Behavioral Programs Come of Age: Analyzing the Savings from Recent Home Energy Report Program Studies

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ABSTRACT

Behavioral energy efficiency (BEE) programs have now been in market for over a decade. Once thought of as a new, uncertain, and relatively small portion of utility efficiency savings, BEE has become the one of the more significant drivers of cost-effective savings for the country's largest efficiency portfolios. At the same time, regulators across the country are re-evaluating how energy efficiency goals should be set to reflect this important resource's role, as a complement to supply-side investments in efforts to decarbonize the utility sector. Given the ongoing role of behavior programs in energy efficiency portfolios, this paper will take a retrospective view of BEE programs to assess what we have learned about encouraging residential customers to make changes through a comprehensive review of home energy reports (HERs). We explore energy savings of HER programs to understand overall impacts and influencing factors such as cohort maturity, HERs components, and distribution methods. The paper will discuss the implications for the future of reporting for these types of behavior-based energy efficiency programs.

Introduction

While only one of many program designs under the broad umbrella of behavioral energy efficiency (BEE) programs, in the past decade home energy reports (HERs) have become the primary residential BEE program in energy efficiency portfolios. HER programs focus on reducing the demand for energy in the residential sector and have a consistent history of savings as well as cost-effectiveness over time (Allcott and Rogers 2014). A recent study by the Brattle Group and Oracle Utilities found that residential demand-side programs could nearly double the amount of avoided greenhouse gas (GHG) emissions that existing supply-side clean energy policies would have on their own. Moreover, while supply-side clean energy policies can take years or decades to realize these GHG reductions, demand-side program offerings like HERs can be deployed rapidly to achieve decarbonization gains more quickly (Sergici et al. 2021).

HERs have historically been distributed via mail as a single page, double-sided report that includes some or all of the following components: similar-home comparison, feedback indicators of this comparison, historical use data, tips to lower home energy use by way of structural modifications or behavioral changes that reduce electricity or natural gas usage, and promotion of energy efficiency programs and rebates offered by the customer's utility.

HERs apply the behavioral science principle that people will change their behavior in response to normative information and feedback. Descriptive norms refer to behaviors that others commonly do while injunctive norms depict what others commonly approve or disapprove of. Behavioral science research shows that both descriptive and injunctive norms influence behavior, including behaviors to protect the natural environment (Smith et al. 2012). People tend to behave as they believe others do. For example, research has shown that simple changes to the

language of public service signs, reflecting descriptive norms, can dramatically increase compliance with environmental goals (Goldstein, Cialdini, and Griskevicius 2008).

Energy utility HERs programs often apply these behavioral science findings by providing information to their customers about how similar households are using energy. The goal is to encourage energy-saving behavior by making energy use descriptive norms more visible and salient. Broadly speaking, the logic of HERs programs relies on behavioral science research showing that when customers receive positive feedback about their home energy use compared to other homes, they will be motivated to maintain their lower energy use. Similarly, households who receive feedback that they are using more energy than similar neighbors will be motivated to reduce their energy use (Allcott and Rogers 2012).

HER programs employ a variety of delivery mechanisms to reach utility customers. Some HER programs deliver feedback via email in place of, or in addition to, paper reports. Other HER programs have started branching into new channels like video. Most programs use an opt-out experimental design by randomly selecting a treatment and control group from a screened group of eligible residential customers. Treatment group customers automatically receive the HER monthly, bi-monthly, quarterly, or on another cadence, while the control group customers do not receive reports. Groups assigned by this randomized controlled trial (RCT) at a point in time are a "cohort." Program implementers and evaluators measure the impact the reports have on energy use by comparing the pattern in energy consumption between the treatment and control groups in a cohort from a pre-intervention period to the treatment period.

HERs programs with experimental designs differ from other programs in that most eligible residential customers can be included in the intervention without taking action. Treatment customers may opt-out if they do not want to receive the report. Consequently, even uninterested participants will, at least initially, receive the treatment. The RCT design reduces the effect of other biases such as self-selection and free-ridership and ensures the treatment and control groups are statistically equivalent. As such, measured differences in energy usage or other program participation uplift can be inferred to be caused by receiving the HERs. The Uniform Methods Project (UMP) Residential Behavior Protocol identifies the RCT approach as the "gold standard" for residential behavior programs (Kurnik et al 2018).

These programs have been extensively researched and evaluated, and are among the most rigorously tested energy efficiency program models (Ashby et al. 2017). Previous analyses have shown that behavioral savings can persist over time, with the greatest interval of impact being within the first two years of receiving HERs. However, there is variation in these longitudinal studies, and they are often limited in scale, either to the level of program implementer or to certain geographic regions.

Despite the well-documented success of HER programs, utility program administrators often ask – do they still work? To what extent has the success of HERs been attributable to their novelty? Have ever-increasing bids for our attention by products and marketing dampened the ability of HERs to break through customers' attentional barriers and influence their behaviors? The goal of this meta-analysis was to examine the question: How have HER programs performed in recent years, and are they still working? This paper will examine this question by first describing the research methods used, followed by a summary of the results, and concludes with a brief discussion of the implications.

Methods

Document Search

To conduct a comprehensive meta-analysis, we searched for research and evaluation reports for HER programs in the US. We identified studies through direct requests to vendors, utility web sites, state-level evaluation repositories, and internet searches. For our search, we looked exclusively for documents from the body of "grey literature" - documents found outside of peer reviewed journals. We included a total of 111 reports in our screening for inclusion in the analysis. We entered several search terms into the Google search engine including "home energy reports," "behavior-based energy efficiency," and "energy efficiency evaluation reports," to find publicly available reports. We also searched for specific HER program implementers after doing a brief market scan to identify current HER program implementers, as well as any implementers who have been purchased by others (e.g., "Tendril"). This list of search terms included "Bidgely," "DNV-GL," "Franklin," "Opower," "Oracle," "Tendril," and "Uplight." We downloaded and screened every relevant evaluation or study document from the first three pages of results from these searches.

Screening Criteria

We screened the 111 documents and excluded documents if:
(1) Findings were for 2017 operations or earlier.
(2) Did not report "unadjusted" savings.
(3) Did not report the inclusion of a control group in its program design.
(4) Did not report the number of participants in the treatment group.

In addition to these document-level exclusion criteria, we excluded study cohorts if:
(1) They had been receiving HERs for less than one year.
(2) No dispersion statistics were reported (standard deviation, standard error, or confidence intervals).
(3) They had been receiving HERs for six years or more.

Of the 111 documents collected, 85 documents were completely excluded, and 19 documents had some cohorts removed from the analysis. We show the full down-selection process in Figure 1. Preliminary evaluation of the excluded documents showed that the most prominent reasons for exclusion included too high a cohort maturity (n=79 cohorts); missing unadjusted savings (n=62); lacking or unspecified control group (n=35); and insufficient additional detail about the study and methods such as missing participant counts, unclear wave start-date, and unspecified experiment type.
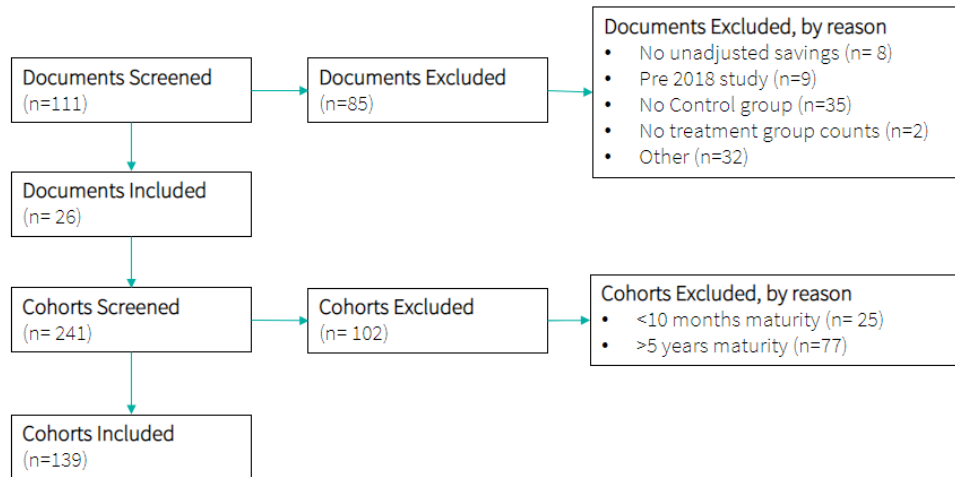
Figure 1. Document and cohort screening steps with reasons for exclusion.

The remaining 26 documents which made it through this screening process by meeting all inclusion criteria cover 241 cohorts. Of these cohorts, we excluded 102 due to having fewer than 10 months of program treatment, or more than 5 years of treatment, leaving 139 cohorts for the meta-analysis.

RESULTS

As the methods for savings uplift adjustment varies considerably among utilities, this analysis used unadjusted savings values (savings that had not been adjusted for uplift). Additionally, as many studies did not report savings at the household level, electric savings were normalized to the household level by dividing the reported estimated savings by the reported size of the treatment group. We acknowledge that this is an imperfect method, as treatment group sizes can vary throughout the year and the reporting of treatment group sizes (i.e., whether the treatment group size is calculated at the beginning of the program year or at another point in the year) varies across evaluations.

The analysis shows that savings from recently studied HER programs remain comparable to earlier studies, which have shown one to two percent annual savings from HER programs (Ayres, Raseman and Shih 2013). Savings from these programs have a moderately strong positive relationship with cohort maturity, indicating that the impacts of HER programs increase as customers are exposed to more reports over time. Savings vary considerably between HER vendors, between HERs that include personalized tips and those that do not, and between HER programs that include emailed reports (eHERs) and those that do not. The findings suggest that HER programs that include personalized tips may provide more electric savings than those that do not, and that HER programs that include emailed reports provide more electric savings than those that do not. These findings are not conclusive, however, due to inconsistencies in reporting between studies.

Inconsistencies in Reporting Format

In our analysis, we noted that there are several inconsistencies in HER program reporting formats across the evaluations we analyzed. The primary inconsistencies we noted are:

(1) We noticed a wide variety of naming conventions for savings values. Some evaluations reported unadjusted savings as both "net" and "gross" savings, while others noted that due to the nature of an RCT design, all savings are "net" savings. There were also a variety of names used to indicate implementer savings, evaluator-verified savings, unadjusted savings, and adjusted savings. Some of these included Relative Savings, Measured Savings, Verified Savings, Net Savings Prior to Uplift, and Savings w/ Double Counting.

(2) We found variation in reporting of standard deviation, error, and confidence interval bounds. Many evaluations reported these values for only one savings value, which could be either total savings, per household savings, or percent savings.

(3) Some evaluations report one value for participant counts for each cohort. Other evaluations give greater detail, reporting participant counts for the time when the cohort began and the count at the start of the program year.

(4) Even when providing participant counts for each cohort, some evaluations provide savings values at the cohort level and some at the program level.

(5) Some evaluations give a detailed explanation of the HERs format, detailing for each cohort whether it was printed, emailed, or both. Other evaluations may instead be vague or even omit reporting the report format.

(6) Some evaluations provide savings values for each cohort by quarter or month instead of by year.

Overall Savings by Cohort

On average, cohorts saved 88 kWh annually per household and 4.4 Thm for those using gas. Electric cohorts saved an average of 1.16% of consumption while gas cohorts saved an average of 0.87%. The average unadjusted per-household annual electric savings by cohort ranges from 19 to 464 kWh, with a weighted mean value of 88 kWh. The average unadjusted per-household annual gas savings by cohort ranges from 0.9 to 12.3 Thm, with a weighted mean value of 4.4 Thm. The unadjusted percent electric consumption saved by cohort ranges from 0.6% to 1.7%, with a weighted mean savings value of 1.16%. The unadjusted percent gas consumption saved by cohort ranges from 0.3% to 1.7%, with a weighted mean savings of 0.87%.

Savings can vary by vendor for a variety of reasons, including the types of components included in the reports, the content and visual characteristics of those components, the quality of the data and the algorithms used to make comparisons, and the energy saving behaviors recommended to customers. The average unadjusted electric per-household annual savings from HERs programs included in the study range from 71 to 92 kWh (Figure 2). Comparing the weighted average annual electric savings per household across program vendors shows that customers receiving Vendor 1 HERs save an average of 92 kWh, recipients of Vendor 2 HERs save 87 kWh, Vendor 3 HERs save 85 kWh, and Vendor 4 HERs recipients save 71 kWh. The electric savings for Vendor 3 have the greatest margin of error, while Vendor 1 has the smallest margin of error. This marked difference in precision is primarily due to the much larger number of Vendor 1 cohorts included in the study compared with other vendors.

The average unadjusted electric savings for Vendor 1 cohorts range from 22 to 464 kWh, with a weighted mean savings of 92 kWh. Vendor 2 cohort electric savings range between 84 and 90 kWh, with a weighted mean of 87 kWh. Savings from Vendor 3 cohorts range from 19 to 196 kWh, with a weighted mean savings of 85 kWh. Electric savings for Vendor 4 cohorts ranges from 27 to 98 kWh, with a weighted mean savings of 71 kWh.
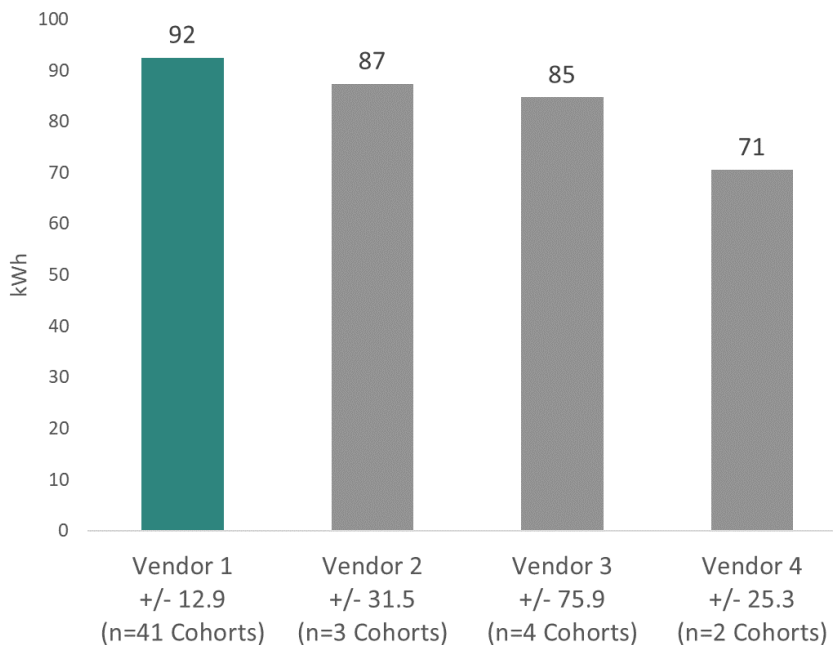

Figure 2. Average Annual Household Electric Savings by Vendor - Weighted by Estimate Precision

Only Vendor 1 reported gas savings with confidence intervals or measures of disperson. The unadjusted Gas savings for Vendor 1 cohorts ranges from 0.92 to 12.32 Thm per household, with a weighted mean savings of 4.4 Thm.

The percent annual electric savings for each cohort were included in the analysis if a study either reported this value directly or if the study provided baseline annual energy consumption for a cohort. If a study provided baseline annual energy consumption, percent savings were calculated as the proportion of baseline energy consumption that was saved by the program. A weighted average of unadjusted electric savings by vendor (Figure 3) shows higher average savings for Vendor 1 cohorts (1.18%) than other vendors (0.84%). The unadjusted total percent gas savings for all Vendor 1 cohorts is 0.88% and is 0.54% for Vendor 3.

The unadjusted percent total annual electric savings for Vendor 1 cohorts ranges between 0.6% and 1.73%, with a weighted mean percent savings value of 1.18%. The unadjusted percent total annual electric savings for Vendor 2 cohorts ranges from 0.74% to 0.97%, with a weighted mean percent electric savings of 0.84%.
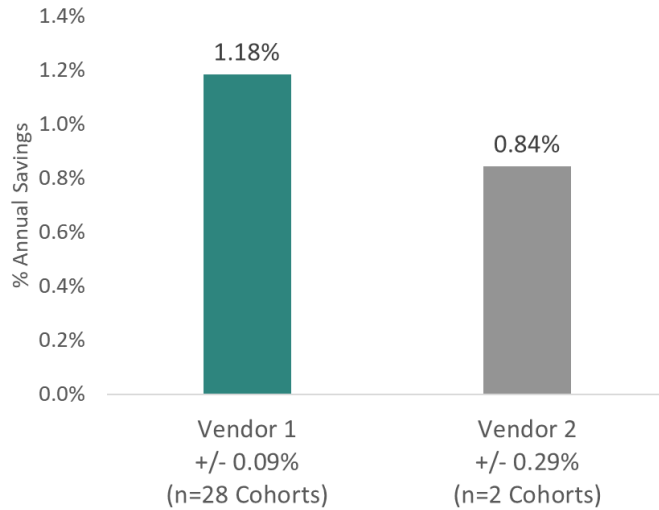

Figure 3. Average Unadjusted % Annual Electric Savings by Vendor - Weighted by Estimate Precision

Only one non-Vendor 1 cohort met the inclusion criteria to be analyzed for unadjusted percent total gas annual savings. The single cohort from Vendor 2 achieved 0.54% total annual gas savings with a margin of error of plus-or-minus 0.62%. The unadjusted percent total annual gas savings Vendor 1 cohorts ranges between 0.30% and 1.70%, with a weighted mean percent gas savings of 0.88%.
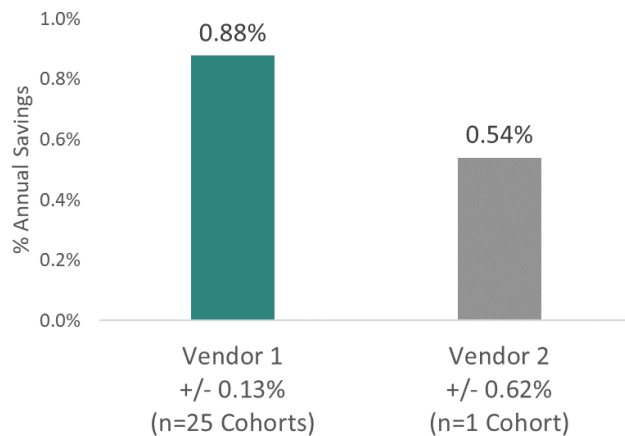

Figure 4. Average Unadjusted % Annual Gas Savings by Vendor – Weighted by Estimate Precision

Percent Program Savings Goal Achieved

A variety of factors influence program goals, including negotiations with local commissions, previous years' performance, and available budgets. Therefore, comparisons between vendors in terms of the proportion of program savings goals should be interpreted with caution.

Any study was included in this analysis, even if it did not meet the criteria described in the methodology discussion. A study's inclusion in this analysis was based solely on whether it included the relevant savings metric (electric, demand, or gas savings) and whether it documented a goal for that metric. Only one study was included for each unique combination of program year and utility.

Vendor 1 programs achieved the greatest proportion of electric savings goals among vendors, saving an average of 119% of program goals, with goal achievement ranging from 81% to 178% across ten studies. The single study of Vendor 5 programs showed 86% of program goals achieved. Vendor 6 programs saved an average of 84% of program goals, with goal achievement ranging from 43% to 111% across five studies. The single study of Vendor 4 programs showed 78% of program goals achieved. Vendor 3 programs saved an average of 72% of program goals, with goal achievement ranging from 5% to 108% across 8 studies. Vendor 2 programs saved an average of 49% of program goals, with goal achievement ranging from 5% to 120% across eleven studies. The single study of Vendor 7 programs showed 32% of program goals achieved.
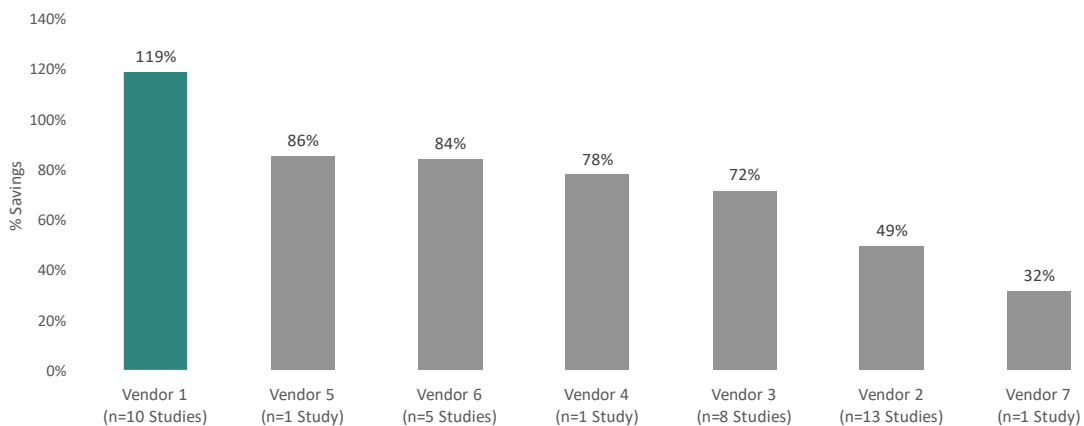

Figure 5. Average % Annual Electric Savings Goal Achieved by Vendor

Vendor 1 programs also achieved the greatest proportion of electric demand savings goals among vendors, saving an average of 138% of program electric demand goals, with goal achievement ranging from 89% to 328% across six studies. Vendor 6 programs achieved an average of 127% of program goals, with goal achievement ranging from 99% to 155% across two studies. The single study of Vendor 4 programs showed 78% of program goals achieved. Vendor 2 programs saved an average of 46% of program goals, with goal achievement ranging from 17% to 107% across five studies. The single study of Vendor 7 programs showed 31% of program goals achieved.
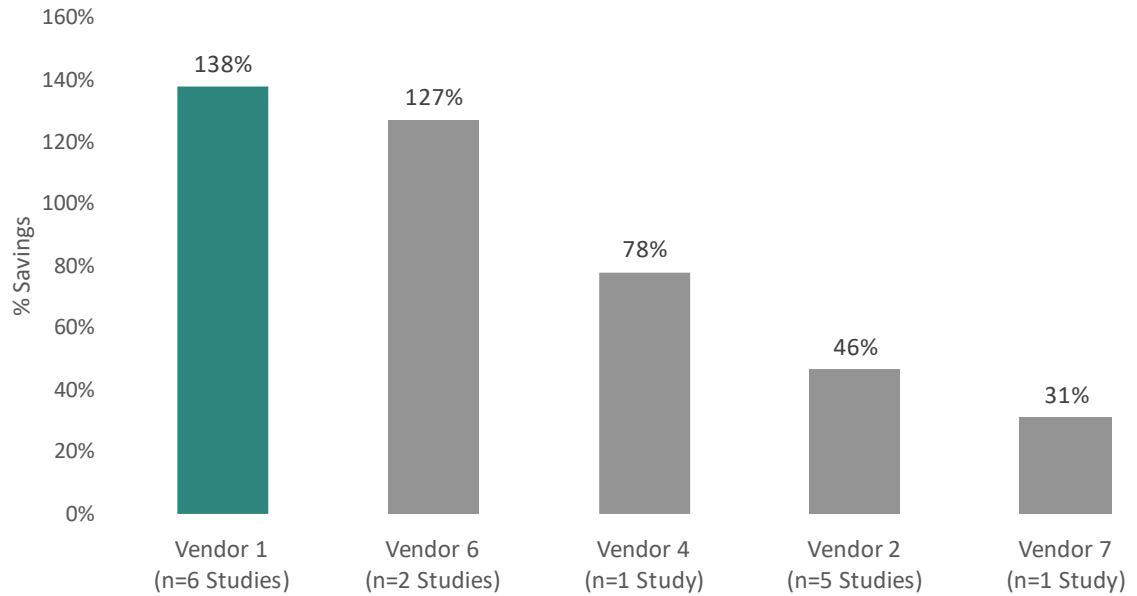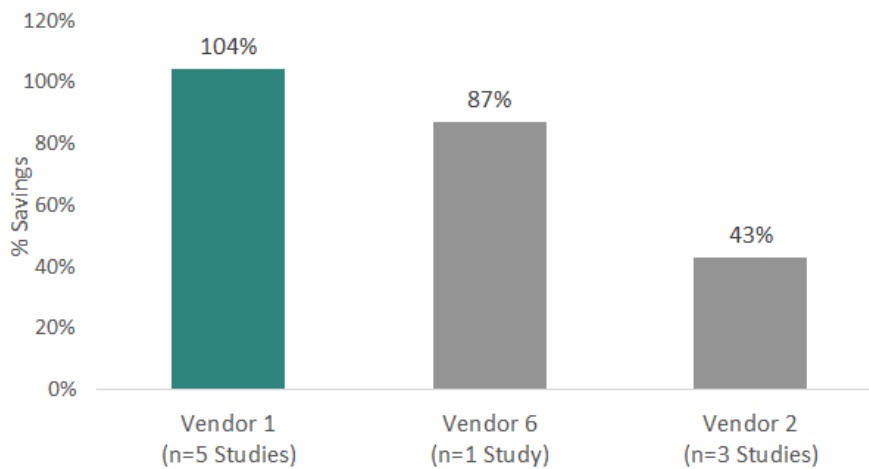
Figure 6. Average % Annual Electric Demand Savings Goal Achieved by Vendor

Vendor 1 programs also achieved the greatest proportion of gas savings goals among vendors, saving an average of 104% of program gas savings goals, with goal achievement ranging from 46% to 156% across studies. The single study of Vendor 6 programs showed 87% of program goals achieved. Vendor 2 programs saved an average of 43% of program gas goals, with goal achievement ranging from 6% to 88% across studies.

Figure 7. Average % Annual Gas Savings Goal Achieved by Vendor

Annual Household Energy Savings by Cohort Maturity

        Cohorts with two to five years of program maturity saved more than twice as much annual electricity consumption (101 kWh) than for cohorts with a maturity of one year (35 kWh). The average unadjusted per-household annual electric consumption saved for cohorts whose maturity is one-year ranges from 19 to 71 kWh. The average unadjusted per-household electric consumption saved for cohorts with two to five years of maturity range between 28 and 464 kWh, with a weighted mean savings value of 101 kWh.

        Cohorts with a maturity of two to five years have higher unadjusted annual percent electric savings (1.21%) than cohorts with a maturity of one year (0.66%). The unadjusted percent total annual electric savings for cohorts with a one-year maturity ranges between 0.6% and 0.7%, with a weighted mean percent savings of 0.66%. The unadjusted percent total annual electric savings for cohorts with a maturity of two to three years ranges between 0.7% and 1.73%. There was a moderately strong positive correlation between the number of years a cohort had received HERs and the annual household electric savings (r=.48). As shown in Figure 9, there is also a small positive relationship (r=.19) between cohort maturity and annual household gas savings.
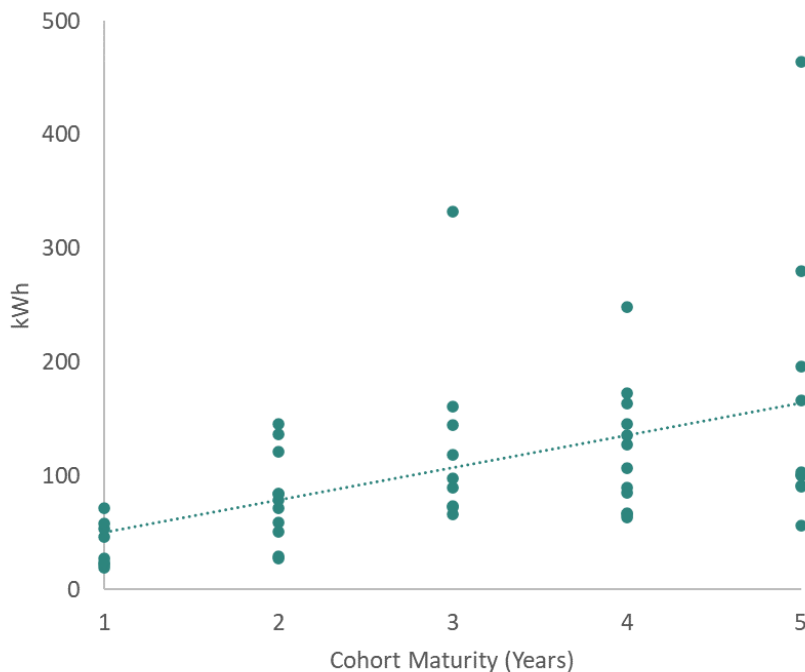

Figure 8. Unadjusted Annual Household Electric Savings by Cohort Maturity.
(n=50 cohorts; Pearson's r=.48)
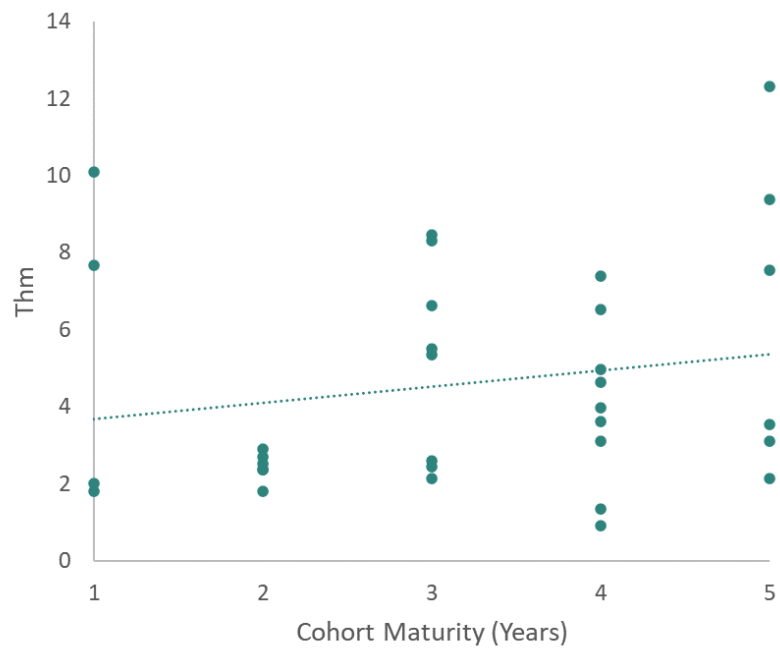
Figure 9. Unadjusted Annual Household Gas Savings by Cohort Maturity.
(n=33 cohorts; Pearson's r=.19)

Savings by Distribution Mode

Very few studies reported whether each cohort received paper HERs only or electronic HERs (eHERs) only, though studies that report both paper and email distribution modes are more common for all metrics except percent of gas consumption saved. Programs that sent paper HERs exclusively or a combination of paper and email HERs saved more gas and electricity than those that sent eHERs exclusively.

The few cohorts that we could confirm received paper HERs only saved more annual household electricity consumption (118.3 kWh) than cohorts that received both paper and emailed reports (113.8 kWh) and cohorts who received only eHERs (53.8 kWh). Cohorts that received only paper HERs saved between 90 and 145 annual household kWh. Cohorts that received both paper and email reports saved between 22 kWh and 464 kWh. Cohorts who received only eHERs saved between 27 to 67 kWh.
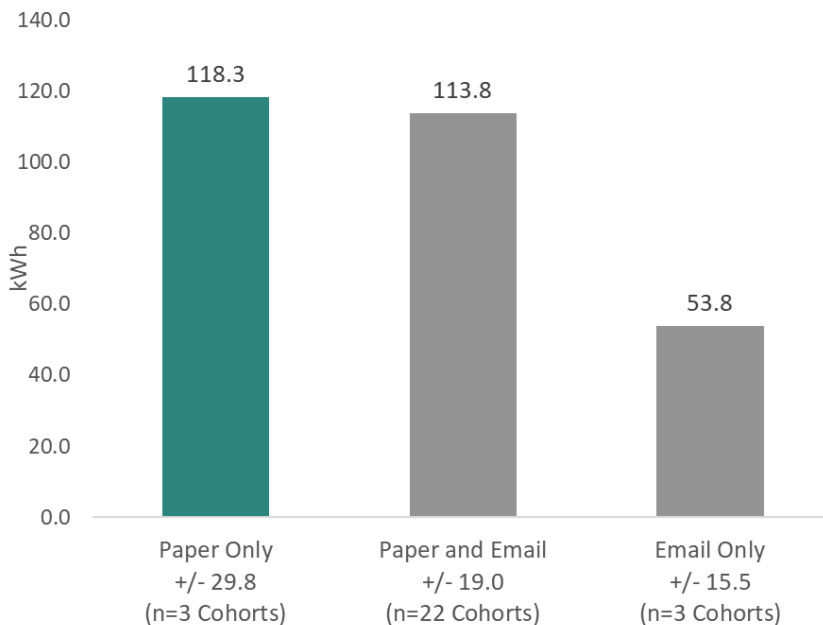

Figure 10. Average Unadjusted Annual Household Electric Savings by Mode - Weighted by Estimate Precision

Cohorts that only received paper HERs saved an average of 1.29% annual electricity consumption. Cohorts that received both paper and email HERs also saved an average of 1.29% annual electric consumption. Cohorts that received only eHERs saved, on average, 1.21% of their annual electricity consumption. The unadjusted percent annual electric savings for the cohorts that received only eHERs ranged between 1.0% and 1.5%. The unadjusted percent annual electric savings for cohorts that received both paper and email HERs ranged from 0.7% to 1.5%. The unadjusted percent annual electric savings for cohorts that received only paper HERs ranged from 1.1% to 1.3%.
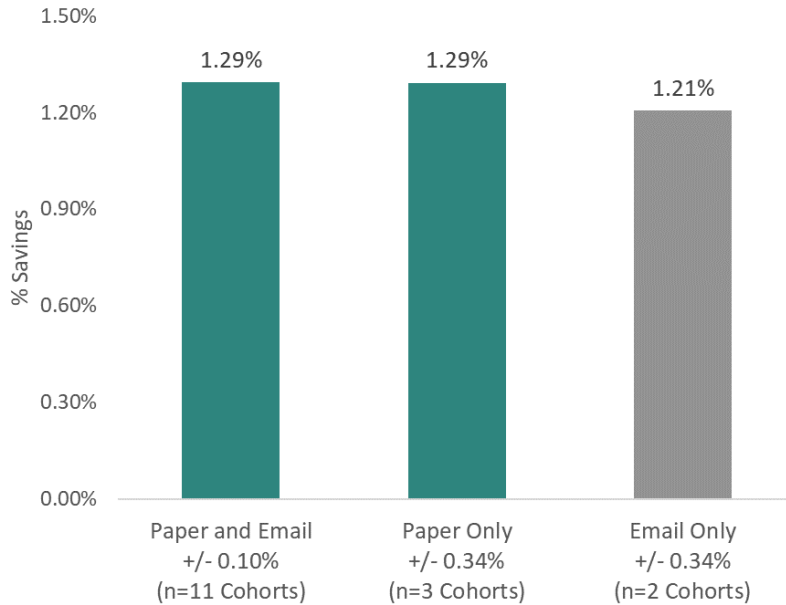
Figure 11. Average Unadjusted % Annual Electric Savings by Mode - Weighted by Estimate Precision

The cohorts that we could confirm received paper HERs only saved more annual gas consumption (4.0 Thm) than cohorts that received both paper and email HERs (3.4 Thm) and cohorts confirmed to receive only eHERs (2.2 Thm). The average unadjusted annual gas consumption saved for cohorts who received only eHERs ranges from 1.8 Thm to 2.4 Thm. Cohorts that received both paper and emailed HERs saved between 2.5 and 4.6 Thm. The range for cohorts that received only paper HERs is from 2.4 to 5.5 Thm.
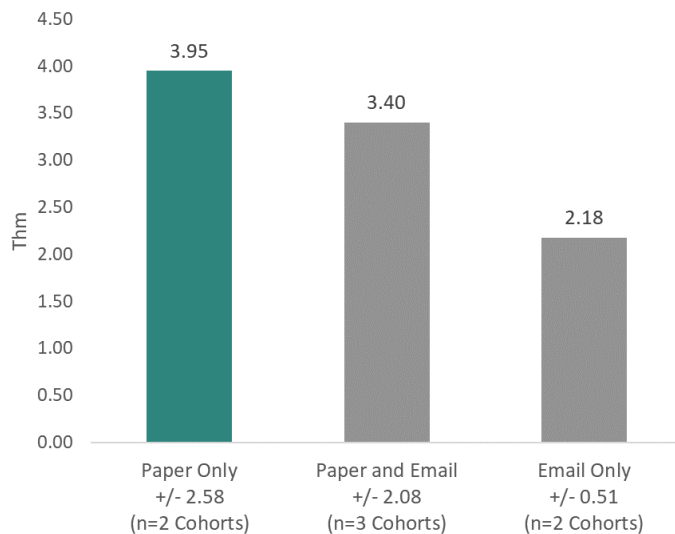

Figure 12. Average Unadjusted Annual Household Gas Savings by Mode - Weighted by Estimate Precision

Cohorts that only received paper HERs saved an average of 0.96% annual gas consumption. We did not identify any studies that met our inclusion criteria where both paper and email HERs were sent to customers and that reported the gas and dispersion metrics required for the analysis. Cohorts that received only eHERs saved, on average, 0.76% of their annual gas

consumption. The unadjusted percent annual gas savings for the cohorts that received only eHERs ranged between 0.70% and 0.80%. The unadjusted percent annual gas savings for cohorts that received only paper HERs ranged from 0.6% to 1.3%.
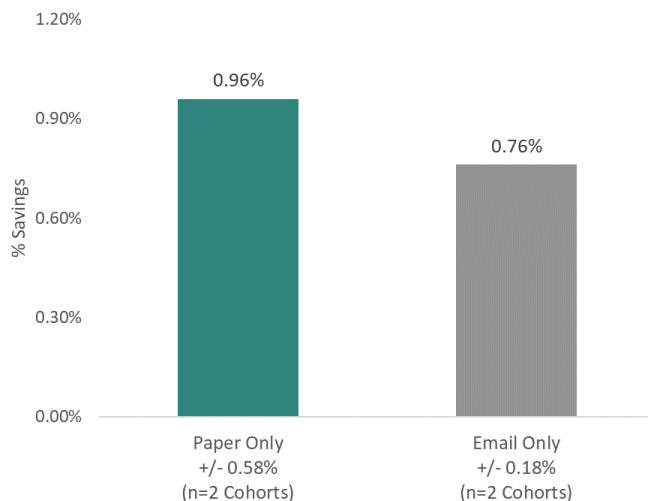

Figure 13. Average Unadjusted % Annual Gas Savings by Mode - Weighted by Estimate Precision

Conclusion

As utilities look for ways to meet the challenge of decarbonization and meeting energy efficiency goals, behavioral energy programs continue to be a source of savings. The results of this meta-analysis highlight the lack of consistency in reporting across jurisdictions and utilities which makes this useful type of analysis challenging. As the industry looks forward to improving understanding around the performance of behavioral energy efficiency, it is important to consider how more standardization can be used to allow for more robust comparisons and deeper insights.

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