Behavioral Energy Feedback Program Evaluations: A Survey of Current Knowledge and a Call to Action

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ABSTRACT

Behavioral-based energy efficiency programs are those that utilize strategies intended to influence consumer energy use behaviors to achieve energy and/or peak demand savings. These programs typically include outreach, education, competition, rewards, benchmarking and/or feedback elements (Todd et al, 2012). In North America, over 110 investor-owned utilities included behavior programs in 2012 as part of their energy-efficiency portfolios, allocating 0.3 percent to 10 percent of their efficiency portfolio spending to these programs. Emerging plans in Massachusetts allocated as much as 50 percent of first year kWh goals to behavior programs in 2014.

Despite the overwhelming growth in spending on these programs, there are many unanswered and important policy questions that must be addressed. This paper argues that the energy industry needs to go further than just assessing energy impacts to address existing gaps in knowledge and find ways to most effectively incorporate these programs into efficiency portfolios. First, the paper presents an overview of behavioral feedback program lessons learned from third-party evaluations across North America. Next, a brief analysis of gaps in industry knowledge of how behavioral programs generate savings is provided. In the last section, policy- and planning-focused research questions that need to be answered as behavioral feedback programs mature are discussed. To date, there has been an overwhelming focus on impact evaluations, and there are many key questions that need to be addressed.

Future evaluations must focus on both impact and policy questions by addressing existing gaps in knowledge about how behavioral programs generate energy savings and exploring the most effective ways to integrate these programs into program portfolios.

Introduction to Calculus Behavior Programs in the United States

As this paper aims to conduct an overview of the status of these programs and our knowledge to date, it is important that we begin with a shared understanding of behavioral efficiency programs. The term “behavior-based energy efficiency programs” has been used to describe a wide range of programs, from marketing and outreach efforts to extensive in-home audits. In the United States, behavioral-based efficiency programs (often called “behavioral programs”) typically refers to a narrowly defined but growing class of programs best described in “The American Council for an Energy-Efficient Economy (ACEEE) Field Guide to Utility-Run Behavior Programs” (Mazur-Stommen and Farley 2013) as a “Calculus” Behavioral Program (CBP). According to the field guide, programs that fall in the “Calculus” rely, in some part, on participants’ rational decision making and may use feedback, games, and incentives (such as rewards) to prompt participants to reduce their energy use. CBPs provide customers with their energy use in regular intervals, either through enhanced billing or through smart meter-enabled usage data in more real-time intervals (15 minute or five minute intervals). Such CBP feedback has been demonstrated to influence a wide range of actions (including conservation actions as well as efficiency investments).

CBPs share a number of common characteristics:

- The use of information to motivate a wide range of behaviors. Unlike traditional rebate programs, behavioral programs do not target a specific piece of equipment or efficiency upgrade. Rather, they attempt to motivate customers to save energy, in general, and the actions taken as a result of these programs can vary dramatically from customer to customer.
- The use of information, namely energy use feedback, at varying levels of detail, to prompt a behavioral response.
- The use of social science theory-based tactics to prompt action, such as benchmarking, social norms, competition, and rewards (not directly linked to the price of efficiency).
- Finally, most programs are designed using an experimental or quasi-experimental approach in order to estimate net savings effects through bill impacts

The most noteworthy examples of these programs are mailed home energy reports that customers receive on a monthly, bi-monthly, or seasonal basis, in-home displays which are stand-alone devices that provide real-time feedback on a digital display, and online enabled feedback which uses a web-enabled platform to provide feedback to participants and allows them to set goals and often receive points toward same-as-cash rewards. These programs have increased in total investment and variety of program designs since the introduction of the first home energy report (HER) program implemented by the Sacramento Municipal Utility District (SMUD) in 2008. The SMUD HER program was the first program to demonstrate verified energy savings using feedback, benchmarking, and social norms drivers to prompt behavior change in the policy landscape that has relied almost exclusively on reducing the first and lifetime cost of energy efficient equipment as the mechanisms to prompt consumer action.

This paper refers *only* to CBPs that are integrated into energy efficiency program portfolios as a resource acquisition strategy, often implemented by utility and/or third party program administrators. CBPs are used to reduce both electric and gas consumption, but this paper focuses primarily on electric programs for the sake of clarity.

The Role of CBPs in US Portfolios

CBP efforts in the United States represent a significant portion of energy efficiency program portfolios, both from the perspective of program savings goals and spending. In 2013, across 111 tracked program administrators in 35 states, CBP programs exceeded $54 million USD in total allocated program budgets, accounted for 751 GWh of allocated first year savings in electric portfolios (approximately 5% of tracked first year savings), and represented over one third of all planned pilots (ESource DSM Insights: May 2014). While these numbers do not represent an exhaustive list of behavioral program portfolio plans, they speak to the dramatic increase in portfolio spending in the past five years nationwide, where only one known pilot was implemented with the specific goal of producing claimable savings from CBPs. Figure 1 (on the next page) illustrates CBP savings goals as a proportion of overall planned savings by state. The figure also illustrates the differences in planned savings by type of state goals (first year savings goals versus lifetime savings goals).

Notably, with few exceptions, US states with first year goals allocate significantly greater portions of their portfolio savings goals (and budgets) to CBP efforts. Relative to other program models, CBP efforts have a low cost to acquire savings in the first year due to their relatively low start-up costs compared to equipment, building envelope, and whole house based programs. In Table 1, the costs to save energy (CSE)[1] in the first year for behavioral feedback programs are compared to other commonly implemented residential programs in two regions: the Midwest and the Western United States. Notably, CBP efforts greatly surpass the first year CSE of other programs, coming in over 50% less per kWh than the nearest low-cost program (prescriptive rebates).

Table 1. Cost of Saved Energy by Program (example: Midwestern State and Western State)

Utility cost of saved energy	**$ per kWh**	
	Midwest	West
Behavior Change/Feedback	$0.04	$0.04
Building/Home Performance	$0.93	$0.74
Direct Install	$0.32	$0.29
Education/Awareness	$0.20	$0.27
Prescriptive Rebate	$0.10	$0.17

ESource DSM Insights, aggregated U.S. Program plans from public filings, sourced in May 2014.

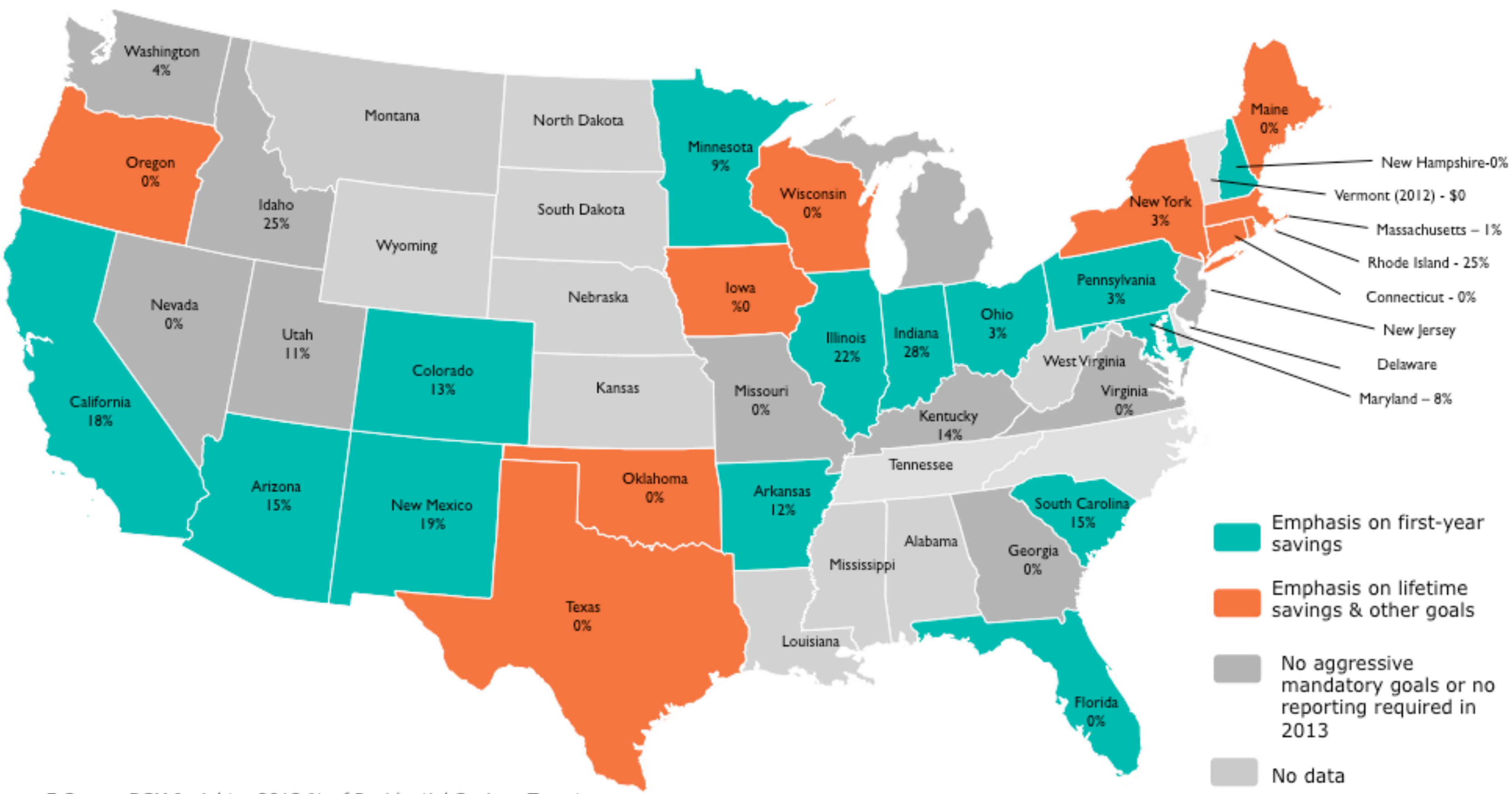
However, the measure life of CBP programs is unknown due to the variety of actions taken as a result of the program. For this reason, CBP programs can only claim savings for the duration of the treatment year, typically verified and measured through an ex-post evaluation on an annual basis. As a result, CBP's measure life assumption is one year, equal to the first-year savings.

Under this planning assumption, the levelized (lifetime) CSE for CBP efforts is not as impressive when compared to lifetime savings for equipment and envelope measures which have a relatively known measure life obtained through engineering and metering studies. Drawing on the recent work of Billingsley et al. (2014), CBP efforts are relatively expensive to acquire at 0.04 USD per kWh, with few residential programs at or exceeding that amount when considered in the context of lifetime savings.

Ultimately, the goal of energy efficiency programs is to reduce demand for energy resources in the long term as a reliable resource for system planning. Taking the CSE into consideration, alongside the growing allocation of portfolio dollars to these efforts, the following question needs to be asked: should CBP efforts play such a significant role in energy efficiency portfolios? In order to deepen and expand the role of CBP efforts, one must first take stock of what we know, and what we need to know, to better leverage CBPs in energy efficiency portfolios. The next section of this paper presents an overview of our knowledge to date based on evaluated CBP efforts.

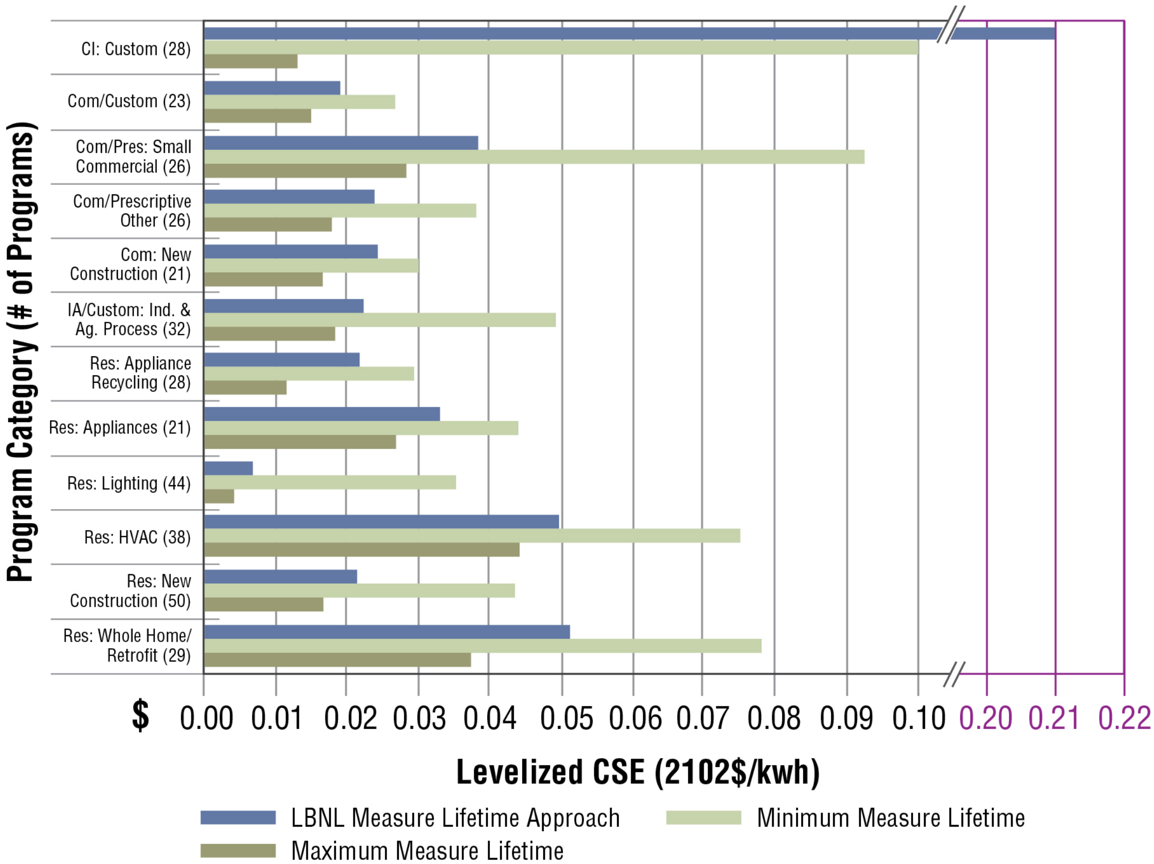
[1] The cost to save energy (CSE) is a simple metric to compare programs based on the overall cost of the program and it's achieved or planned savings. CSE is expressed as the dollars spent to acquire a kWh or therm.

Figure 1. Percent of Residential First Year Program Savings Targets by State (2013)



Source: E Source DSM Insights; 2013 % of Residential Savings Targets

Figure 2. Levelized Cost of Saved Energy by Program Type (Billingsley et al. 2014)



Overview of Existing Knowledge

While there are a number of evaluated CBP programs as a result of the recent dramatic increase in portfolio spending on CBPs, knowledge of CBP efforts is largely limited to two types of programs that have been rigorously evaluated using experimental and quasi-experimental approaches: Opt-out HER programs and Opt-in Online Feedback programs. Opt-out HER programs use monthly, bi-monthly, or seasonal reports to motivate customers to reduce their energy use. These reports are sent to an assigned segment of customers with high energy use often as part of a large-scale randomized control trial (RCT). In most cases, the program is implemented indefinitely, with minor variations in the frequency of reports over time, and evaluated on an annual basis by comparing differences in bill impacts between the treatment and control group. Opt-in online feedback programs use mass communications and outreach to drive customers to a website where customers can view their usage at will. Often, customers have the option to review email reports as part of a core set of features. Opt-out programs are the most widely adopted model in terms of utility contracts, particularly in the form of HERs. However, the Opt-in models have the greatest diversity of programs designs and represent the greatest number of program types.

To date, HER programs have been the most rigorously evaluated as the longest standing and most widely adopted program model in the US. Of all CBP efforts, the majority of rigorous evaluations focus on HERs using an RCT design, and most evaluations of HER focus on verifying claimed savings at the close of each program year. Table 2 below is an illustrative account of studies conducted to date, based on the authors' on-going review of evaluation literatures.

Table 2. Amount of Information for Key Planning Questions by Program Type

Key Planning Questions	HER Opt-Out	Online Feedback Opt-in	Amount of Information Legend
How do savings vary by program type (opt-in vs. opt-out)?	✔ due to the absence of systematic comparative analysis between models in the energy context		✔✔✔✔ = Substantial information
How are savings generated and from which end use?	✔✔✔	✔✔	✔✔✔ = Moderate information
How long will savings persist?	✔✔	✔	✔✔ = Some information
How do savings vary by participant type?	✔	✔	✔ = Limited information

Few studies, across both program models, have sought to answer important planning-related questions, such as "how do savings vary by program (or treatment) type?" and "How do savings vary by participant type?" Select program administrators have commissioned more extensive studies aiming to address these questions, with the greatest level of exploratory research focused on HER efforts. These include the work of SMUD, Puget Sound Energy (PSE), National Grid, and Pacific Gas and Electric (PG&E). The findings from these key studies, among others, are discussed throughout this paper as each of the following questions are addressed:

- How do savings vary based on program design strategies, such as frequency of engagement, etc?
- How are savings generated and from which end use?
- How do savings vary by participant type?
- How long will savings persist?

How do savings vary by program type and how long will savings persist?

As noted earlier, there are two primary CBP models that are widely funded in the United States: opt-out HER programs and opt-in online feedback programs. Per household savings are slightly greater in opt-in online feedback efforts relative to the HER opt-out models. However, opt-out HER programs have greater overall reach and tend to garner more overall savings due to the number of "participants" treated with the reports over time.

Table 3 below provides a summary of the savings as a percent of total electric household energy use, comparing the savings from opt-in versus opt-out programs. Notably, the opt-out models treat a single group of customers over time with limited amounts of attrition due to customers' opting out or relocating. In contrast, opt-in programs treat a changing group of customers, where participants matriculate into the program over time.

Notably, both program models generate persistent savings with continued treatment, with measured savings for up to five years in some cases, with no clear indication that savings gains are waning over time.

Table 3. Example Programs by Treatment Type (Opt-Out Paper Reports versus Opt-in Digital Online Programs) (SMUD, 2012) (National Grid, 2013) (ComEd, 2014) (MyMeter, 2014)

	Savings by Program Year per Household				
Program Administrator and Program Cohort	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Paper Opt-out Programs					
SMUD HER (2008 cohort)	1.8%	2.4%	2.4%	2.1%	NA
National Grid HER (2009 cohort)	1.6%	2.1%	2.2%	NA	NA
Online Opt-in Programs					
ComEd C3 Program	4.4%	3.8%			
Lake Region MyMeter*	2.6%	2.6%	2.6%		
Wright Hennepin MyMeter*	2.2%	2.2%	2.2%	2.2%	2.2%

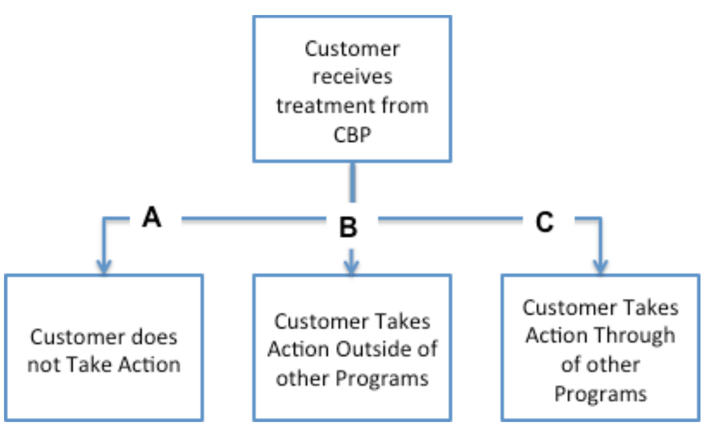
*Estimated average year-over-year savings with treatment over time based on savings across the treatment period.

How are savings generated and from which end use?

Figure 3 below is an illustrative diagram used to convey the paths through which customers may choose to save energy based on CBP treatment. As information-driven programs, CBPs have the ability to influence action through encouraging participants to participate in other programs (C) or taking action outside of programs (B); as shown in Figure 3, actions taken through Path B can include both conservation actions and energy efficiency actions.

To date, most research examining the source of CBP savings comes from opt-out home energy report (HER) program efforts. Evidence across multiple studies has confirmed that the great majority of CBP program savings are achieved through Path B, direct action outside of other programs, with the savings sources weighted toward conservation-focused behavior changes vs. energy efficient installations or changes to the building envelope.

Figure 3. Simplified Demonstration of Paths to Energy Savings Via CBP programs (Goldman and Dougherty 2014)



Based on a recent survey-based engineering analysis conducted for SMUD, approximately 60% of the savings obtained through SMUD's HER program was derived from conservation actions (SMUD, 2013). Of conservation actions, the majority of savings was comprised of the following frequently reported changes in behavior: thermostat adjustments, cleaning out clothes dryers, lighting only in areas that are occupied, using full loads of laundry, and using the sun for passive heating. Notably, another recent study suggested that the majority of savings from HERs may be due to changes in thermostat settings (Todd et al. 2014). The remaining 40% of measure-based savings included switching to compact florescent lighting (CFL) and upgrading appliances to energy-efficient models.

That said, there are a number of unanswered questions that currently prevent policy makers and program planners from allowing a multi-year measure life, including the following: (1) What proportion of measure-based savings come from short-term measures (such as lighting) versus long-term measures (such as building upgrades)? (2) What proportion of the savings associated with conservation behaviors is habituated and expected to persist? and (3) When were these savings acquired during the implementation of the program (such as program year one versus program year three) and how does one account for this variation in actions taken over time?

Current metering data infrastructure and data analysis technologies are insufficient to effectively answer these questions. However, with advances in meter data disaggregation technologies that can detect changes in load at the appliance level combined with advances in machine learning technologies, one can expect to be able to more effectively answer these questions within the next five years. Until that time, it is unclear whether an extended measure life will be adopted for CBP programs

How do savings vary by type of participant?

Of all research questions outlined in Table 3, the least research has been conducted to assess the impacts of CBPs on different segments of the population. This is due, in large part, to the way CBP programs are designed. At present, most programs target high usage customers to achieve the greatest absolute savings from their efforts. As a result, most studies to date have confirmed what is already known about CBP efforts and confirmed in design strategies: customers with higher usage will achieve greater savings. Simply put, a customer who uses 50 kWh per day is going to save more kWh with a 2% reduction in usage compared to a customer who uses 30 kWh per day. No studies identified by the authors have thoroughly examined how differences in income, education, ethnicity, region, and age affect CBP savings while controlling for usage. This is a much-needed area of research and will require a commitment to additional experimentation among program administrators.

Discussion: The Current and Future Role of Behavior Programs

To date, the great majority of evaluative research has focused on the question "Do behavioral programs save energy?" and to a lesser extent on the question "How do behavior programs work to save energy?" However, given the sharp increase in portfolio spending in this category and the implications for resource planning, it is vital that one step back at this point and discuss a more pertinent question: How should CBP efforts be utilized to support energy efficiency portfolios? Key considerations when attempting to answer this question include:

- Should behavioral feedback be treated as a unique resource or as portfolio "support" to more traditional equipment based programs?

- If a unique resource, what is the ideal proportion of the portfolio that should be devoted to these programs?

These questions are discussed in the following section of the paper.

Should behavioral efficiency programs be treated as a unique resource or support to other program portfolios?

CBPs have emerged coincident with a number of troubling trends in energy efficiency portfolio performance among US program administrators. After peak year-over-year spending in 2007, which saw an increase in energy efficiency spending of 25% over 2006, year-over-year investment in energy efficiency began to slow to roughly 7% year-over-year investment in 2012 (EIA 2013). Simultaneously, program portfolios are struggling to meet targeted goals. Table 5 illustrates significant changes in performance from 2010 to 2012, as portfolios struggle to meet their goals within budget.

Table 4. Summary of U.S. Energy Efficiency Program Portfolio Performance (Residential and Commercial) across 111 Program Administrators

Year	Percent of Portfolios that Exceeded Savings Goals as Compared to Plans	Percent of Portfolios that Overspent as Compared to Plans
2010	62%	13%
2012	52%	31%

ESource DSM Insights, aggregated U.S. Program plans from public filings.

Many attribute this waning performance to the residential sector, which has experienced dramatic changes in market baselines among lighting-focused programs and increasingly high CSE for emerging program models, such as home retrofits and whole-house initiatives. In many ways, CBPs have stepped in to replace lighting as a source for cheap and easy savings.

While previously cited research suggests that the great majority of CBP savings are behavioral in nature (60%), a relatively large proportion of savings is associated with direct measure installations outside of other programs. This is due, in part, to program design. Few CBPs actively promote other energy efficiency programs such as rebates or whole house initiatives for fear of losing those savings upon evaluation where evaluators discount effects through other programs (see Todd et al. 2012 and Goldman and Dougherty 2014).

While obtaining unique savings is critical to CBPs' continued success, evaluation evidence suggests that CBPs have the potential to support struggling portfolios by driving greater savings through installed measures. Table 6 illustrates the savings obtained through CBPs based on four different evaluation studies. Looking across the results, CBPs have demonstrated savings through other programs with known persistence levels. Notably, these cross-program savings were achieved under circumstances in which the CBP program administrators are penalized, rather than incented, to promote other programs in the energy efficiency portfolio.

Table 5. Example Results of CBP Cross-Program Savings as Reported in Five Program Evaluations (PG&E 2013; PSE 2013; SMUD 2012; National Grid 2013)

Electric Feedback Program Examples		**Estimated Savings via Other Programs**	
Program	**Cohort Year**	**Total Savings (kWh)**	**Percent of HER Savings**
Upstream			
Pacific Gas and Electric HER	All cohorts	6,600,000	11.6%*
Puget Sound Energy HER	2012 cohort	97,730	1.8%**
Downstream			
Pacific Gas and Electric HER	All cohorts	230,317	0.4%
Puget Sound Energy HER	2012	3,554	0.1%
SMUD HER	2008 & 2010	910,594	33%
National Grid HER	2009-2012	5,298,000	2.0%

*Reported effects from onsite verification, not statistically significant. **Reported effects from end user survey

In order to move towards a portfolio versus program mindset for CBP efforts, it is important that policy makers and program administrators develop incentive mechanisms that design rewards based on gains in overall portfolio performance versus individual program outcomes. This approach would require a shift in program planning, evaluation, and policy to focus on cost-effective energy saving portfolios or measure “bundles” rather than aiming to achieve cost-effective savings for specific measures or programs. Importantly, evaluations would need to shift their focus to top-down examinations of energy efficiency and market performance, rather than the bottom-up, program-by-program evaluations that characterize the vast majority of evaluations in the United States.

If a unique resource, what is the ideal proportion of the portfolio of programs that should be devoted to these programs?

This question raises more questions than answers. When accounting for first-year goals, CBP efforts are gaining an increasing share of residential portfolio plans. Looking at Massachusetts alone, the US’s largest per capita spender in energy efficiency programs, CBP program efforts have increased as a proportion of the residential portfolio goal. At National Grid, the state’s largest program administrator, the annual percent of savings goal on residential CBP is targeted at 53% of the portfolio in 2015.

Table 6. Example Allocation of Electric Portfolio Goals on Residential CBPs in Massachusetts (Annual vs. Lifetime Goals) (Dougherty and Schlegel 2014)

Electric Program	Plan Year	Annual Savings (% of Portfolio)	Lifetime Savings (% of Portfolio)
National Grid	2012	41%	8%
	2013	38%	7%
	2014	49%	11%
	2015	53%	12%
NSTAR	2012	7%	1%
	2013	22%	4%
	2014	25%	4%
	2015	26%	4%
WMECO	2012	23%	3%
	2013	27%	5%
	2014	33%	6%
	2015	36%	7%
Cape Light Compact	2013	1%	0%
	2014	3%	0%
	2015	4%	0%

While this increase in CBP spending is a promising step toward recognizing alternative mechanisms to foster energy efficiency changes, the lack of reliable and transparent information on the source of the savings, and the associated measure life of CBPs, makes it difficult to determine when CBP efforts should be capped to ensure that portfolios are achieving long-term savings. However, if we look to lighting as an example of how quickly markets change in response to programs, we should take the long view and assume that we may not get continued performance at current levels from CBP programs without a clear strategy for how to utilize these programs. Further, there are indications that regulators' willingness to support CBP efforts, as currently designed, may be weakening over concerns that the planners are over-relying on CBP efforts to meet energy efficiency goals. The state of Minnesota's Average Savings Method (Minnesota Department of Commerce, 2013) policy is a clear example of these concerns, where savings are divided by three and applied across three years in order to create a disincentive to use CBPs as a cheap program strategy to meet first year goals in the state. While there is no clear answer to this question, evaluators, planners, and policy makers need to be proactive in answering these questions and developing longer term strategies for CBPs lest we find portfolios more vulnerable to shifts in political will and market effects.

How can we improve evaluation to support planning?

Currently, evaluation research is largely confirmatory; the primary goal of evaluation is to confirm or deny whether a program has reached its savings targets and whether its program processes are designed to do so. With this as its first mandate, little funding is allocated to determining how program savings are obtained and whether program savings might change under varying social and market circumstances.

Experimentation is critical to testing program impacts under varying social, market, and design scenarios. However, there has been little investment in true experimentation to support program design and planning goals. In order to answer many of these questions with the level of rigor needed to persuade planners and regulators, program implementers and other stakeholders interested in improving our knowledge base have to commit to investing in exploratory research.

Recommendations

Evaluations are necessarily focused on quantifying the energy impacts of CBP efforts and answer key process-related questions. However, given the relatively low cost of CBP programs and the way evaluation funds are allocated (roughly 5-7% of the program budget), there is little funding to address key policy-related questions. The authors recommend the following research efforts to support planning efforts for CBP programs in addition to traditional impact evaluation research:

Recommendation 1. Continue to invest in, and increase investment in, planning-focused research on CBP efforts including on-going persistence analyses and studies focused on establishing a more appropriate measure life for CBP efforts. As we noted earlier, there are a few studies to date that have explored the persistence of CBP efforts without treatment. Such studies are conducted jurisdiction-by-jurisdiction and program-by-program. To more adequately answer this question, a cross-program meta-analysis study should be considered in order to develop a measure life that can be reasonably applied to this class of programs.

Recommendation 2. Carefully examine the source of CBP efforts through longitudinal smart meter data analyses at the premise level utilizing appliance-level disaggregation analyses. Such technologies are available for major end use analysis and may prove to be an impactful analysis tool to directly identify the source of savings associated with CBP efforts, rather than impute a savings.

Recommendation 3. Foster policy environments that promote field experimentation. Such environments should be used to determine how to garner the greatest savings from CBP efforts across the population and within the portfolio. Specifically, these experiments should focus on CBP experiments aimed at examining the potential impacts of CBPs on the overall energy efficiency portfolio if they are better utilized to actively promote and support non-CBP programs efforts. In addition, experiments should be conducted to assess how to achieve savings across different target populations, including the potential to achieve savings in lower-usage household.

Recommendation 4. Conduct portfolio savings forecast simulations to examine the impact of CBP efforts on reliable, long-term savings under varying savings assumptions, including: (1) low, medium, and high levels of measure installations as a result of CBPs and resulting persistence outcomes, and (2) varying levels of portfolio investment in CBP efforts. Using this work, policy makers and planners can better understand the potential of CBP efforts and their impact on program portfolios under varying performance and spending scenarios.

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