

# Achieving Residential Energy Savings: Combining Behavior Change and Home Upgrades

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## ABSTRACT

With the number of appliances and electronics proliferating, reducing energy use from plug loads is increasingly important for residential efficiency. In California homes, energy use is split almost evenly between space conditioning and plug loads: in 2009, 54% of residential energy use was for heating, cooling, and water heating, while 46% was for other uses (Kavalec 2011). Instead of addressing *either* behavior change or home retrofits, a successful program should tackle both and effectively target services through segmentation to create a truly “whole-house” approach to energy savings.

The Energy Council, a local government agency serving Alameda County, California, launched a pilot in fall 2013 that uses online analysis of SmartMeter™ data to segment customers for targeted follow up. The pilot program, Home Energy Analyzer, directs participants with high HVAC use to Energy Upgrade California’s retrofit programs, while those with high plug loads receive phone follow up with recommendations for no/low-cost changes. In addition, the Home Energy Analyzer platform creates ongoing engagement with residents regarding their home energy use. Recruiting users by offering a free online tool has a low barrier for participation, and initial outreach has been extremely successful: over 500 people registered in the first five months of the program. On average, each household is already saving \$46 per year in energy costs, or 185 kWh and 38 therms annually. This totals over \$14,000 in cost savings, and is a 3% reduction in electric use, and 8% reduction in natural gas usage.

## Introduction

For at least the last 30 years, experts have claimed that energy efficiency upgrades in existing homes can lead to significant reductions in energy use. Household energy use could be reduced by 20 percent within ten years using proven technologies (Dietz et al. 2009), which adds up to substantial savings if applied to every home in the nation. McKinsey & Company (2009) estimate that by adopting all cost effective energy efficiency measures, an upfront investment of \$520 billion, U.S. households and businesses could earn an ROI of \$1.2 trillion in present dollars. Yet efficiency programs, particularly those geared towards households, have failed to meet expectations.

Energy Upgrade California is proof of this challenge. The program aimed to upgrade 100,000 homes over three years, yet reached only about 12,200 households with a budget of more than \$230 million (Baker 2013). Low uptake for this type of upgrade program is explained by the number of barriers that homeowners face, including large up-front costs, lack of financing, lack of information about the right steps for their home, and competing priorities for participants’ time and attention. Energy efficiency retrofits also require many complex steps, making them unappealing to homeowners (Fuller et al. 2010).

To bridge this efficiency gap for residents, programs need to make participation easy for residents, and provide the right motivation for them to take action. This paper focuses on the Home Energy Analyzer program run in Alameda County, California by the Energy Council. This program uses a free online tool that disaggregates a home’s utility smart meter data and provides customized recommendations on how participants can save energy. Promoting a free tool provides an easy sell to residents, giving the program more widespread applicability than a home upgrade program. It also allows for targeted follow up to high energy users, and for ongoing customer engagement. As participants learn more about how their home uses energy, they may be more likely to invest in upgrading their home.

In addition, existing “whole-house” programs fail to comprehensively address the whole house due to their limited focus on building envelope, seasonal heating/cooling loads, and domestic hot water systems without regard to plug load. People use energy at home both to provide comfort (via space heating or cooling) and to power all sorts of devices. The Home Energy Analyzer program is designed to address *both* upgrades and plug load management.

With the number of electronic devices growing, this part of the energy use equation is becoming more and more important. In California, the percentage of residential energy use that comes from plug loads is increasing dramatically (Figure 1). Since 2010, plug loads have accounted for over at least 30% of residential energy use, a number that is projected to increase rapidly.

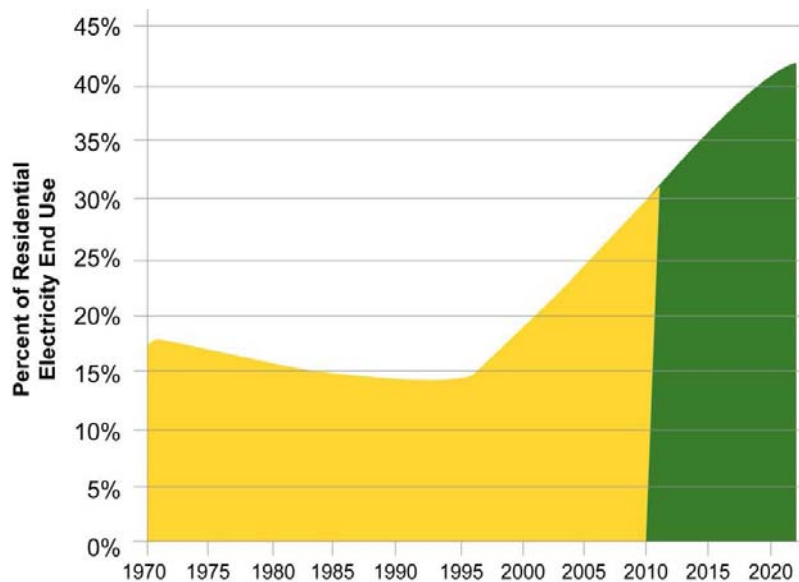


Figure 1. Residential electric plug loads compared to all electricity end use in California; *Source:* Based on output from demand forecasting models used in Kavalec 2011.

In total, plug loads (appliances, electronics, and other devices) and lighting (both plug-in and built-in fixtures) account for almost half of total energy use at home, or 46% in 2009, up from 38% only six years before (Figure 2). A comprehensive residential program must be able to help participants reduce their energy use from these uses, as well as from space conditioning. By disaggregating utility bill data, the Home Energy Analyzer (a tool powered by Home Energy

Analytics<sup>1</sup>) can segment users and target custom follow up to high energy users; participants with heavy heating and cooling load are targeted for home upgrade programs, whereas those with high plug loads receive custom follow up to encourage behavior changes. The analysis that Home Energy Analytics provides divides energy use into five load categories: heating, cooling, base (e.g. phantom load), variable (usage at varying times of day), and recurring loads (regularly repeated usage, such as a pool pump), which helps pinpoint specific opportunities for improvements.<sup>2</sup>

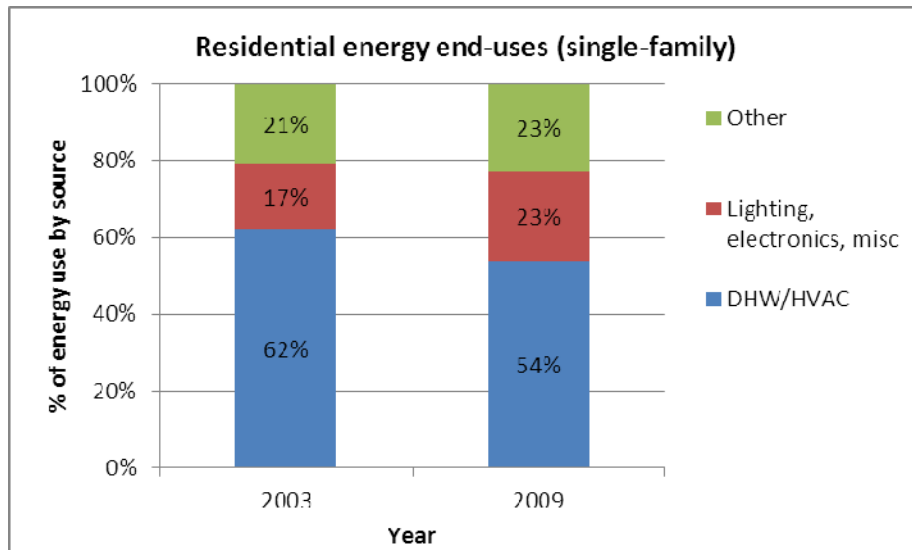


Figure 2. Growth in plug load as a percent of California residential energy end-use. Source: DNV KEMA's Residential Appliance Saturation Survey, 2009.

## Program Overview

Launched September 2013, the Home Energy Analyzer program uses on-the-ground outreach, including door-to-door canvassing and neighborhood workshops, to enroll residents into a free online energy assessment that uses smart meter data to profile a home's energy usage. The online tool, powered by Home Energy Analytics, disaggregates energy usage into load type (heating, cooling, base, recurring and variable loads). The tool provides customized energy saving recommendations for the user, and segments users for follow up based on their usage. Home Energy Analyzer uses a "high tech, high touch" approach; once a participant has signed up for the online tool, program staff target high energy users for personalized follow up, either to promote a home upgrade or for one-on-one phone consultations to identify plug load opportunities. A program flow chart is shown in Figure 3.

<sup>1</sup> Home Energy Analytics (HEA) software automatically creates unique home energy profiles from utility smart meter data, more information is available at <http://corp.hea.com/>.

<sup>2</sup> Home Energy Analytics uses 1-hour interval energy use data, weather data, square footage and a few characteristics about the home to estimate usage attributed to each load category.

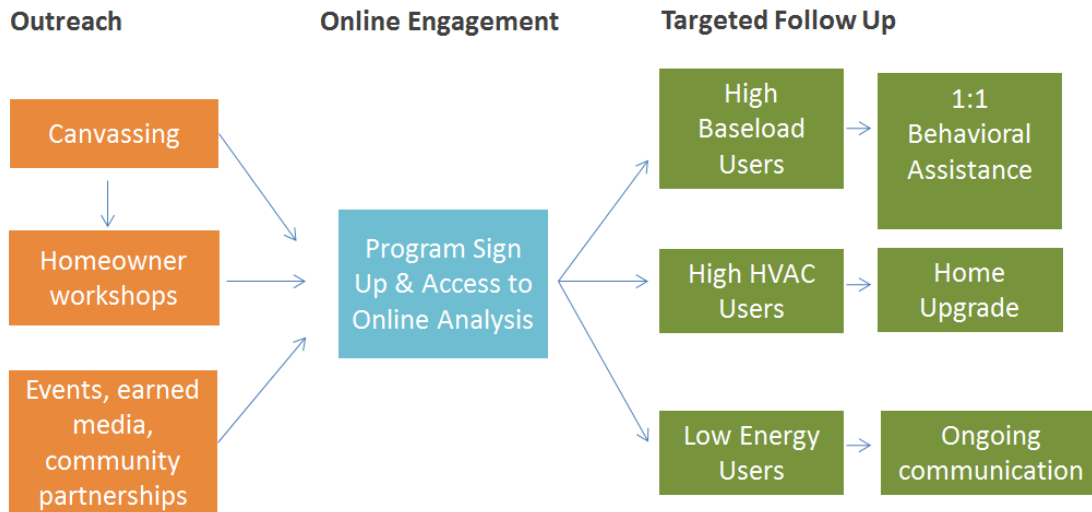


Figure 3. Home Energy Analyzer program flow chart illustrating customer acquisition and segmentation.

From a customer perspective, Home Energy Analyzer provides specific information and personal support to motivate action. Steve is a typical Oakland resident; he wanted to save energy but didn't know what to do. He learned about the Home Energy Analyzer from a friend, signed up, and was notified that his home is using more energy than average. He received a call from Wanda, a program staff person, who walked him through his online home energy report and worked with him to eliminate "phantom" electricity drain using smart power strips. Inspired by Wanda's help, Steve has started tackling other energy wasters too. Steve described, "The Home Energy Analyzer answered my questions and motivated me to actually get the systems installed. It helps to have someone who will help set the goals needed and to check back to be sure they are accomplished."

In addition to this type of support for immediate actions and direct energy savings, the program creates a platform for ongoing engagement to promote future programs and resources. Engaging residents through online energy assessments, support services, and monthly feedback builds an ongoing relationship between the Energy Council and Alameda County residents. All program participants receive both a monthly newsletter with general information, such as tips on using smart power strips and available rebates, and a customized email that lets them know if they are using more or less energy than the previous month. This continued relationship with residents around energy efficiency improves the likelihood that they will complete a home upgrade through Energy Upgrade California<sup>3</sup> during a future trigger or lifestyle event, such as when their HVAC system fails, or they decide to remodel or sell their home.

The program also collects data on residential energy usage for program implementers. Through the online tool, which connects to participant's utility accounts, the Energy Council can

<sup>3</sup> Energy Upgrade California (EUC) is a program of the California Public Utilities Commission, with the California Energy Commission, local governments and the state's investor-owned utilities. EUC is the umbrella brand for residential energy efficiency programs in California and focuses on using whole building science to provide retrofit rebates largely for space conditioning and domestic hot water. The Energy Council implements EUC for Alameda County, as part of the Bay Area Regional Energy Network (BayREN), which implements the Home Upgrade program in the Bay Area. High HVAC users are referred to the BayREN Home Upgrade Advisor for follow up.

access energy usage data and track real energy savings and progress towards local governments' greenhouse gas reduction goals. Actual energy savings from behavior change, do-it-yourself (DIY) projects, and upgrades can all be captured; though additional follow up to determine what changes were made would be necessary to attribute the savings to a specific behavior or installed measure. In addition, the Energy Council is partnering with Portland State University on research about how people use energy in their homes, combining data on building assets and behavior.

Funding for the Home Energy Analyzer pilot comes from three sources; the Energy Council received funding from Pacific Gas and Electric Company to fund part of the pilot launch and additional funding for outreach and behavior follow-up is coming from the Energy Council's budget and from the Bay Area Regional Energy Network. The total pilot budget is about \$150,000 to date, much of which has gone to licensing the software and other startup costs.

## **Outreach Strategies**

The program uses a number of on-the-ground and online outreach strategies, which has resulted in over 500 people signing up in the first five months of the program. Program staff has held six workshops to date, with additional workshops planned in 2014. In advance of workshops, a team canvassed nearby neighborhoods, targeting areas with high energy use (using "hot spot" maps provided by Pacific Gas and Electric (PG&E)). The team promoted both the workshops and signed residents up for the Home Energy Analyzer at the door.

The program also supported a city "energy challenge." During the fall of 2013, the Energy Council partnered with the City of Dublin on the "Dublin Energy Challenge"—a citywide competition to promote energy efficiency and enroll residents in the Home Energy Analyzer. The City set benchmarks for sign up, and the program made a donation to the Dublin Library for each benchmark accomplished. Almost 120 people participated, a rare accomplishment for Dublin, which tends to have little community engagement for environmental programs.

The program also partners with community organizations to reach out to their members, promotes the program through earned media, and paid online advertising. In addition, the Energy Council actively maintains a Facebook page to promote Home Energy Analyzer, build community and social engagement around energy, and provide energy-related information. The program will look for additional opportunities to layer outreach with existing networks and activities, such as retail partnerships, neighborhood competitions, and real estate networks.

The Home Energy Analyzer is available to all Alameda County residents (with at least 12 months of smart meter data and no PV panels with net-metering); though outreach targets residents that are likely to have high energy use and significant savings opportunities. Outreach focuses on neighborhoods with high average energy use, high percentages of homeowners (versus renters) and moderate income levels.

## **Segmentation and Follow Up**

Once the participant enrolls in the program and provides their utility online account information, the Home Energy Analyzer tool accesses the previous year of smart meter data and analyzes usage. Participants can log into the Home Energy Analyzer website to learn more about how their home is using energy. The online interface of the Home Energy Analyzer compares a participant's energy use to both the average California resident and average Alameda County program participant (Figure 4). Users can work through topics online, such as heating and base

loads, to learn more about how they are using energy. The tool identifies both no/low-cost and home upgrade options appropriate to their energy profile, and provides information on available programs and rebates. Participants can also request help, and program staff follows up personally.

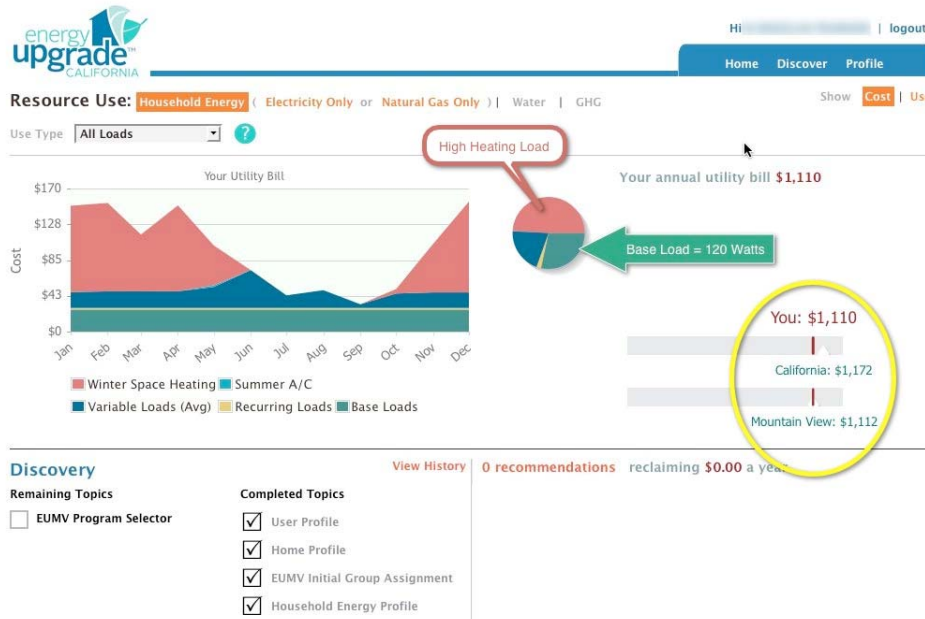


Figure 4. The Home Energy Analyzer dashboard that shows a participant’s energy usage and compares them to average California and Alameda County residents (highlighted in yellow).

The core of the program is the targeted follow-up for high-energy users, either to address home upgrade needs or plug load behavior change, as appropriate. All program participants are sorted into one of four categories based on their energy use, as shown in Table 1. Participants with high heating and air-conditioning (HVAC) loads (High HVAC Users) are referred to Energy Upgrade California’s Home Upgrade program, while High Plug Load Users receive personal phone calls to identify behavior change opportunities. Low Energy Users receive special messaging to encourage continued conservation.

Table 1. Sorting criteria for customer segmentation

Program Group	Criteria	Follow Up
High HVAC Users	4btu/sf/Cool Degree Day <u>or</u> 8btu/sf/Heating Degree Day AND annual energy bills > \$1,500	Leads to Home Upgrade Advisors Bimonthly emails
High Plug Load Users	Non-HVAC energy use > 4000 kWh annually	Program staff follow up by phone to identify specific actions Bimonthly emails
Low Energy Users	Annual energy bills < \$800	Messaging to encourage ongoing conservation Bimonthly emails
Everyone else	NA	Bimonthly emails

High HVAC Users receive follow up calls from the Bay Area Regional Energy Network’s (BayREN) Home Upgrade Advisors, Building Performance Institute (BPI) certified professionals that can help them identify appropriate measures to implement. The Home Upgrade Advisors are an independent third party that can advise home owners in working with contractors. They also help participants find appropriate rebate programs.

High Plug Load Users receive follow up calls from BKi serving as program staff. The BKi team contacts participants by email and phone, and provides direct consultation to recommend no cost/low cost energy savings opportunities. By phone, staff walk participants through their online home energy profile, ask questions about their home and appliances, and identify the specific loads (base, recurring, or variable) responsible for wasted energy. Each individual in the High Plug Load segmentation receives unique recommendations customized to their energy usage trends and home characteristics, either behavior based suggestions or non-invasive DIY projects, through BKi’s direct phone and email communications. Within 24 hours of a phone consultation, the same program staff member sends a detailed email to the homeowner reviewing their discussion and providing clear next steps, including a proposed timeline for homeowner implementation and a date that staff will follow up to ensure the participant was able to achieve their goals.

BKi’s communications integrate behavioral science best practices, such as reciprocity, commitment, social approval, and language framing techniques to help drive homeowner action to save energy. This customer dialogue serves as an education opportunity to reduce immediate and long-term energy usage, and also connects participants with resources on rebates and home upgrades, raising awareness of additional opportunities and priming them for future trigger or lifestyle events where a retrofit might be appropriate.

In addition to providing recommendations, BKi helps participants navigate and interpret the Home Energy Analyzer results, allowing people to maximize the effectiveness of the online tool. Staff provides live demos of the tool, defining energy terms to educate the homeowner such as differentiating between base load, variable load, and recurring load. By taking the time to educate and openly discuss these items with homeowners, the program raises residents’ awareness and interest in their plug load habits and gains insights into how residents think about energy and identify their motivation for reducing their energy use.

## Accomplishments

As of the middle of May, the Home Energy Analyzer had over 650 participants. Of this, 12% are classified as High HVAC Users, and 25% as High Plug Load Users (Table 2).

Table 2. Sign ups by customer segmentation

Program Group	Number of Participants	Follow Up
High HVAC Users	79	59 leads to Home Upgrade Advisors
High Plug Load Users	162	Over 45 consultations with program staff
Low Energy Users	68	Bi-monthly emails achieving over 30% open rates
Total number of participants	654	--

Program data as of May 19, 2014. Note that participants can fall in both the High HVAC Users and High Plug Load Users categories.

## One-on-One Consultations Create Detailed End Use Data

The one-on-one consultations for High Plug Load Users have been particularly effective. Of the 162 people that program staff have contacted, over 50 have participated in a 20-30 minute conversation in which staff identified ways that the participant can immediately save energy. These conversations help participants understand how their behavior influences their energy use and allow the program to be framed as a personal resource. Like Oakland resident Steve, many people are interested in saving energy, but need help and accountability to actually take action.

These conversations identify specific behaviors that Alameda County residents, and probably most Americans, can and should perform to reduce their energy use. The BKi team documents and tracks the type of appliances or electronics identified during the phone consultation, including the quantity and behavior patterns associated with each applicable end use; a tally of results is shown in Figure 5. This in-depth communication allows the program to extract information such as the following consultation notes:

- Two laptop computers plugged in all the time, although they only use the laptops for a few hours in the evenings.
- Game console/DVD player constantly plugged in but rarely used (once a month).
- iPad/tablet chargers throughout the house always plugged in.

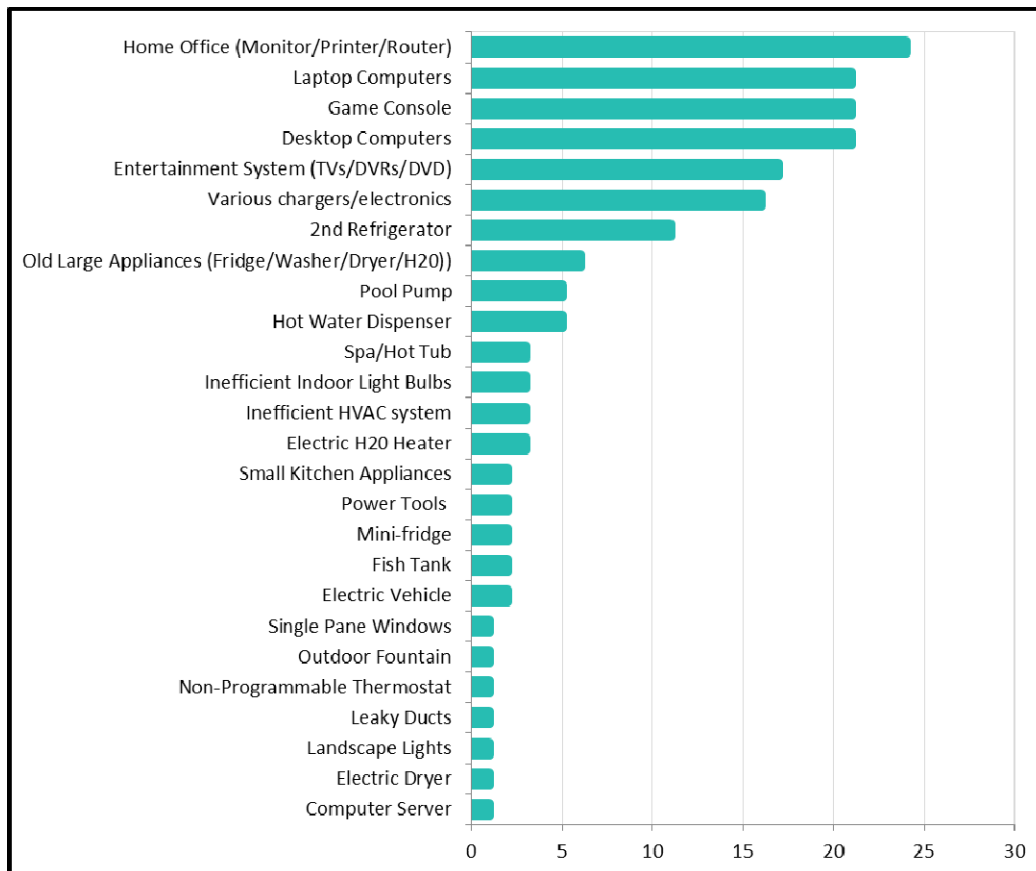


Figure 5. The distribution of opportunities identified through BKi one-on-one consultations for 51 program participants.



Collecting this detailed information allows the program to track the frequency of common measures among participants, provide specific resources based on their needs, and tailor recommendations to their situation. Some examples of specific questions or insights provided through this direct consultation include the following notes:

- Participant has halogen track lighting and was not sure if they could change to LEDs.
- Participant is not aware their TVs, game consoles, etc. are using energy even when they are not plugged in and could use a smart strip to save them \$10 a month.
- Participant is interested in making improvements and lowering their energy bills, but is not sure what is "low hanging fruit" and where they should start.

Identifying these specific points of confusion and opportunities for energy savings allows BKi staff to help people overcome several barriers to action, from lack of information to comfort with the process. Moreover, participants feel accountable to the program to follow through.

### **Positive Customer Response & Preliminary Energy Savings Results**

Feedback has been overwhelmingly positive from the over 50 participants with whom BKi has spoken to date. Participants appreciate the personal follow up as it gives them an opportunity to ask specific questions and get direct feedback that relates to their energy usage and unique home conditions. For example, one homeowner had 12 components for his home theater/entertainment systems and wanted to know what he could use for his specific setup. The Home Energy Analyzer recommended a smart strip, but the homeowner did not understand how they worked and was unsure if it was the appropriate device for his system. After program staff outlined how a smart strip works and how it could be incorporated with the entertainment system, the homeowner committed to purchasing and installing a smart strip in his home.

Many homeowners have also stated their appreciation for the detailed follow up email that outlines the conversation, next steps, and links to resources. They are then able to reference back to the email as needed. Representing the data through visual graphs and charts has also received positive feedback, and almost every homeowner has mentioned they are particularly interested in seeing how they compare to similar homes in Alameda County and statewide.

In addition to the people that program staff assists directly, simply providing a bimonthly reminder about how people are using energy reminds them to conserve. On average, participants are already saving energy and money. After just the first few months of outreach and engagement, on average, Home Energy Analyzer participants (the 316 that have enough data to estimate) are saving \$46 per year in energy costs, from energy reductions of 185 kWh and 38 therms per year. This is a 3% reduction in electric use, and 8% reduction in natural gas, and totals over \$14,400 in total energy savings.

While this is much less than the total program cost (\$150,000 to date), the pilot has run for less than a year; the timeframe is far too short to judge the program's full cost-effectiveness. The Energy Council sees this program as an important long-term strategy to build a community of residents interested in energy efficiency and a platform for ongoing engagement that can promote a range of future environmental programs. At the same time, the program creates short term benefits by identifying immediate opportunities for easy no- and low-cost changes that reduce energy waste, benefits that we expect will increase substantially in the near future.

## Conclusion

The Home Energy Analyzer program is still in its infancy, but the program is poised to build upon initial success, and highlights new opportunities for residential program design enabled by smart meter technologies. Unlike existing “whole-house” programs that fail to truly address the full picture of home energy use, the Home Energy Analyzer program model uses energy use disaggregation to segment and target the largest end uses within each home, addressing both typical retrofit program measures and plug load opportunities. This program design, especially the personalized follow-up, uses behavior science principles to motivate participants to change their behavior and conserve energy.

The Home Energy Analyzer educates people both about how their homes consume energy and appropriate energy saving behaviors. As participants begin to make changes to reduce their energy use, ongoing engagement from the program raises awareness and helps transform participants’ identities. Participants begin to see themselves as a person that knows about their home and how it uses energy, which can lead to greater commitment to conservation and efficiency. This shift in identity may make them more interested in pursuing additional actions, and more likely to complete more conventional home retrofits, especially as future trigger/lifestyle events occur.

Importantly, the Home Energy Analyzer measures *actual* savings on an ongoing basis. Reported savings are real, rather than modeled, and the program can quantify usage patterns over extended time periods, and associate specific plug load savings with when measures were implemented. Even the best energy models cannot accurately predict energy savings from asset upgrades, due to both limitations in the modeling itself, as well as variations in occupant behavior and tendencies for occupants to “backslide” and use more energy after retrofits (Brown 2013). Using real utility bill data allows the calculation of real savings, and the Home Energy Analyzer method of regular feedback looks to prevent backsliding. Using real energy use data also allows the program to capture energy savings from DIY retrofit projects and provides quantifiable, long-term savings data to support behavioral programs as a resource program.

A program like the Home Energy Analyzer has great potential to scale beyond Alameda County. Its approach allows it to be run by local governments, non-profits or utilities with only minor modifications. Engagement through a free analysis is a very low barrier for engagement and outreach, allowing for broader participation with very little initial commitment by participants. As governments and other organizations look toward meeting their climate action and greenhouse gas reduction goals, the Home Energy Analyzer program model is one that can help support greenhouse gas reductions in the residential sector by thinking comprehensively about behavior, plug load and HVAC, while creating ongoing engagement for residents.

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