way to accurately track energy changes against a baseline.

Using this method we have measured the following savings in community energy efficiency programs (both the Fresno and Claremont programs are still active):

Program	Participants	Duration	Average reduction in kWh	Average reduction in therms	Reported by
Energy Upgrade Mountain View	1,239	3 years	5.5%	16.4%	HEA
Energy Upgrade Mountain View (top quartile)	310	3 years	14.5%	32.6%	HEA
Alameda County	500	1 ½ years	11%	19%	BKi and HEA
Silicon Valley Energy Watch	85 low income seniors	1 year	10.2%	12.2%	Green Pro Network & HEA

- What is new now?

Access to AMI data offers the potential to radically change EE programs by making them significantly more cost effective. It is now possible to remotely analyze a home's energy consumption, provide targeted recommendations and then track the changes in consumption specifically related to those recommendations. But achieving this requires thinking differently about how energy is used. AMI data provides a wealth of information but does not map directly into all of the more traditional consumption categories: heating, appliances, water heating, electronics & other, lighting, cooling and pool.[1] Instead, we need to determine what we can reliably measure using AMI

[1] Categories used in PG&E MyEnergy portal

data. HEA has been able to divide energy into the categories described above to achieve measured energy reduction. It is likely other energy categories can be extracted from AMI data and they will prove useful in enabling energy reductions. The goal of regulatory agencies should be to provide a framework for proving how new methods of using AMI data can lead to measurable energy changes.

A straightforward example of this is measuring and tracking a home's idle load. The idle load is a concept presented by the NRDC in their May 2015 paper: "Home Idle Load: Devices Wasting Huge Amounts of Electricity When Not in Active User"[2]. The idle load is a new energy category that can only be measured accurately through AMI data; a home's idle load – measured in continuous Watts -- can be easily quantified via hourly data. Users can then take easy and inexpensive steps to reduce it (install smart strips, unplug old appliances, put appliances on timers, etc) and the associated "base load" reduction in electric consumption can be measured and tracked on a week by week basis.

- Are there new opportunities that make this project level approach to M&V scalable for programs?

Yes, remote software analysis scales very well. In general, software becomes less expensive per user as the number of users increases. Outreach and support costs will likely remain comparable to current programs; it will still take time and money to reach participants and utilizing energy advisors to guide customers increases savings. But outreach and support costs can now be directed to the most cost-effective measures. One residence might benefit most by reducing their base load, another home might benefit more from a lighting retrofit and another from an HVAC upgrade. Instead of providing a one size fits all service, ESCOs can tailor their offerings based on the specific needs of a particular home, identified through smart meter analysis. And since energy changes can be measured and reported, ESCOs can continually tune their offerings to increase their cost effectiveness. Using AMI meter data can make the existing EE workforce more effective.

- Key challenges and opportunities
  - *How are time series challenges like how long to measure and collection of pre and post data handled?*

    HEA already collects energy data from the four main IOUs: PG&E, SCE, SDG&E and SoCalGas; only customer authorization is required. We collect at least 12 months of prior data, and continue to monitor a user's energy use after interventions. For HVAC-related interventions a full year of post-intervention data is needed for analysis, but for interventions that affect the other four categories a few months is often sufficient. For idle loads in particular, a few weeks can be sufficient to see the persistence of changes.

  - *How are persistence of the savings identified and accounted for multiyear effects?*

    Energy changes in each of the eight categories can be continuously tracked across multiple years once a baseline has been established. Households are complex systems and continuously changing, so the energy change achieved by a specific intervention may be subsumed by other changes effecting the same energy category: changes in occupancy, additional appliances, new EV, etc.

  - *How are savings account structures set up to capture the cumulative effects?*

    HEA can measure savings against a baseline year and savings in each category is measured separately for each home. Tallying both whole home savings and these category-specific savings across a community for extended periods of time has already been implemented through custom SQL reports. We also provide real time "Dashboards" for each of our program administrators.

[2] http://www.nrdc.org/energy/files/home-idle-load-IP.pdf

- *Routine and non-routine adjustments, how are the handled? Do they matter? Why or why not? How is maintenance handled? (routine or non-routine?)*

  In general we do not apply adjustments to measured residential savings. However, we do exclude results from homes with major changes, including remodels, Solar PV installations, and new EV charging.

- *How does the method deal with detecting small interventions versus big interventions?*

  This method measures actual energy changes so the size of the intervention is relevant as it relates to the size of the associated energy change (is it detectable?) not as it relates to cost or effort to implement. If a large intervention to reduce energy consumption is offset by another change in the home that falls into the same category, it won't be detected. But even a small change in continuous idle load can have a large cumulative effect and will be detected.

- *Which meter is appropriate to use? What are the tradeoffs of a whole building meter or sub-meter for orienting the information to customers, settlement with a vendor, and grid planning?*

  As long as a residence has a smart meter, energy use in these eight specific categories can be analyzed and tracked which means multi-family dwellings can benefit. Residences with solar PV currently present a problem since only net energy consumption is measured, i.e. there isn't a meter showing energy production and total energy consumption for the home. To solve this problem, additional meters would need to be installed to directly measure Solar PV production.

- *Are proprietary models or methods required and how does it relate to the need for transparency to ensure a level playing field for market actors as well as confidence in the results?*

  We consider our algorithms and software proprietary but strongly support methods to standardize the use of meter data to measure energy changes. The process for validating the accuracy of different software services – either algorithmically or against some test data set -- should be transparent and the results verified.

  We introduced the concept of the Home Idle Load earlier as an example of a new energy category. Regulatory agencies – the CPUC, CEC and possibly national agencies – should focus on defining similar energy categories that can be measured using AMI data. These categories may be new, such as the idle load, or could be more traditional, such as heating and cooling efficiency. The goal of regulatory agencies should be to incentivize technical creativity by defining the process for adding new energy use categories.

  As energy efficiency transitions to being measured at the meter, everyone benefits from developing new creative ways to use AMI data to detect specific types of energy waste. If incentives are given for measured savings market forces will make the most cost-effective solutions the most compelling: ESCOs will want to fix energy waste for the lowest cost to receive the largest incentives. Everyone benefits from the competition to develop ways to identify energy consumption categories in AMI data, perform an intervention to lower the consumption and then verify the reduction.

  An energy category should have 2 defining qualities:
  1. The baseline for the category can be measured in sample AMI data selected as a standard benchmark.

2. The changes in the category can be measured in another set of AMI benchmarking data showing the energy changes.

Unlike modeling software, defining and measuring different energy loads through the meter should produce consistent results across different software packages. Software accuracy can be verified by utilizing algorithmic evaluations or test suites of AMI data.

Panel 2: Potential program designs.

- What customers or market segments will most benefit from your programs? (i.e. what does it supplant in the existing portfolio?)

All residential customers benefit from our program: renters and owners in single or multi-family residences.

Many large-scale energy efficiency programs are based on the assumption that to achieve significant energy savings requires reducing the level of energy needed for heating and cooling. This assumption has several negative consequences:

1. HVAC and envelope modifications are usually expensive and require a substantial time commitment on the part of the resident.
2. Residents in multi-family residences are excluded from the programs.
3. Renters in all housing types are excluded from the programs.

Not only does the assumption about home energy use – that most energy goes to heating and cooling -- exclude large portions of the population from participating, it is also incorrect. Across 1,800 San Francisco Bay Area homes analyzed, HVAC energy consumption averaged about 30% of total home energy consumption. This figure increases a modest amount to 36% for homes in the Central Valley. This leaves approximately two thirds of residential energy consumption unaddressed by most traditional programs. We have shown that AMI data can be mined to detect other energy categories.

As an example, the idle load represents 22.5% a home's energy use[3]. The idle load is usually much easier to address because reducing it is cheaper and causes much less disruption, and all residents can benefit. Changes in the idle load can be detected with 30 days of AMI data so that an accurate assessment of true energy savings is possible and much more timely.

HEA has identified how to detect and track other residential energy categories, and we believe other software entrepreneurs will develop algorithms to find and track additional categories if there is a market to do so.

- What strategies or past experience are you exploring for investing in upfront costs, providing incentives and balancing against savings that are quantified after the after the intervention?

Doing an inexpensive, accurate remote audit before providing an intervention reduces the cost of achieving energy savings. If the resident participates in this remote audit and is educated in the process, immediate savings can result due to behavioral and plug load changes. More significant interventions are selected to address energy waste in a cost effective manner. Interventions are not performed that will have little or no impact, or cost far more than the energy savings that can be achieved.

The following table compares 3 programs that used HEA software to perform a remote audit (with associated resident education for the first two) prior to any interventions.

- EUMV was an ARRA-funded program administered by the City of Mountain View. HEA and Acterra collaborated on outreach. Acterra performed tier 1 home energy audits for a subset of participants based on their energy consumption profile. Approximately ¼ of the participants received smart strips as an incentive to participate.

[3] http://www.nrdc.org/energy/files/home-idle-load-IP.pdf

- The Alameda program was administered by StopWaste. All residents in the county were eligible to participate. Outreach was managed by StopWaste; BKi provided phone consultations for participants having high variable loads; participants with high HVAC loads were referred directly to EUCA.
- SVEW was part of the Silicon Valley Energy Watch program administered by Santa Clara County. Low-income seniors living in senior apartment communities were recruited to participate by GreenPro Networks. Participants received an in-person energy education based on their energy consumption and appropriate low-cost interventions.

The statistics in the table below for the PG&E administered EUCA program come from the 2010-2012 Whole House Retrofit Impact Study, pages 5, 13, 32, 34 and 37. Statistics for HEA programs were calculated based on AMI data. Reports for all 3 programs are available.

Program Metric	EUCA by PG&E (2011-12)	EUMV by HEA (2011-14)	Alameda by HEA (2013-14)	SVEW by HEA (2014)
Total number of participants	3,823	1,576	753	172
Participants analyzed using Billing Data	1,625	1,239	462	77 [a]
Electric savings per participant (kWh)	203	301	325	289
Natural Gas savings per participant (therms)	74	62	54	4 [b]
GHG savings per participant (lbs CO2e)	1,101	993	896	207
Reduction in electric use	5.40%	5.52%	5.6%	10.2%
Reduction in natural gas use	16.40%	16.44%	12.9%	12.2%
Total cost across all participants	$25,310,500	$409,000	$50,000	$2,500
Program cost per participant	**$6,621**	**$260**	**$66** [c]	**$15** [c]

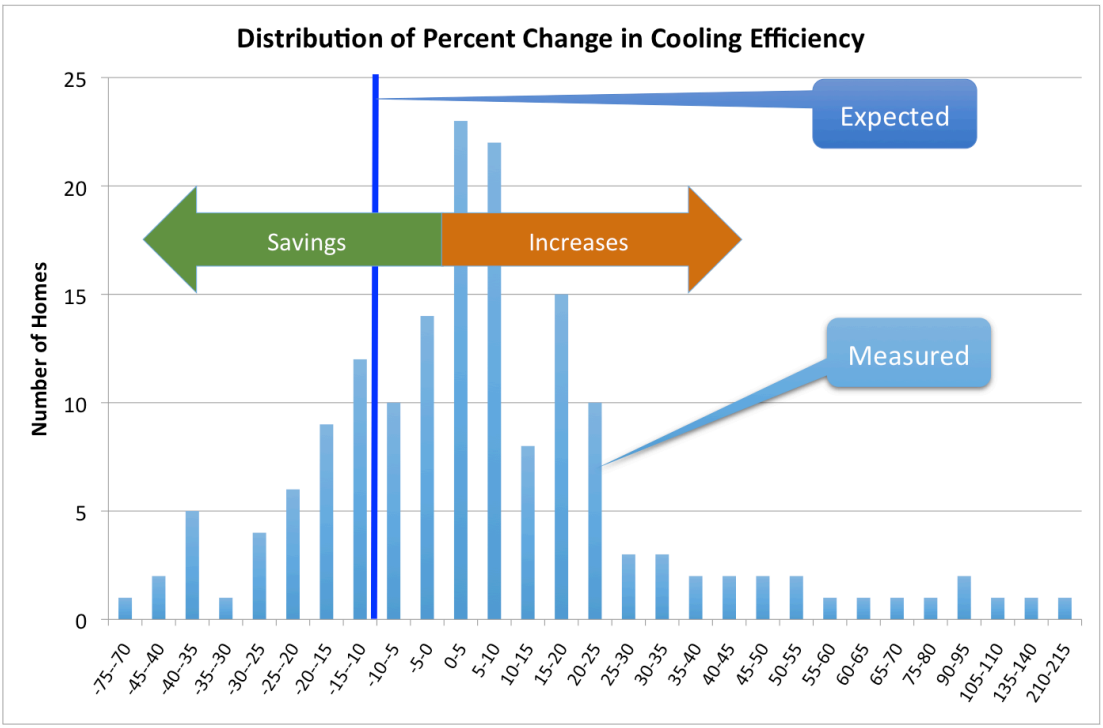
Notes: a: Energy savings results for Treatment group only
b: Most participants did not use natural gas
c: Cost of online software (SaS) only, no outreach or customer support included.

- How are you insuring persistence of savings? How do you value (or not) persistence in the context of your service offerings? How do regulations support or hinder persistence?

Persistence can only be reliably established by monitoring energy changes over time. HEA does this, and provides feedback to both residents and program administrators via monthly email messages and real time dashboards and on-demand SQL-based reports.

Traditional methods for guaranteeing persistence are based on assumptions about how equipment will perform in actual installations and human behavior. But homes are complex systems and equipment can perform differently from what was measured in the lab; residents may decide to increase their use of equipment reducing or eliminating any projected energy savings.

The following chart illustrates the problem.



This analysis was done to compare the cooling efficiency pre and post installation of a cooling optimizer in 165 single family homes in the Central Valley. The devices were installed between August and December 2014. Using hourly AMI data, a baseline for each home was determined by calculating the cooling efficiency (in BTUs/sf/CDD) for the year prior to the installation. Twelve or more months of post-installation smart meter data were then analyzed to determine the post installation efficiency. Balance point temperatures were computed for each home.

The expected decrease in energy use was between 12 and 15%. Instead, there was a 2.2% average increase. But just as importantly, changes in cooling energy ranged from a reduction of -72% to an increase of +212% -- a huge variation which should be investigated.

The reason for using this example is not to highlight problems with a particular device but to illustrate that concerns about persistence and achieving predicted savings are independent of using meter data. In fact, measuring energy changes using meter data provides an opportunity to accurately measure actual savings and work towards achieving desired persistence.

- What reporting protocols are you typically using in program implementation and tracking, how is tracking and reporting part of your business practice?

We track energy changes for each participant in eight energy categories and that information is updated continuously as new energy data is collected (daily) for each participant. Participants have access to this information through their online HEA account. Reporting energy changes for an EE program is a matter of aggregating information from all participants through program dashboards or customized reports.

There is no standard for reporting energy changes based on meter data but we've reviewed our algorithms with industry experts and in a number of completed projects have reported on the measured changes. We'd welcome the chance to participate in a forum on how best to measure and report energy changes. As stated above, the protocols for measuring energy changes should be open and transparent.

- For behavior, retro-commissioning and operations effects, how are you ensuring the activity is related to your intervention to demonstrate value to the customer and justify the cost?

Metered measurements quantifying the actual savings in specific, well-defined categories can be more straightforward than deemed savings, but it may still be difficult to determine attribution. Attribution is important for justifying large retrofit investments. But if the goal is reducing residential energy use the incentives should be to reduce energy consumption at the lowest cost so that consumers see the greatest benefit: they see savings on their monthly bill and they paid as little as possible to achieve it. We can measure these savings.

This drive towards achieving energy savings at the lowest possible cost should also reward ESCOs for being innovative and providing creative solutions. They could accept an energy reduction goal for a program and then be given freedom to determine how best to achieve that goal. Their incentives would be to achieve it at the lowest possible cost. If the ESCOs also receive bonuses for exceeding the energy reduction goal they will have even more incentive.

- What cost effectiveness barriers or opportunities come from embedding savings quantification -- normalized metered energy consumption – in your service offerings?

HEA recruits participants largely by offering proven energy savings (averaging over 12% through an educational virtual home energy audit). In some cases we also offered inexpensive incentives (a smart strip or timer) or low cost consulting (30 minutes to an hour with an energy advisor or volunteer) so receiving credit for metered savings would only enhance our services by justifying more consulting time and other incentives.

- What would be the impacts of tying incentive payment to performance? Perceived adverse impacts to participants?

Clearly all parties will benefit if incentives are paid on actual, achieved savings as opposed to projected or deemed savings. Incentive structures could be significantly different between commercial and residential programs.

- What consumer protections are in place in a pay-for-performance approach? What if the savings are not realized?

In the residential sector we are unaware of any successful pay-for-performance energy efficiency programs, nor are we aware of any relevant consumer protections.

If savings are not realized, or they evaporate over time, the ESCO should be penalized an equivalent amount. This will promote continued savings.

From our experience, many non-HVAC interventions can be detected and measured relatively quickly: 30 to 60 days after completion. Tying pay for performance incentives to such immediate measures, and avoiding pre-payments, reduces the risk to both consumers and ESCOs.

Currently, under the EUCA incentive structure consumers have no protection if upgrades do not achieve predicted energy savings.