Designing for Evaluation in Residential Plug Loads

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ABSTRACT

By some accounts, "plug load"—household appliances, electronics, and tools that consume electricity—accounts for 20 percent of California residential electricity load. In spite of the many factors driving greater efficiency in these devices (innovations in product design, voluntary labeling programs, national and state standards, and consumer advocacy), growth in the number of devices consumers are plugging in overshadows efficiency gains. As the number of plug load devices grows, the efficiency gains observed in lighting and building envelopes are offset by the growing proportion of energy use attributable to plug loads. Until residential plug load growth is reversed or seriously reduced, California's plans for achieving zero net energy in new homes by 2020 is not possible.

Since per-unit energy savings potential is small in many product categories, traditional "widget-based" approaches to program design are less effective. As a result, utilities need to develop innovative programs to tackle plug loads that are not evaluable within existing evaluation paradigms. Close collaboration between program designers and evaluators will be required to position these new programs for successful evaluation.

This paper presents an overview of an effort to mitigate the evaluation risks of new plug load energy efficiency programs through thoughtful program design. Collaboration between program designers and evaluators is framed using a specific example of an evolving plug load program at one utility that builds on painful lessons learned from prior evaluations.

Introduction

In spite of the success of basic CFL rebate programs, stricter codes for major appliances, and the success of information programs to encourage conservation, per capita residential energy use in California continues to grow. The California Energy Commission forecasts that the average annual growth rate for electricity consumption in the residential sector is 1.6% (CEC 2012). According to the 2011 California potential study, which drives the goals of the California IOUs for future energy efficiency programs, the future market potential for existing residential energy efficiency programs is virtually flat. The potential study identifies plug loads—devices in homes that are plugged in and consume energy such as consumer electronics, power tools and other miscellaneous devices that consume power—as a large area of growth in energy use and remaining energy efficiency potential. As shown in Figure 1, the study indicates that plug load potential climbs from 6% of incremental market potential in 2013 to over 30% by 2021 (CPUC 2011a).

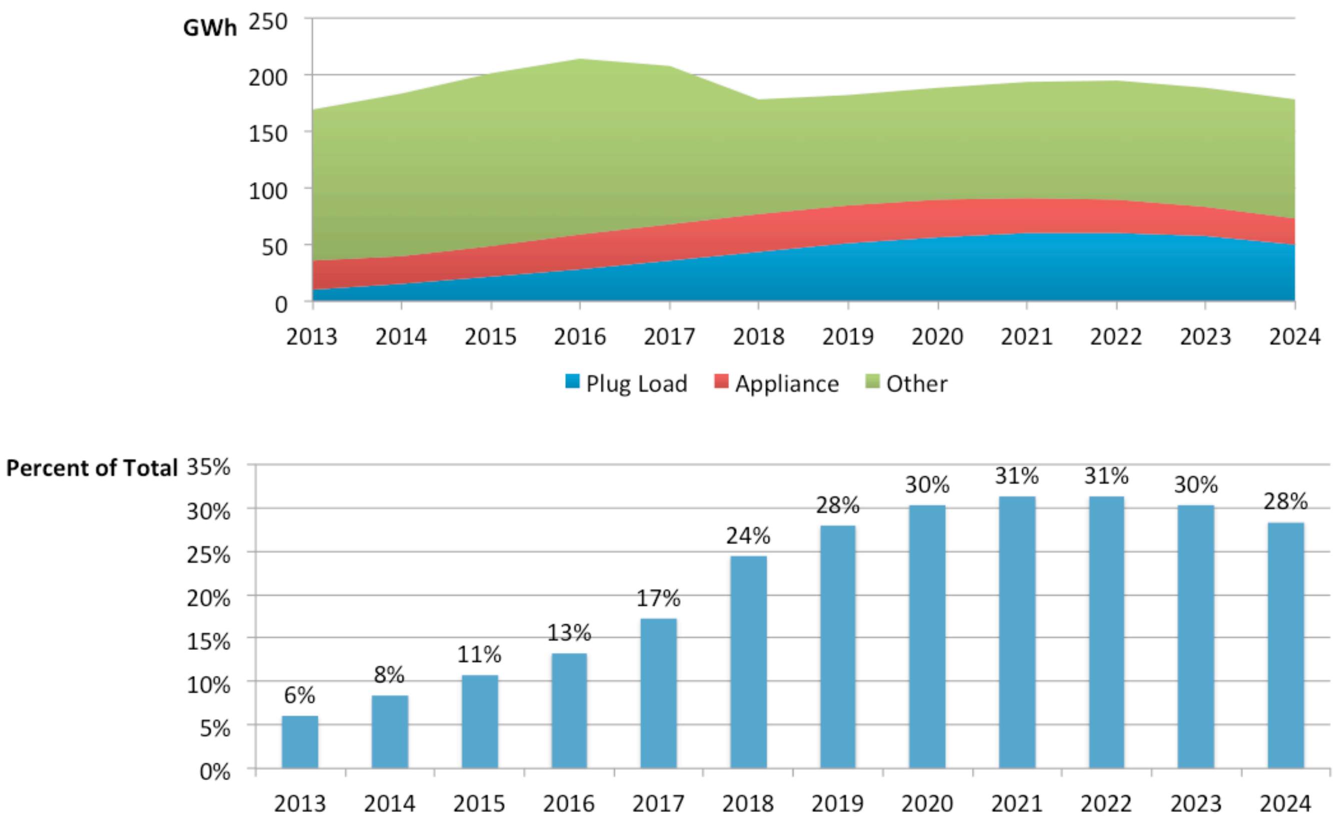

Figure 1. California Residential Gross Incremental Market Potential Energy Savings from 2013 to 2024

The growing problem of plug load was identified in the California Long-Term Energy Efficiency Strategic Plan (CPUC 2008) as one area in need of utility intervention. This Plan directed the California's Investor-Owned Utilities (IOUs) to develop "comprehensive, innovative initiatives to reverse the growth of plug load energy." For the 2010 to 2012 program cycle, televisions in particular were identified as a key technology within the plug load category. In response, the IOUs launched the Business and Consumer Electronics (BCE) program in 2010. The BCE program was an aggressive midstream intervention that focused on incentivizing retailers to change their product assortment practices so that more energy-efficient models would be in stores, which would thereby lead to an increase in the proportion of energy-efficient televisions sold. The BCE program covered televisions, desktop computers, and computer monitors, but the main focus of the program was televisions, which provided over 95% of the energy savings for the program in the 2010 to 2012 program cycle.

While the importance of addressing plug loads in residential programs grows, there are a number of challenges facing utilities in designing cost-effective energy efficiency programs for plug loads:

- Even though the number of plug load devices is large, many of the devices use a relatively small amount of energy individually. This means it is difficult, if not impossible, to design cost-effective customer rebate programs focused on influencing customers.
- Customer behavior related to these devices makes the energy use and savings potential for plug loads highly variable. While there are reliable estimates for hours-of-use for some plug load devices (such as refrigerators, set-top boxes, and televisions), there is little understanding of how much customers are using devices such as room air cleaners, computers, monitors, game consoles, and device chargers. While disaggregation of interval data from smart meters offers some promise in determining usage patterns for these products, the limited power of this technique makes it unlikely to offer meaningful insights for devices with lower and/or more erratic consumption patterns.

- Many products that contribute to residential plug loads, such as consumer electronics, are rapidly becoming more efficient due to a host of existing influences external to utility run programs. These influences include: (1) quick product revision cycles and high levels of innovation driven by competitive markets, (2) labeling programs such as Energy Star and FTC energy labeling, (3) advocacy organizations such as the Natural Resources Defense Council (NRDC), and (4) pressure from national and state code development.

These factors combine to pose enormous challenges for creating credible energy consumption baselines to serve as the basis for measuring program impacts. Given the sheer number and variety of devices consuming relatively small amounts of electricity, there are many product categories for which creating baselines would not be worth the cost. Fast declines in average energy within a given product category demands the development of "dynamic baselines" that are challenging and expensive to create—and make it more difficult to verify program impact given that energy consumption is declining in the absence of utility interventions. For these reasons and many others, the California IOUs are looking for new program models to address residential plug load that move beyond single product, "widget-based" approaches.

The BCE program was an innovative new approach to addressing plug loads, and its midstream focus did not fit cleanly into the existing California Evaluation protocols. Over the course of program implementation there was a fast-moving decline in average energy of televisions nationally. However, there were multiple other program efforts contributing to the decline of television unit energy consumption (UEC) over the course of the BCE program implementation, including large shifts to more efficient display technology, three revisions to the Energy Star specification, a California state standard, and FTC labeling requirements (EMI 2012). The BCE program was just one of many influences driving energy efficiency in this national market, and therefore there was a large burden of proof on utilities to demonstrate that the BCE program significantly accelerated the ongoing transformation of this market and directly produced significant energy savings attributable to program activities.

A number of recent studies have highlighted the evaluation challenge with the BCE program model. A program experience review funded by two of the BCE program utilities found significant sources of evaluation risk for the program design (RIA and EMI 2012). The impact evaluation commissioned by the CPUC found a very low net-to-gross for the program, though the report noted that the uncertainty around the net-to-gross was extremely high due to potential bias and the lack of consensus in the qualitative Delphi approach they used for the study (KEMA 2013). Compounding the evaluation challenges facing California IOUs, evaluations of the BCE program model outside of California have also identified that there is difficulty in developing robust estimates of attributable savings to the BCE program based on available data sources (EMI 2011 and RIA 2013).

The Strategic Plan Progress Report highlights BCE as a ". . . first step to addressing plug loads" (CPUC 2011b), but additional advances in plug load program design are sorely needed to address the growth in plug load. As a result, Pacific Gas and Electric Company (PG&E) is designing a new midstream program trial aimed at plug load products that moves beyond approaches that focus on single product categories called the "Retail Product Portfolio" (RPP) program. To ensure that the RPP trial results in energy savings that are effective and evaluable, the program is being designed collaboratively by an interdisciplinary team with deep experience in program design, manufacturer and retailer outreach, standards-settings advocacy and processes, energy use estimation, and evaluation.

The remainder of this paper describes lessons learned from evaluations to date of the BCE program model, followed by how these lessons-learned are being applied in the development of the new RPP program.

Lessons Learned From Plug Load Program Implementation and Evaluation

To address plug loads, the BCE Program was launched by three California IOUs: PG&E, Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E). The program was part of the 2010 to 2012 California statewide energy efficiency program portfolio, and was implemented in collaboration with the Sacramento Municipal Utilities District (SMUD), the Northwest Energy Efficiency Alliance (NEEA), and Nevada Energy (NVE). The long-term goal of this midstream and upstream program was to transform the market for consumer electronic products by offering midstream incentives to retailers to reduce key market barriers. The program also aimed to strengthen efficiency standards for target products.

Toward that end, the program included four main market interventions:

1. Providing retailer incentives to increase the assortment and sales of highly energy-efficient plug load products.
2. Supporting development of stricter Energy Star specifications for plug load products.
3. Performing outreach to manufacturers to raise awareness of the program.
4. Providing retail store-level signage and sales associate training to help customers and sales staff identify high efficiency products.

These four interventions are discussed in more detail below.

Retailer Incentives. The BCE program offered retailers incentives on the sale of energy-efficient electronics to motivate them to assort a higher proportion of efficient products. This approach was developed after a 2009 research report published by McKinsey identified the potential retailer role in energy efficiency. According to the report, retailers' strong position with consumers makes them a natural energy efficiency partner for major appliances, small appliances, and electronics. The McKinsey report further indicated the potential for using midstream incentives to change the retailer buyer's behavior so that they would assort more products that meet or exceed Energy Star specifications by incenting either (McKinsey & Company 2009).

Support for Stricter Energy Star Specifications. The goal of this effort was to increase the stringency of the Energy Star specification levels by: (1) petitioning Energy Star to support higher efficiency levels and (2) petitioning Energy Star to accelerate the introduction of higher specification levels. According to the program theory, the stricter efficiency criteria aimed at manufacturers would work in combination with the retailer incentives to drive the market towards greater levels of energy efficiency.

Manufacturer and Industry Outreach. This effort consisted of multiple types of communication that were designed to make manufacturers aware of the program that incented retailers to sell high efficiency products. The outreach focused on ensuring that manufacturers were aware of the upcoming program specifications for the following year and preparing them to meet the anticipated demand.

Retail Store-Level Signage and Store Associate Training. This effort was designed to place point-of-purchase (POP) information on qualifying products so that the consumers and the store associates would be able to identify the most efficient products in the store. The program educated store associates about energy efficiency and the utilities' efforts to promote the most efficient electronics products. This was a secondary effort that followed the primary effort to increase the portion of efficient products from which consumers could choose. While still important, the signage and training was expected to have a smaller impact on sales of efficient products relative to the stores' decision to assort them in the first place.

Challenges in BCE Program Evaluation

In 2011, two of the BCE program sponsors, PG&E and SCE, funded a process evaluation that focused on the BCE program (RIA and EMI 2012). The goal of this research was to understand what worked well and what did not work as effectively in this first generation of programs focused on consumer electronics plug loads. The research identified a large amount of evaluation risk due to the difficulty of attributing savings to the program that are independent of those that result from nationally-focused program interventions in such a dynamic and national market. Among other challenges, the report further highlighted the need to establish a dynamic counter-factual baseline prior to the program intervention, and the lack of established protocols in California to evaluate unique programs like the BCE program.

Subsequently, the CPUC Energy Division has recently completed an impact evaluation of the 2010-2012 BCE Program. The evaluation relied on a single qualitative method—a Delphi panel—to estimate the net-to-gross ratio (NTGR), which is a measure of how much of the observed gross energy savings in the market can be attributed to the program. Unfortunately, the impact evaluation faced many challenges and, after careful review, the California IOUs concluded that the single method did not provide a reliable estimate of the NTGR.

These evaluations found that a single static baseline could not be used for the dynamic consumer electronic markets covered by the BCE program. Typically, an evaluation of a traditional energy efficiency program establishes a baseline of energy use prior to launch of program activities. Adoptions of targeted measures and associated energy savings over the program cycle are compared against this baseline. The very fast product development cycle for the measures promoted by the BCE Program makes this "single baseline" approach infeasible. The baseline for the consumer electronics changes multiple times during a program cycle thereby making a single baseline insufficient to determine program impact. For example, new television models are introduced in any given year and over the following year their market share increases to the point that they become the new baseline for the newer and more energy-efficient models introduced at the beginning of the following year.

Another challenge is the lack of appropriate protocols for evaluating the innovative midstream program model used by the BCE program. The challenges of establishing a dynamic baseline or determining program attribution for a midstream program in a complex and dynamic market are not fully addressed in California Energy Efficiency Evaluation Protocols (Hall et al., 2006). The electronics markets are very turbulent, with multiple interventions occurring simultaneously with the implementation of the BCE Program. Attempting to tease out the net incremental benefit of the BCE Program from the many other interventions has been challenging for evaluators. Given that there are no adopted evaluation protocols that have been developed to address the unique challenges of the BCE Program, the CPUC Energy Division must wrestle with the issue as to what counts as credible evidence of program efficacy in a regulatory environment that demands extraordinary precision.

Lastly, CPUC policy states that savings can only be claimed if the intervention occurred within the same funding cycle. The impact of many of the BCE Program activities are aimed at generating energy and demand impacts in future years, but the program has no way of claiming these longer-term energy savings outside of the program cycle.

Lessons Learned from Program Evaluations of the BCE Program.

In summary, these efforts at evaluating the BCE program produced the following important lessons-learned:

1. New methods of addressing dynamic baselines must be developed to measure net program effects in dynamic markets.
2. Additional evaluation methods that follow industry best practices should be developed in California to assess these innovative new programs. Evaluations of these programs should not rely on a single qualitative approach such as the Delphi panel. For example, a mixed methods approach utilizing triangulation could be used since the likelihood that a single evaluation approach will yield definitive results seems unlikely.
3. California should develop a vehicle for measuring and claiming longer-term energy savings from market effects leading to market transformation.

Collaboration in New Plug Load Program Design

In the second half of 2012, PG&E began developing a new innovative approach to address residential plug loads through retailer-focused, midstream interventions. This new approach, the Retail Product Portfolio (RPP) Program, is in development as a new subprogram under the California Statewide Plug Loads and Appliances (PLA) Program. This subprogram is being designed to help achieve the PLA objective, as outlined in the program implementation plan (PIP), of transforming the market to "achieve sustainable adoption of energy-efficient PLA products where ongoing intervention would no longer be required." To help drive this long-term goal, the PLA subprogram fits within the strategy of using short to medium-term incentive mechanisms to "increase availability, awareness, and adoption of energy-efficient products" (PG&E 2012).

In order to maximize the chance of program success, PG&E program designers involved the PG&E evaluation staff and associated consultants to develop the evaluation approach for this innovative program concept. It is critical that this collaboration between program designers and evaluators happens early in the program development process so the program logic, underlying theory, evaluation data needs, and program and evaluation risks are identified as early as possible in the program design process. A key element of this collaboration was to ensure the program design and evaluation approach took into account all the lessons learned from the implementation and evaluation of the BCE program, described above.

An additional critical element is engaging regulators sufficiently early in the process. This enables regulators to provide input and be comfortable with the program elements and evaluation approach before the filing of program applications. Getting regulator buy-in before locking down program design is a critical component of this design process, and is especially important in this case due to the lack of established evaluation protocols for this type of program.

Retail Product Portfolio Program Description

The RPP Program concept is a retailer-focused, midstream intervention targeted at lowering the average energy use of a product category sold at retail stores that contributes to residential plug loads. Incentives provided to retailers will be based on a reduction in the "energy profile" of the target product categories. The energy profile will be the average, sales-weighted, energy consumption of all the products sold by retailers in a specific target product category.

The program would establish the baseline by determining the energy profile of the target products before the program intervention, and then offer incentives for retailers that are able to reduce this energy profile over time by whatever means a retailer chooses. For product categories where a preexisting downward trend in energy consumption is evident (e.g., televisions), the program would use prior sales data (obtained directly from each retailer or other sources) to establish a dynamic baseline forecast. Retailers would then have to exceed this forecast in order to earn incentives. By measuring reductions below forecasted trends, the program would pay incentives on net program impacts that are customized for each retail participant. While retailer activities may lead to short-term resource acquisition energy savings, they would contribute to longer-term market transformation goals. Figure 2 provides an early program logic model.

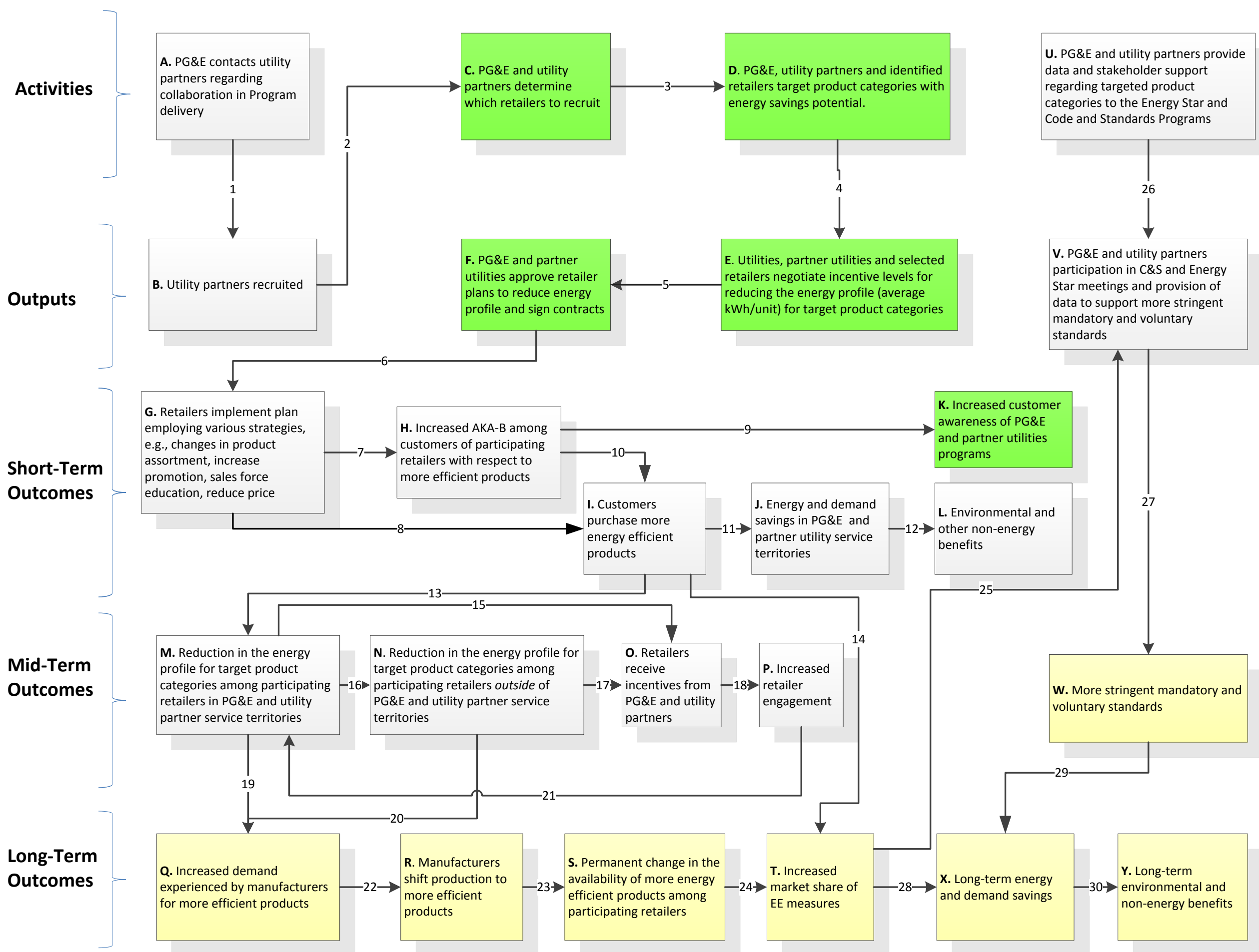

Figure 2. RPP Program Concept Logic Model

Currently, PG&E is in the process of designing and implementing a trial of this program. Key issues identified for the program trial include determining the details of how to engage and pay incentives to retailers and determining the data needs and sources for calculating each retailer's baseline. The program trial aims to engage one to two retailers and to offer incentives on two to three product categories. The product categories for consideration are those products that are covered by Energy Star, but not currently covered under other PG&E programs. Targeting Energy Star product categories is important because a key aspect of Energy Star specifications are product definitions and measurement of power and energy consumption that will be useful for program implementation. For the RPP program trial, program designers are currently considering the following eight products: (1) Blu-Ray players, (2) home theatre in a box, (3) television sound bars, (4) desktop computers, (5) notebook computers, (6) printers and multi-function devices (MFDs), (7) air cleaners, and (8) computer monitors.

To best establish a causal linkage between program activities and measured impacts, and therefore to make a case for significant program attribution for measured energy savings, the program concept requires that retailers create a plan for the specific activities they will engage in to reduce the energy profile of the target products. These could include the following activities: (1) changes in product assortments, (2) offering product discounts, (3) other promotional activities such as changes in product placement, and (4) increased sales force training on energy efficiency.

After the retailers have begun to faithfully implement their plans for reducing the energy profiles of the target products, the program would measure reductions below the forecasted baseline and provide incentives, likely based on a direct incentive per kilowatt-hour payment, in a similar manner as a custom energy efficiency program.

Approach to Program Design

As a first step in developing this program, the program design staff shared a draft white paper outlining the RPP program concept with PG&E evaluation staff. Next, the combined team of program designers and evaluators discussed elements of the program design and potential evaluation challenges. A key outcome of this session was helping the program designers and implementers understand the importance of robust evaluation and the data needed to support it.

The next step in developing this program was creating the program logic model shown above in Figure 2. The creation of a program theory and logic model (PTLM) is important as this helps ensure that program designers, implementers and evaluators all have a shared understanding of the activities, outcomes, and outputs of the program, as well as the causal mechanisms and logical linkages on which the claim of program attribution rests. The draft PTLM features both resource acquisition components designed to capture immediate energy savings as well as market effects designed to contribute to the longer-term transformation of the market.

To foster collaboration in development of the program PTLM, PG&E evaluation staff organized a full-day meeting with the program designers and potential program implementers. This team included: (1) PG&E program design staff, (2) PG&E evaluation staff, (3) program design consultants experienced with the design and implementation of the BCE program, (4) evaluation consultants familiar with California Protocols and the BCE program model, and (5) program design staff from other organizations interested in partnering on the RPP program.

A very important aspect of this design process is identifying and discussing potential challenges in evaluation, and *addressing them explicitly in the program design*. At the early stages of program development, it is tempting to ignore evaluation challenges and plan to solve them later, or rationalize that evaluation challenges are going to be "the evaluators' problems." However, this mentality dramatically increases evaluation risk if the necessary data is not available at the time of evaluation. Absent a solid evaluation methodology and the appropriate data to measure the relevant performance metrics, the program is at risk of not being evaluated correctly on its merits.

In good program design, evaluation challenges must be balanced by challenges in program implementation. Evaluators will always want as much data as possible, but there are practical limitations to the data that are available. Available data can be limited by the time and money required to collect it. If participation requires a large number of onerous data requirements to support an evaluation, it will be difficult to recruit program partners. Because the evaluators themselves work under serious budget constraints, they must carefully choose the most relevant metrics to support a robust evaluation of the program. Collaboration in program design is important so that the right balance can be struck between access to critical evaluation data and the cost and burden to both program participants and evaluators of collecting these data.

The largest challenge identified in this process was teasing out the net program impacts from the numerous national interventions that play a role in reducing the energy consumption of certain products over time. For products with dynamic markets that are trending down in energy use, the program must be able to show that it is *accelerating* the pace of energy reductions in the market beyond the current trend.

To meet this burden of proof, the program designers and evaluators plan to develop a process for creating a dynamic baseline forecast that shows the prevailing trend of energy reduction for each retailer and product category, and measure any reductions in energy use beyond the forecasted trend, with any difference defined as net savings.

Dynamic Baseline Approach

PG&E is funding a program trial through the Emerging Technologies Program to develop the baseline concept for the RPP program. This is necessary because developing a dynamic baseline for this innovative new program design will be difficult and the process is rife with uncertainties. The dynamic baseline will estimate what the sales-weighted average unit energy consumption (UEC) would have been for each retailer and product category in the absence of the program. Two methods for determining the dynamic baseline are now under consideration: (1) using past data to forecast the UEC over time, and (2) using representative non-participant comparison stores to model the baseline. The first option is represented in Figure 3. The difference between the dynamic baseline and the actual UEC performance would give you a measure of net unit energy savings (UES) due to the market lift of the program. This baseline could then be recalculated each year to continue to drive greater efficiency in the market.

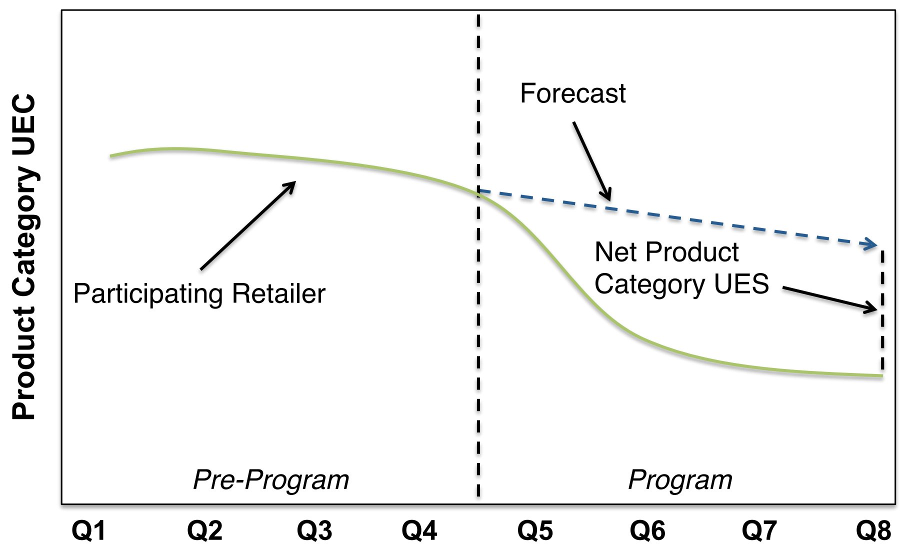

Figure 3. Example of a Dynamic Baseline Approach to Calculate Net Program Savings

Basing a market lift program on average UEC has an important advantage over tracking year over year market share of energy-efficient units. This is because the definition of what is "energy-efficient" is always changing as the whole market gets more efficient. For example, it is difficult to track the market share of Energy Star-qualified units year-over-year, because the Energy Star specifications are updated frequently in fast changing markets, such as televisions.

Calculating this dynamic baseline will require a large amount of data, and some of it may be difficult and costly to obtain. Developing this dynamic baseline will either require multiple years of past sales data or sales data and store characteristics from a representative non-participant store. In addition, the approach will require *model level* UEC data or assumptions for every product sold.

A key challenge in the trial program implementation will be determining whether these data can be collected in a cost-effective manner and if the burden on retailers is too onerous for retailers to agree to participate in the program. Lastly, the program trial will have to determine if the available data are robust enough to create a dynamic baseline that impact evaluators are willing to count as credible evidence, in combination with other impact-related data that they might collect. PG&E and its consultants are currently working with program implementers and retailers to obtain this data and test these approaches during the program trial during the summer of 2013.

Conclusion

While there are many challenges to utility programs aimed at plug load energy savings, the potential energy savings among these products is too high and important to ignore. Tackling this issue will be critical if California is to meet its goal of reaching zero net energy in residential homes by 2020. Because of the difficulty in addressing residential plug loads, new and innovative program designs will be needed with even more innovative evaluation approaches to fairly assess program influence in a regulatory environment that is not accustomed to these new approaches and standards of evidence. The only way to accomplish this goal is for program designers to design their new programs with evaluation in mind, to engage evaluators and regulators early in the process, and to strike a balance between the needs of program implementers, program evaluators, and key program partners.

There is a need for the development of new evaluation methods tailored to the unique characteristics of innovative plug load programs in California. Developing a set of methodological best practice guidelines for assessing program attribution for innovative program designs involving dynamic baselines such as the one described here can be accomplished through the collaboration between the Energy Division and IOUs. Triangulation, which relies on multiple methods and data sources, could be used to assess the efficacy of these innovative programs. A multiple methods approach should be preferable to the reliance on a single method for evaluating new program models that face these challenges. In addition, new policies that allow IOUs to claim savings for market transformation programs beyond a given funding cycle should be included to allow for credit for achieving market affects and making progress toward market transformation goals. The new generation of plug load programs could be an ideal proving ground for the development of these new policies and methods.

PG&E's RPP program trial is a timely example that illustrates how holistic program design can be used to try to address this important market. While there are many challenges that still must be met in the implementation of this program concept, successful collaboration between program designers and evaluation professionals is an essential first step. Only time will tell if the challenges with midstream program evaluation identified through the BCE program can be overcome and if a robust evaluation can reliably tease out the unique contribution of the IOU program from the multiple national interventions. What is clear is that program designers and evaluators agree that it is worth the effort to find out through effective collaboration.

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