

Behavior Change Programs: Status and Impact

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Contents

About the Authors.....	v
Acknowledgments.....	v
Executive Summary	vi
Results.....	vi
Recommendations.....	viii
Introduction.....	1
What Is a Behavior Change Program?.....	2
Types of Behavior Change Programs and Strategies	2
Methodology of This Study.....	5
Information-Based Programs.....	5
Home Energy Reports (HERs)	6
Overall Savings.....	9
Ramp-Up and Persistence.....	10
Frequency and Delivery of HERs.....	10
Opt-In Versus Opt-Out Programs.....	11
Spillover.....	13
Which Behaviors Are Changed?	14
Advances in HERs.....	15
Rhode Island's Augmented HER Program	16
Summary of Programs.....	16
Real-Time Feedback.....	20
Home Energy Management Systems and Smart Thermostats	20
DTE Energy Insights Smartphone App.....	23
Audit Programs	24

Narragansett EnergyWise	25
eScoreCard	25
FirstEnergy Online and Phone Audits	26
Energy Kits	26
The Most Effective Persuasive Messages.....	27
Financial Versus Nonfinancial Appeals.....	27
Selling Comfort.....	29
Avoiding Choice Overload	29
Prompting.....	29
Changing Defaults	30
Social Interactions.....	30
Competitions and Games.....	31
Cool California Challenge.....	33
Biggest Energy Saver (San Diego Energy Challenge)	33
Office Competitions in the Northwest	34
CALS Green Energy	34
Battle of the Buildings.....	34
Cool Choices.....	35
Community-Based Programs	35
Community Energy Savers	36
Vermont Home Energy Challenge.....	36
PowerED.....	37
Narragansett Residential New Construction Program.....	37
Community-Based Social Marketing (CBSM)	37
The Best In-Person Strategies	39

Foot in the Door.....	39
Public Commitment.....	39
Observability.....	40
Goal Setting.....	40
Guided Group Discussion.....	41
Social Networks.....	41
Energy Champions.....	41
Education and Training.....	42
Strategic Energy Management	43
Bonneville Power Energy Management Pilot	44
Continuous Optimization for Commercial Buildings.....	45
Hospitals and Healthcare Initiative.....	45
Refrigeration Operators Coaching for Energy Efficiency (ROCEE).....	45
Using a Human-Building Interaction Approach in SEM.....	46
Other Education and Training Programs	46
E-Power Wise.....	46
iSMART	46
K-12 and College Campus Programs.....	47
PowerSave, PowerED, Sprint to Savings, and Other K-12 Programs	47
LiveWise Energy.....	48
Campus Programs.....	48
Stacked Approach	48
Discussion.....	49
Summary of Results.....	49
Evaluation	56

Maximizing Savings	58
Innovative Behavior Change Strategies That Could Boost Energy Savings.....	59
Energy Champions.....	59
Effective Underused Strategies	59
Recommendations.....	60
Conclusion	61
References	62
Appendix A. Research Methodology	80
Appendix B. Curtailment Versus Efficiency Behaviors	82
Appendix C. References for Table 1: Home Energy Reports	84
Appendix D. Competitions and Games References	92

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Executive Summary

Utilities and regulators increasingly rely on behavior change programs as essential parts of their demand-side management portfolios. In 2013, the American Council for an Energy-Efficient Economy (ACEEE) published the *Field Guide to Utility-Run Behavior Programs*, which surveyed and categorized the various programs available at that time.¹ In this current report, we update those findings and evaluate the effectiveness of currently available programs, focusing in particular on programs that have been assessed for energy savings. We incorporate research from other recent reviews, as well as our own survey of formal program evaluations, academic peer-reviewed literature, and conference proceedings. We focus on behavior change programs that primarily rely on social-science-based strategies instead of traditional approaches such as incentives, rebates, pricing, or legal and policy strategies. Our objective is to help program administrators choose effective behavior change programs for their specific purposes. We classify programs using a taxonomy derived from previous reviews.

Our three categories of behavior change programs are information (sometimes called calculus), social interactions, and education (sometimes called cognition). *Information* includes home energy reports (HERs), real-time feedback, and energy audit programs. *Social interactions* include competitions and games and community-based programs. *Education* includes strategic energy management (SEM), training for community members, and K-12 and campus programs.² Some of these programs generate energy savings on their own, and others are used primarily to increase participation in existing programs.

RESULTS

Our central finding is that behavior change programs can reduce energy consumption. However reported energy savings from these programs vary greatly, depending on the type of program, the target audience, and the evaluation methods. Many studies do not report percentage savings, and results from those that do cannot be reliably compared across program types because of the disparate study and evaluation designs. In addition, many programs are in the pilot stage and are targeted toward smaller groups of participants who are more likely than others to respond to the interventions.

The highest savings from systematically validated strategies come from SEM programs and competitions, some of which have reported gross electricity savings as high as 22% and gas savings as high as 23%.³ However these programs require more data and systematic

¹ S. Mazur-Stommen and K. Farley, *ACEEE Field Guide to Utility-Run Behavior Programs* (Washington, DC: ACEEE, 2013). aceee.org/research-report/b132.

² Strategic energy management programs train commercial-sector energy managers and track their progress on efficiency goals.

³ Net savings were not reported, and average savings across programs could not be calculated due to differences in sample size and evaluation methodologies. The highest reported savings are cited in A. Dougherty et al., *Energy Efficiency Behavioral Programs: Literature Review, Benchmarking Analysis, and Evaluation Guidelines* (St. Paul: Minnesota Department of Commerce, 2015). mn.gov/commerce-stat/pdfs/card-report-energy-efficiency-

evaluation to bear out their findings. On the lower range, robust evaluations of HERs describe savings of up to 3% for those who are automatically enrolled in the program and up to 16% for those who opt in.⁴ Of course, the actual upper limit to potential savings from behavior programs is unknown because the field is relatively young and research in this area is still evolving.

As might be expected, programs that use many behavioral strategies usually save more energy than those that involve fewer strategies, and the residential, commercial, and industrial customers that consume more energy respond to interventions with greater energy savings.

Some programs use opt-out strategies for recruitment (e.g., utility customers are enrolled by default) as opposed to opt-in strategies, where customers choose to enroll. Opt-out programs generate lower average savings per customer but enroll more people. Programs that use this approach in conjunction with HERs save more electricity than those that use an opt-in strategy. However researchers know little about the relative usefulness of opt-out designs for other program types, both because they cannot be used for most programs and because evaluations rarely compare opt-in and opt-out strategies. Evaluators who study opt-in programs are likely to use simple methods (e.g., a pre-post comparison) that are prone to bias and may overestimate savings.

Little is known about the persistence of savings from behavioral programs. Research into HER programs suggests that savings may decay annually by 11%–32% (averaging 20%) during the two years immediately following the end of two-year programs.⁵ These findings suggest that energy use habits and behaviors can stay changed for long periods, but more research is needed across all types of behavioral programs.

Programs to reduce electricity use are usually transferable to gas or water consumption.⁶ In industrial programs (e.g., SEM), gas savings are sometimes higher than electricity savings; typically, the opposite is true for residential initiatives such as HER programs. The potential for both gas and electricity savings may be higher in industrial settings than in residential

[behavioral-prog.pdf](#). They are based on existing rebate programs coupled with SEM programs, rather than SEM savings alone.

⁴ ACEEE findings; Dougherty et al. 2015; A. Todd, "Default Bias, Follow-On Behavior and Welfare in Residential Electricity Pricing Programs," in BECC 2015 Conference Proceedings. beccconference.org/wp-content/uploads/2015/10/presentation_todd.pdf.

⁵ M. Khawaja and J. Stewart, *Long-Run Savings and Cost-Effectiveness of Home Energy Report Programs* (Waltham, MA: Cadmus, 2014). www.cadmusgroup.com/papers-reports/long-run-savings-cost-effectiveness-home-energy-report-programs/.

⁶ For example, P. Yollen, D. Gomez, and W. McBride, "Behavioral Water Efficiency – Drought Relief or a Way of Life? (BECC 2015 Conference Proceedings). beccconference.org/wp-content/uploads/2015/09/abstract_mcbride.pdf. beccconference.org/wp-content/uploads/2015/10/presentation_mcbride.pdf.

ones, where home temperatures are vital to comfort and temperature-related behaviors may be difficult to change. However researchers require further data in order to verify this hypothesis.

RECOMMENDATIONS

Utilities and third parties can use a variety of behavior change programs, each with its own strengths and weaknesses, to reduce consumer energy demands. In order to choose the ideal program, administrators should first consider the audience and behavior they want to target, and then tailor a program to address them. Community-based social marketing offers one effective model for this process.⁷

Although there is no single best program to use in every situation, we recommend a few methods that can increase the energy savings of most programs. For example, we suggest recruiting energy champions, project champions, or leaders of change for group-based programs (e.g., community, multifamily residential, commercial).⁸ We also recommend combining multiple evidence-based strategies to increase the potential effects.

Program implementers should focus not only on immediate results but also on continued savings over the long term. Programs in which customers install efficiency upgrades have built-in persistence. However programs that target small, frequent curtailment behaviors have to be carefully designed to ensure long-term savings. They should aim to

- Change habits (disrupt old habits in order to allow new ones to be adopted)
- Provide intrinsic motivation (e.g., satisfaction or happiness from the behavior)
- Change how people think about the behavior (e.g., that the behavior is more important or desirable)
- Change the perception of future costs (make the new behavior easier and less costly than changing back)

Effective evaluations are vital. Program administrators should strive for the most rigorous research design that they can feasibly implement, and third-party evaluators should use a mix of quantitative and qualitative methods. The percentage of energy saved is one important end-point that evaluators should include whenever possible, but other measures of behavior (e.g., frequencies of specific actions) may be helpful as well.⁹ Given a large

⁷ D. McKenzie-Mohr, *Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing*, 3rd ed. (Gabriola Island, BC: New Society, 2011).

⁸ Note that energy champions, project champions, and leaders of change are not necessarily the same as the opinion leaders referred to by E. Rogers, *Diffusion of Innovations*, 5th ed. (New York: Free Press, 2003).

⁹ B. Karlin et al., *What Do We Know About What We Know?* (Paris: International Energy Agency, 2015). www.ieadsm.org/wp/files/Subtask-3-Deliverable-3-Methodology-Review1.pdf.

representative sample of participants, experimental or quasi-experimental methods with long-term follow-up periods provide convincing evidence of program effectiveness.¹⁰

Table ES1 summarizes findings for each type of program included in this review.

¹⁰ For a summary of effective evaluation designs, see A. Todd et al., *Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs* (Washington, DC: SEE Action, 2012). eetd.lbl.gov/publications/evaluation-measurement-and-verification.

Table ES1. Summary of findings

Category	Description	Findings	Energy savings	Quality of evaluation
Information				
Home energy reports (HERs)	Reports intermittently sent to residential customers with feedback about energy use, energy efficiency tips, normative comparison to similar neighbors, and occasionally notes about rewards or incentives.	Savings ramp up over two years and continue for at least five years in ongoing programs. Savings from programs that are discontinued after two years persist for at least two years, with an average decay of approximately 20%/year. ^a Customers receiving more frequent reports save more energy. High-baseline users save most energy (and are targeted by most programs). Opt-out programs save more energy overall than opt-in programs (despite lower average savings per customer). Report recipients are slightly more likely to participate in other utility program offerings. The program works primarily by changing small, repeated behaviors but may also encourage participation in rebate programs. Information about disaggregated home energy use may potentially improve HERs, but this hypothesis requires additional testing.	Traditional opt-out programs save 1.2–2.2% of electricity and about 0.3–1.6% of gas by the second year. Opt-in programs may save up to 16% of electricity per customer, but for fewer people (in one study, approximately 20% of customers participated in an opt-in program; approximately 98% participated in an equivalent opt-out program). Preliminary research suggests that disaggregated energy reports for opt-out customers may save up to 4.2% of electricity, but this is from the last month of data in a four-month study. More data are required to confirm this result. ^b	High. Most results are based on third-party evaluations using randomized, controlled trials in large, representative samples.
Real-time feedback	Information about immediate energy use, provided by websites or devices including home energy management systems, feedback “dashboards” installed in workplaces, and similar devices.	Both control-based devices, which sense and automatically regulate energy use, and information-based devices, which sense energy use and provide information in a display) can save energy at home or work. Smart thermostats may achieve energy savings approximately twice as large as previous-generation programmable thermostats. Human behavior can interfere with savings potential of smart thermostats if default settings are changed.	Information-based devices can save 1–15% of electricity or gas, and control-based devices can save 1–17%. Savings range dramatically due to differences in target behavior, device, and method of evaluation. Most programs report net electricity savings in the 5–8% range using opt-in designs. In one study, peak electricity use during heat events was reduced by 48% using control-based devices, but energy use increased immediately following the events by 22%. ^c	High. Most studies use experimental or quasi-experimental designs and report net savings.

Category	Description	Findings	Energy savings	Quality of evaluation
Energy audit programs	Audits done online or in person, in which a personalized evaluation of energy use in a home or business is followed by specific recommendations for reducing consumption.	Energy audits reduce consumption by encouraging home or business energy efficiency upgrades (as well as some curtailment behavior changes). They also provide immediate reductions through direct installation of low-cost or no-cost measures. They are most effective when auditors guide customers through three types of barriers: information barriers, decision-making barriers, and transactional barriers.	Only audit programs with unconventional elements, such as online or telephone options, were included in this review. Audits reduce energy consumption primarily by encouraging participation in other programs (e.g., rebate programs). Therefore, estimates of direct energy savings from audit programs are rare. Online and phone-based audit programs may reduce net electricity consumption by 1.3–6.5%. ^d	Low. Most programs are not evaluated using control groups and typically report gross absolute savings rather than net percentage savings; often savings estimates are based on existing rebate programs rather than data taken directly from the audits.
Persuasive messages	Written communications that use behavioral insights to encourage energy conservation.	Benefits of energy conservation should be framed in financial, health, comfort, or environmental terms, depending on the audience. Messages emphasizing comfort are effective in encouraging efficiency upgrades. Reducing choice overload, using visual prompts, and changing default options could be effective strategies for reducing energy consumption. Other strategies as yet untested in the context of energy efficiency may also work.	Modifying message frames, as part of a larger program, can increase electricity savings by 1.2–8%. Installing prompts/signs reminding people to engage in certain actions can increase the frequency of those actions by 10–30%. ^e	Moderate. Most studies use strong evaluation methods but small numbers of participants; evaluations focus on changes in specific actions, such as turning off lights, rather than whole-building percentage energy savings; results may not scale up.

Category	Description	Findings	Energy savings	Quality of evaluation
Social interactions				
Competitions and games	Competitions in which participants try to achieve the highest rank compared with other individuals or groups. Games in which participants try to reach goals by reducing energy consumption.	Effective competitions use a large number of behavior strategies to motivate and engage all participants. Persistence of energy savings from competitions and games is rarely measured, but theoretically, persistence could be increased by changing habits and providing intrinsic motivation for participants.	For residential programs, gross electricity savings ranged from 0.7–14% and gas savings from 0.4–10% (only three programs included gas savings). For commercial programs, gross electricity savings ranged from 1.8–21% (no gas savings were reported). Most programs reduce electricity consumption by approximately 5% or less, but competition winners have saved more than 30%. ^f	Moderate. Some programs are evaluated using control groups or quasi-experimental methods, but they typically report gross rather than net savings.
Community-based programs/stacked approach	Community-based social marketing (CBSM) and other innovative community outreach strategies. These approaches draw from a number of available behavior change tools to create tailored programs that are designed to work with specific populations.	Systematically designed programs, specifically targeting certain energy behaviors within certain populations and incorporating evidence-based behavior change strategies, can effectively change behavior, drive customers to other efficiency programs, and reduce energy use. Using many strategies within one program increases chances of success but makes evaluation of specific strategies more difficult.	Percentage of energy savings directly attributable to the program (rather than to existing retrofit programs) are usually not reported. Gross absolute savings ranged from an estimated 117,000 kWh/year (annualized) to 813,000 kWh and 71,150 therms (in one year). Estimated electricity savings from three CBSM programs was 0–16%. The biggest savers from one commercial program reduced consumption by more than 20% at several sites; one site reduced consumption by 34%). ^g	Low. Other than CBSM programs, most are not evaluated using control groups and typically report gross absolute savings rather than net percentage savings.
In-person strategies	Direct social interaction by one or more people.	Several specific in-person behavioral strategies have been recently used to effectively reduce energy consumption. These include the foot-in-the-door technique, public commitment, public observability, goal setting, guided group discussion, and energy champions. Other strategies could also be used but have not been directly tested in the context of energy consumption.	In-person strategies evaluated for energy savings were found to reduce electricity consumption by approximately 4.4% (goal setting) to 27% (public commitment) compared with controls. But these strategies also produced other important results, such as increasing—by nearly 300%—enrollment in utility programs allowing control of A/C units during heat event days, and reducing frequency of lights left on in classrooms by 34%. ^h	Moderate. Most studies use strong evaluation methods but have small numbers of participants; evaluations focus on changes in specific actions, such as turning off lights, rather than whole-building percentage energy savings; results may not scale up.

Category	Description	Findings	Energy savings	Quality of evaluation
Education				
Strategic energy management (SEM)	Program administrators work with industrial and commercial customers to train energy managers and encourage curtailment and efficiency behaviors within those organizations by helping to set goals and track progress.	SEM programs have five criteria: (1) adoption of an organization-sanctioned goal, (2) documentation of planned activities to achieve the goal, (3) allocation of resources toward the goal, (4) implementation of planned activities, and (5) regular review of progress. The largest obstacle for implementing SEM in commercial businesses is allocating resources, including hiring a dedicated energy manager. Two key components for success are an effective energy manager/champion and management support for the program.	Gross electric savings are 0–22% and gross gas savings are 0–23%, but the savings from the higher end of the spectrum are calculated from existing rebate programs rather than SEM directly. ⁱ	Moderate. Some programs use strong evaluation methods but report only gross savings, and these can often include savings from existing rebate programs.
Other training programs	Non-school-based education or training programs teaching community members strategies for reducing energy consumption.	Based on the two programs included in this review, these have great potential to increase energy literacy through education and training of low-income community members, but more data are needed.	One program was evaluated, and it reported estimated gross electricity savings of 1,454,240 kWh/year among 2,440 participants. Home energy kit installation rates ranged from 79–94% per item in the kit. ^j	Moderate. One of two programs includes a strong quasi-experimental approach, but it has yet to be evaluated. The other provides gross absolute savings without a control group.
K-12 and campus programs	Programs in K-12 schools or on college campuses that involve education of students on energy efficiency.	These programs reduce consumption by teaching students about their energy use, providing hands-on activities, and (occasionally) by providing home energy kits with low-cost/no-cost upgrades.	Gross electricity savings in schools ranged from 13–37%. Usually savings are reported to be about 20%, but the methods of evaluation are often unknown. ^k	Low. Program details and evaluation methods for many of these programs are unclear, and they typically report gross rather than net savings.

^a Khawaja and Stewart 2014. ^b Khawaja and Stewart 2014; Opower 2016; ACEEE findings (see table 2); Todd 2015; Malatest 2014. ^c NEEP 2015; Harding and Lamarche 2016. ^d Ignelzi 2015; Southern California Edison 2013. ^e Asensio and Delmas 2016; Trottier 2014; Sussman and Gifford 2012; Ackerly and Brager 2012. ^f ACEEE findings (see Appendix D); Dougherty et al. 2015; Vine and Jones 2015; Donovan 2014. ^g GreenerU 2014; Schultz et al. 2015; Ruiz 2014. ^h Harding and Hsiaw 2014; Pallak and Cummings 1976; Yoeli et al 2013; Werner et al. 2012. ⁱ Ochsner et al. 2015; Dougherty et al. 2015; Therkelsen and Rao 2015. ^j Cadmus 2014. ^k Crosby and Metzger 2014; Snell, Crosby, and Patton 2016.

Introduction

Encouraging energy efficiency actions can be challenging. In the city of Bozeman, Montana, business owners can participate in the Bozeman Energy Project, a free program whose purpose is to reduce energy-related operating costs. Yet, securing business enrollments in this program is difficult without hand holding and repeated phone calls (H. Higinbotham, energy conservation technician, City of Bozeman, pers. comm., March 31, 2016). Such lukewarm responses to their offerings often surprise program administrators. With the economic barriers removed, what prevents customers from taking action? In this case, a default bias may have been at work; homeowners chose the default option of doing nothing rather than taking action. This bias is one example of a nonstructural barrier that may reduce participation in energy efficiency programs. Noting the presence of these types of barriers, several authors have argued that traditional economic models and market barriers are insufficient for explaining the adoption (or not) of energy efficiency technologies. They suggest that program administrators should consider the fundamentals of human behavior and decision making as well (e.g., Sullivan 2009; Moezzi 2009).

A range of behaviors can reduce energy consumption in homes and businesses. Recognizing these possibilities in recent years, utilities and program administrators have overseen an explosion in the number of behavioral programs that target such actions and reduce energy use. Across North America, behavior programs account for a substantial portion of utilities' first-year energy efficiency savings goals for residential demand-side management portfolios. The top 10 states most reliant on these programs in 2013 claimed that 13–28% of their savings came from behavior programs (Opinion Dynamics Corporation and DNV-GL 2015).¹

In 2013, the American Council for an Energy-Efficient Economy (ACEEE) examined and categorized this emerging area of programming in the *Field Guide to Utility-Run Behavior Programs* (Mazur-Stommen and Farley 2013). Although the authors classified nearly 300 programs, relatively few were evaluated for energy savings, mainly because most of these programs were new or never designed with systematic evaluations in mind. This study not only updates the ACEEE *Field Guide* but also evaluates the programs that have come to light since 2013. Its goal is to help program administrators understand the keys to successful behavioral approaches and design future programs more effectively.

We begin this review with a brief discussion of the definition and background of behavior change programs and the various taxonomies used to describe them. We then summarize the energy savings findings from previous reviews and additional new reports. Notably, the recent review of evaluated behavior change programs created for the Minnesota Chamber of Commerce was particularly helpful (Dougherty et al. 2015). We examine many of the programs described in that paper as well as in newer reports and peer-reviewed academic

¹ Indiana, Idaho, Rhode Island, Illinois, New Mexico, California, South Carolina, Arizona, Kentucky, and Colorado.

studies. Our focus is on observed behavior change, evaluated energy savings, persistence of savings, and explanatory variables that might shed light on what makes programs effective.

What Is a Behavior Change Program?

Our definition of behavior change programs is based on those of the investor-owned utilities (IOUs) of California² and the Minnesota Chamber of Commerce review (Dougherty et al. 2015). It includes programs that are based on social science theories of behavior change and excludes those that rely on traditional program strategies such as incentives, rebates, or regulations.³ It also emphasizes the importance of systematic evaluation.

Behavior change programs in this report

- Deploy one or more behavioral insights derived from social science research
- May be evaluated using experimental design, quasi-experimental design, or other evaluation methods
- Are typically evaluated for energy savings on an ex-post basis, but may also be evaluated by other metrics of behavior change such as frequencies of particular actions
- Omit traditional behavior intervention strategies such as financial incentives and legal strategies
- Omit energy pricing (because this tends to be a demand-response strategy)⁴

Types of Behavior Change Programs and Strategies

Most classification schemes, or taxonomies, for behavior change activities distinguish between behavioral intervention *strategies* and *programs*. Strategies are small pieces of programs. They are based on social science concepts about human behavior, such as the idea that people are more likely to take action after making a public commitment or learning about the behavior of others. Programs, on the other hand, rarely rely on a single strategy to affect behavior. They typically combine multiple behavioral science-based strategies (e.g., public commitment, goal setting, and comparison to others' behaviors). Whereas behavioral scientists research effective strategies, organizations interested in energy efficiency (e.g., utilities) implement programs that use those strategies.

² Southern California Edison, "Rules Governing Behavior Programs in California."

library.cee1.org/sites/default/files/library/11659/CA_IOUs_Behavior_Definition_Proposed_to_CPUC.pdf.

³ Two of the primary drivers of behavior (sometimes argued to be the only drivers of behavior) are reward and punishment (e.g., Skinner, 1969). However these two drivers are deeply embedded in the traditional approaches to changing energy efficiency behavior: monetary incentives (e.g., rebates for energy-efficient installations or reduced prices for off-peak use) and policy changes (e.g., efficiency standards and legal consequences). Therefore, they are not emphasized in this report.

⁴ Demand-response strategies reduce energy consumption by increasing prices. In particular, utilities may increase prices during peak demand periods (e.g., on very hot or very cold days) to reduce the need for auxiliary power production (or purchase).

ACEEE and others have proposed a number of taxonomies for organizing behavior change strategies and programs. These taxonomies can have anywhere from two categories (Abrahamse et al. 2005; Steg and Vlek 2009) to 10 categories (Gonzales et al. 2013), or some number in between (Schultz 2014; Ashby et al. 2010). The taxonomy in this report is a modified version of the one used by the 2015 Minnesota Department of Commerce review (Dougherty et al. 2015), which was based on the work of Mazur-Stommen and Farley (2013).

Figure 1 shows the three primary categories in the taxonomy used in this report: *information* (sometimes called *calculus*), *social interactions*, and *education* (sometimes called *cognition*).



Figure 1. The three categories of behavior programs

The text box below outlines the key elements of each of these categories, which are described in greater depth later in the paper.

Information-based programs deliver information to customers.

- *Home energy reports (HERs)*. Deliver intermittent information to participants about their energy use (generally monthly, bimonthly, or quarterly). Unlike traditional utility bills, HERs typically use social science insights about the power of social norms to encourage behavior change.⁵
- *Real-time feedback*. Informs users of their immediate energy use through devices or websites, including home energy management systems, feedback dashboards installed in various workplaces, and similar technologies.
- *Audit programs*. Conduct online, over-the-phone, or in-person energy audits, in which a personalized evaluation of energy use for a home or business is followed by specific recommendations for reducing consumption.⁶

Social interactions programs rely on interpersonal interactions.

- *Competitions and games*. Competitions encourage participants to achieve the highest rank compared to other individuals or groups. Games participants try to reach goals by reducing energy consumption in fun ways.
- *Community-based programs*. Target communities with innovative outreach strategies, including community-based social marketing (McKenzie Mohr, 2011). These approaches draw from a variety of behavior change tools to create programs tailored to specific populations. Programs often stack multiple strategies to achieve behavior change (e.g., monetary incentives, competitions, direct installations of efficient technology, and feedback devices).

Education and training programs include some form of consumer education.

- *Strategic energy management (SEM)*. Utilities work with industrial and commercial customers to train energy managers and encourage curtailment and efficiency behaviors within those organizations.⁷
- *Training programs*. Non-school-based education or training programs teach community members strategies for reducing energy consumption.
- *K-12 and campus education*. Programs that take place in public schools or on college campuses educate students on energy efficiency.

⁵ Social norms are based on others' behavior. People will often change their behavior to follow social norms by aligning with what they perceive others to be doing (descriptive norms) or what they ought to be doing (injunctive norms).

⁶ These could also be classified as in-person strategies, but given that audits are sometimes provided online, we left them in the information category, concurring with earlier review papers.

⁷ Although these programs include large training components, they also rely heavily on repeated energy audits, tracking, rebates, feedback, and other strategies.

Methodology of This Study

Our research for this report relied on more than 60 personal communications with program administrators, energy program managers in local and federal government, and other experts. We also drew on behavior change reviews published since the ACEEE *Field Guide* was released in 2013, surveying a total of 296 reports, studies, and program evaluations obtained through database searches and our personal communications. We used two types of published sources:

- Large-scale reviews of behavior change programs. These reviews focused on energy savings across program types (Dougherty et al. 2015), strategies of behavior change (Schultz 2014; Abrahamse and Steg 2013), real-time feedback programs (Karlin, Zinger, and Ford 2015; NEEP 2015), games and competitions (Grossberg et al. 2015; Vine and Jones 2015), SEM (Ochsner et al. 2015), and Opower HERs (Allcott and Rogers 2013; Khawaja and Stewart 2014).
- Literature on behavior change and energy use not specific to a particular program or portfolio. This category comprises academic peer-reviewed studies, formal program evaluations, and conference proceedings that were not included in the reviews discussed above. Some of the program evaluations were proprietary studies commissioned by utilities; we share them with the permission of those organizations.

Our findings are organized in the following sections according to the taxonomy previously described. We emphasize information published in the past three years and highlight several examples that are particularly successful or interesting. We focus primarily on data from North America, but also note a few studies that were conducted abroad. See Appendix A for a complete list of the resources we drew on.

Information-Based Programs

Nearly all programs employ, in some form, the strategy of changing behavior by providing information. Most behavioral science researchers agree that information is necessary, but not always sufficient, to change behavior (e.g., Marteau, Sowden, and Armstrong 1998). For example, North Americans' awareness and knowledge of climate change has increased since the 1980s, but their levels of concern and action have not always followed (e.g., Sussman and Gifford 2014). Providing more information about climate change may not be enough to convince the average person to drive less frequently, eat less meat, or restrict his or her air-conditioning use. Similarly, more information is usually insufficient for convincing climate deniers to change their beliefs. The idea that people fail to change behavior because they do not know any better is called the knowledge- or information-deficit model (e.g., Marteau, Sowden, and Armstrong 1998). Although a lack of knowledge is certainly one factor that drives over-consumption of energy, it is often not the sole factor. Information-based programs and strategies can provide facts regarding the consequences of certain behaviors or they can provide persuasive messages that motivate action.

This section does not address the question, "Does providing information encourage energy savings?" but rather, "What kind of information results in the greatest degree of energy

savings?"⁸ Generally, facts are not enough; they must be accompanied by a behavior change strategy to be effective. For example, generic appeals to promote demand-pricing programs are less effective than social norm messages (in which people are told how others respond) or appeals for public commitment (Sintov and Schultz 2015). More persuasive messages can also incorporate strategies that frame decisions in terms of avoiding loss rather than achieving gain, or that make specific rather than general requests for behaviors (e.g., general "energy reduction").

In this section, we describe and evaluate three types of information-based programs and then discuss specific message-framing strategies. The three program types are:

- Home energy reports
- Real-time feedback
- Home energy audits

HERs and real-time feedback are both derivatives of the feedback strategy. Although other reviews (e.g., Karlin, Zinger, and Ford, 2015) often group them together, we reviewed them here as independent categories because of the large number of programs that specifically rely on each type.

HOME ENERGY REPORTS (HERs)

By far the most common utility-run energy efficiency behavior change programs involve HERs (Mazur-Stommen and Farley 2013; Dougherty et al. 2015). Although some utilities, such as Duke Energy, have created and implemented their own HER programs, the most prolific implementer is Opower, whose reports reached over 8.9 million households in 2013 (Allcott and Rogers 2013). Opower's collective energy savings is an estimated 11 terawatt-hours (TWh) since its inception (Kotran 2016).

HER programs are usually cost effective, and generally save residential customers 1.2–2.2% in electricity per year by their second year of use (Opower 2016). They operate on the principles of feedback and social norms comparisons. Individuals who receive periodic reports comparing their energy use (electricity, gas, or both) to that of 100 similar homes tend to reduce their consumption in order to fall in line with their neighbors (Allcott 2011). Nolan et al. (2008) and Schultz et al. (2007) demonstrated this effect in a series of studies before implementers like Opower adapted it to large-scale markets.

Initially, comparison information included a smiling or frowning emoticon along with the social norms information. The purpose of the emoticon was to counter any rebound effect customers might experience after learning that they used less energy than their neighbors (Cialdini, Kallgren, and Reno 1991). However large-scale studies of HERs appear to demonstrate that these additional (injunctive norm) messages are less important for achieving HER savings than initially thought, especially for low-usage customers (Allcott 2011). Opower now includes messages about how each household compares to "average"

⁸ We refer here to written communications. In-person information will be discussed later in this report.

neighbors and “high-efficiency” neighbors, using only happy face images. The comparison to high-efficiency neighbors may work because it shows residents that even efficient households can still improve, and thereby eliminates the potential rebound effect (The elimination of the unhappy face also reduces unpleasant reactions from customers).

Typically, a HER is sent to customers separately from their utility bills and on a monthly, bimonthly, or quarterly schedule (see figures 2 and 3). It usually includes a summary of the home’s recent and historical energy use, energy-efficiency tips (including utility energy efficiency program offerings), a normative comparison of the home’s energy use to that of similar neighbors, and offers of rewards or incentives for reducing energy use, if they exist (Khawaja and Stewart 2014). It is also frequently accompanied by a web portal, available to customers, that provides similar information.



Figure 2. A typical home energy report (front)



Figure 3. A typical home energy report (back)

The HER program is unique among behavior change programs in that it easily lends itself to an opt-out design and a randomized control trial. By providing access to customer energy use and marrying that information to other customer data (e.g., zip codes and dwelling characteristics), utilities have enabled HER program implementers to conduct large, high-quality experiments with an unprecedented number of participants. Such large sample sizes are necessary to detect savings from an intervention that produces a relatively small effect (e.g., in the 1-2% range for electricity). Nevertheless, this combination of rigorous evaluation and large sample sizes bolsters the argument that HER programs influence consumers to reduce energy consumption at home.

The flexible study design, coupled with large amounts of high-quality data, allows Opower to investigate the change in energy savings over time, the persistence of savings, the effect of using opt-out or opt-in designs, and the effects of various HER delivery methods and frequencies (e.g., email or paper, delivered monthly, bimonthly, or quarterly). To assess why Opower programs lead to energy savings, third-party evaluators often conduct telephone or Internet surveys of a subsample of participants. The evaluators ask consumers what behaviors they enacted, and determine if receiving HERs increases the likelihood of participating in other energy efficiency programs (i.e., spillover, also referred to as *channeling*, given the intention to channel customers into additional programs). Importantly, however, HER programs have only been evaluated against no-intervention control groups, and Karlin et al. (2015) cite this as one potential shortcoming of HER evaluations.

Some non-Opower HER programs (e.g., BKi or Ecotagious) use smart meter information to provide more-specific (disaggregated) feedback to customers about the various types of energy uses within their homes. Other HER programs have also attempted to move beyond traditional residential energy feedback to business feedback (e.g., Xcel Energy's Business Energy Feedback pilot) and water programs (e.g., WaterSmart's Home Water Reports).

Overall Savings

Estimates of overall electricity savings from HERs fluctuate slightly, but generally vary from 1.2 to 2.2% per year (Opower 2016).⁹ Electric savings are nearly always equal to or higher than gas savings. In our review of 31 recently evaluated Opower programs, we found that electric savings ranged from 0.5 to 5.2%, and gas savings ranged from 0.3 % (nonsignificant) to 1.6%. A crude median estimate suggests that electric savings are roughly double gas savings in Opower HER programs (~1.6% versus ~0.8%). One might speculate that this is because gas is most commonly used for space and water heating, whereas electricity is used for a variety of purposes in addition to heating and cooling. Heat-related behaviors, such as wearing warm clothing rather than increasing thermostat set points, or using a fan rather than air conditioning, are possibly more difficult to change than behaviors such as reducing plug loads or curbing air-conditioning use.¹⁰ Researchers will need more data in order to test this hypothesis.

Typically, residences with higher baseline usage, more space, and fewer occupants can reduce both absolute and percentage savings—and more so than other residences (Khawaja and Stewart 2014; Ashby et al. 2012; Davis 2011). For this reason, many Opower programs (10 out of 28 in our review) either include only the highest baseline energy users, or make a special effort to recruit high-baseline users in addition to other cohorts.¹¹ Furthermore, two programs that compared savings from dual-fuel and electric-only customers found that electric-only customers showed a greater percentage of electricity savings than their dual-fuel counterparts (~1.25% versus ~2%).¹² Evidently, a large percentage of residential energy savings comes from generating heat and, therefore, customers using gas to generate heat do

⁹ When comparing percentage savings, note that savings increase over the first two years; therefore a program running for less than two years will likely have a lower savings percentage than a program that has run longer than two years. This is discussed in the next section.

¹⁰ Air-conditioning use, although a significant source of energy consumption, is still generally less significant than heating in most areas of the United States. For region-specific residential energy consumption data, see the U.S. Energy Information Administration state fact sheets:

www.eia.gov/consumption/residential/reports/2009/state_briefs/.

¹¹ Importantly, average savings across Opower programs is estimated based on this sample of primarily high-baseline users. Therefore, savings among the general population could be lower than those reported by these programs. Several programs measured differences between savings from high-, medium-, or low-baseline users. For example, Duke Energy found that high-baseline users reduced electricity consumption by 1.87%, whereas low- and medium-baseline users saved 1.45–1.62% (Glinsmann et al. 2014). Connecticut Light and Power found that their cohort of high-baseline electricity users saved an average of 2.31%, whereas the average-baseline electricity users saved 1.17%. However in this case the average users also received reports for only one year, whereas the high users received the reports for two years (Russell et al. 2014).

¹² National Grid New York: 1.5 versus 2.3%; Baltimore Gas and Electric: 1 versus 1.7%

not save the same percentage of electricity as those who use electricity to generate heat (savings are split between gas and electricity for duel-fuel customers).

Ramp-Up and Persistence

Given that some Opower HER programs were implemented as early as 2008 and 2009 (e.g., Sacramento Municipal Utility District, Commonwealth Edison in Illinois, and Seattle City Light), several reviews have examined their long-term pattern of energy savings.

Encouragingly, data from four-year programs suggest that, rather than declining over time, Opower program savings increase sharply in the first two years and then plateau (Allcott and Rogers 2014; Khawaja and Stewart 2014). Our examination of fifth and sixth year evaluations of Opower programs further supports the view that savings from ongoing programs continued. Opower also voluntarily suspended reports after two years from a random subset of HER recipients in five of its longer running cohorts. In these cases, savings declined at a rate of 11–32% per year, an average of approximately 20% per year for two years (Khawaja and Stewart 2014). However persistence was far lower for one program that was stopped after only six months, while customers were still in their initial ramp-up period (an 83% reduction in savings in the six months following program termination [Khawaja and Stewart 2014]). This result suggests that energy savings from programs terminated before the end of the second year (during the ramp-up period) might not persist for an extended period.

Data about the persistence of ongoing and suspended programs are limited by the duration of analyses (four years in total, including two years of suspended programs in this case). Opower HER programs are among the best-established behavior change programs, but they were implemented relatively recently. Long-run analyses of these programs should be conducted again 5–10 years following implementation. Unlike programs that focus on the physical installation of energy-saving devices, these programs mostly rely on the persistent behavior of people. Therefore the question of how energy savings are affected by the changing social roles, dynamics, and compositions of households as they age would be interesting to answer. At this point, utility regulators looking for long-term energy-saving programs should not assume that ongoing programs would produce savings beyond five years. They also should not rely on persistence of savings after a program has been terminated for more than two years (at a 20% decay rate, assuming the program was running for at least two years prior to termination). However these estimates may change as time passes and more data become available.

Frequency and Delivery of HERs

Household energy-saving behaviors follow a pattern of action and backsliding as people receive reports, act on them, and then wait for future reports (Allcott and Rogers 2014). This pattern is particularly noticeable early in HER programs (the first two years), when savings increase most steeply (Allcott and Rogers 2014). It suggests that program savings are a result of habitual curtailment behaviors rather than the installation of energy-saving devices (for a discussion of this distinction, see Appendix B). Consequently, large-scale reviews and our review of recent evaluations agree that frequent deliveries of HERs result in larger energy savings (Allcott and Rogers 2014; Patterson, Goldman, and Arnold 2015). In particular, HERs that are delivered monthly result in higher savings than those delivered quarterly

(Khawaja and Stewart 2014) and seem to be preferred (Schultz, Schmitt, and Javey 2015). These conclusions are in line with the body of literature on feedback—it is more effective for changing behavior when it is provided closer, in time, to the opportunity to act (e.g., Abrahamse et. al. 2005; Karlin, Zinger, and Ford 2015).

The mode of delivery of HERs also matters. Surprisingly, despite the widespread adoption of Internet communications, programs delivered through email or web portals are consistently less effective than those delivered by traditional mail (Nexant 2014; Schultz et al. 2015; Wells and Ossege 2015; Cadmus 2015; Navigant and Illume Advising 2016). The difference in savings for recipients of paper HERs and recipients of email or web-based feedback was approximately 0.1–0.5% in two studies (Nexant 2014; Wells and Ossege 2015). Program administrators have hypothesized that this is because emails are easier to ignore or, in some cases, because customer email addresses are unavailable or cannot be used for delivering HERs (Navigant and Illume Advising 2016; H. Higinbotham, energy conservation technician, City of Bozeman, pers. comm., March 31, 2016).

Nine Opower HER programs in our review specifically include assessments of their accompanying customer web portals, which tend to be infrequently used (AEP Ohio, Indiana Michigan Power, Indianapolis Light & Power, Ameren Illinois, Duke Energy, Central Hudson, National Grid Rhode Island, Efficiency Nova Scotia, and Berkshire Gas). In customer surveys, only 2–5% of opt-out Opower program participants accessed the website. However, in one of these programs, participants who accessed the website saved more energy than those who did not (2.1% for those who accessed the website, and up to 1.6% for the overall participant sample [Glinsmann et al. 2014]).¹³ Websites can also be useful methods for recruiting opt-in program participants and for recording information about their behaviors (CRA and Econoler 2016).

The look and feel of HER websites could potentially increase the effectiveness of HER programs. Participants in a survey on a Swedish HER-type website (energiinfo) indicated a strong preference for seeing their usage disaggregated to the appliance level (Bartusch and Poratne 2011). They also tended to value comparisons to historical usage information more than comparisons to other similar households and information about environmental impacts (although all three types of information were important to some groups).

Opt-In Versus Opt-Out Programs

Most HER programs are opt-out and, therefore, lend themselves to randomized controlled trials. Assuming they work with large and representative samples, these designs are optimal for inferring causation and help support the argument that HERs cause reductions in energy

¹³ This is a correlation only. There is no indication that visiting the website causes HER program participants to save more energy. There is a strong possibility that the type of people who visit the website are also likely to be the type of people who are motivated to save energy.

use.^{14,15} Although not yet tested, one innovative practice would be to replace randomized controlled trials with novel statistical analyses (from Bayesian and econometric schools). Such analyses would be helpful because they would allow power companies to provide all customers with HERs, rather than reserving a subset as controls who do not receive reports. However replacing the randomized trials with these alternative statistical analyses is not yet supported (Smith and Schellenberg 2015).

A few HER opt-in programs were evaluated using quasi-experimental designs, which offer a slightly lesser degree of certainty regarding causation, but still offer good support. In these evaluations, each household that chose to enroll was matched in energy use, household size, and so on with a similar household that was not offered the opportunity to enroll in the program but arguably might have done so if given the opportunity. While this is a reasonably effective approach, a difference in energy use could nevertheless be attributable to the characteristics of the sample rather than to the HER program. This effect is partially, but not completely, controlled for.

Opt-in programs may be appealing from a program administrator's viewpoint, however, because customers who enroll save more energy and become more engaged with the utility (Navigant 2015c; Henschel and Corsetti 2014). The AEP Ohio program, for example, implemented a standard opt-out HER program for some customers, and allowed other customers to opt in to the program if they wished. The relatively small number of participants who chose to enroll in the program reduced their electricity use by 5.9%, while the opt-out participants showed energy savings of 0.9–2.0%. Given that typical opt-out rates are less than 1%¹⁶ and that opt-in rates are estimated at approximately 20% (with far greater outreach efforts required [Todd 2015]), most experts agree that opt-out programs earn greater absolute savings potential (e.g., Dougherty et al. 2015). Nevertheless, a program that allows both options (e.g., CRA and Econoler 2016) takes advantage of the strengths of both

¹⁴ Randomized control trials are the optimal method for reducing bias from systematic differences between study groups. However reducing bias is not the only concern of researchers conducting studies of behavior. Other concerns, such as external validity (the applicability of results in the real world), are important as well. For example, large historical data sets with representative samples (e.g., census data correlated with energy-use data for thousands of people) might predict real-world behavior better than small randomized controlled trials conducted with narrow samples (e.g., lab-based studies with a few dozen participants in each condition). Furthermore, representative samples can be difficult to obtain, and randomized controlled trials are often not possible to conduct. Many energy efficiency programs, including behavior change programs, cannot be evaluated using these experimental designs. In that case, a variety of quasi-experimental methods can be used, each with its own strengths and weaknesses. For a broader discussion of evaluation, see the Evaluation section of this review or refer to Dougherty et al. (2015).

¹⁵ In order for the randomization procedure to be truly effective, neither group can be systematically different from the other in non-random ways. Therefore, all participants in each group must be included in the analysis, regardless of whether they opted out of the program. Fortunately, few participants typically opt out and they do not significantly affect the outcome of the analysis.

¹⁶ The notable exception is the Central Hudson Gas & Electric HER program in which 14% opted out (Applied Energy Group 2014).

and thus possibly has the greatest opportunity for savings (but also requires a more complicated evaluation strategy).¹⁷

Todd (2015) persuasively demonstrates the advantage of the opt-out design. In this direct comparison of participants who were (1) not contacted, (2) encouraged not to opt out, or (3) encouraged to opt in, there was a 78% difference in enrollment between groups 2 and 3 (98% versus 20%). Interestingly, opt-out participants, despite simply going along for the ride, actively engaged in the program (e.g., by reducing peak energy use by 3.6%), and were less likely to later drop out of the program than the opt-in participants. The whopping 16.2% savings achieved by opt-in participants was not enough for the author to recommend opt-in programs over opt-out programs.

Spillover

Does participating in a HER program lead to additional actions outside the home? Several behavior theories suggest that this should not occur. Theories regarding the rebound effect or moral licensing suggest that, after engaging in good actions, individuals are subsequently more likely to engage in poor actions (e.g., Mazar and Zhong 2010; Gifford 2011). However evidence from most HER program evaluations in our review suggests that households that receive HERs are slightly more likely to participate in other utility program offerings (e.g., appliance recycling or home audits) than those randomly assigned not to receive the reports. Yet HER savings are not primarily derived from channeling participants to other programs either. The degree of spillover can be quantified and savings removed when calculating net savings attributable to the program.

According to Allcott and Rogers (2013), Opower HER programs sometimes channel participants to other programs, such as home improvement rebates or the installation of compact fluorescent lightbulbs (CFLs), but these account for only a small fraction of overall savings. In one cohort from that report (the only one with substantive data), HER recipients were 0.4% more likely to participate in other efficiency programs (48 out of 1,000 versus 44 out of 1,000), and this accounted for less than 0.02% of savings from HER programs. Purchases of durable equipment, CFLs, and envelope measures account for a small percentage of HER savings (usually less than 5% [Khawaja and Stewart 2014]). This suggests that curtailment rather than efficiency behaviors may be at the heart of HER program savings.¹⁸ Nevertheless, a recent study also demonstrates that HER recipients may be more likely to engage in large-scale actions. Those who are participate in a rebate program save more electricity (5.7%) than those who are offered rebates only (1.7%) or who are enrolled in the HER program only (1.7% [McClaren et al. 2016]).

¹⁷ One possibility might be to automatically enroll high-baseline users (opt out), but allow other users to opt in if they wish. HER program implementers typically target high-baseline users because they can achieve the greatest amount of savings (e.g., Glinsmann et al. 2014).

¹⁸ According to Stern (1981), curtailment behaviors are habitual small behaviors that must be done repeatedly to experience energy savings (e.g., turning off lights), whereas efficiency behaviors are one-time investment behaviors that involve a single action (e.g., insulating the attic).

Which Behaviors Are Changed?

Opower evaluates HER programs, in part, by surveying participants about the types of behaviors they may have changed, and whether those behaviors were influenced by the HERs. In some cases, the survey implementer interviews both treatment and control participants, thereby allowing comparison of both groups. In 2013, Allcott and Rogers reviewed 6,000 of these surveys and determined that the primary action most commonly conducted by HER recipients, compared to controls, was to invite an in-home energy audit.

However some evidence also suggests that a large proportion of HER program participants save energy by reducing their use of air conditioners and heaters. Generally, the highest rate of energy savings takes place during the summer and winter, when heating and cooling requirements are highest (Khawaja and Stewart 2014). Furthermore, residents who can control an air-conditioning system typically save more energy in the summer (but not in the winter) than other HER participants (Todd et. al. 2014). Indeed, six Opower programs included in our review recorded households' peak demand usage each year and noted considerable savings during peak periods. These savings were either recorded as percentage savings per customer (0.43–2.2%) or overall annual savings for the power company (e.g., 9,291 therms, or 1.45–15.4 MW).¹⁹ When asked, however, program participants rarely indicated that the HERs were the primary reason for their change of behavior and did not necessarily perceive the usefulness of the reports (e.g., DNV KEMA 2014). This response highlights the potential flaws in self-report measures as compared to direct observation (e.g., of billing analysis). Even though statistical analyses clearly demonstrate that the reports influenced behavior, the self-reports did not always reflect this influence.

In our review, most participants claimed to do nothing in response to receiving HERs. Those who chose to take any action stated that they engaged in such behaviors as "turning things off" or investing in high-efficiency lightbulbs (e.g., DNV KEMA 2014). Navigant for AEP OHIO devised a clever method for overcoming the biases of self-reports (Navigant 2015c). They called participants and, as part of the customer survey, asked them to conduct a short and immediate home audit while on the phone with the interviewer. Participants reported their current thermostat setting, the number of lights left on, the number of high-efficiency bulbs in the home, and so on. This method confirmed that the primary behavior changes were to reduce lighting usage and to invest in high-efficiency bulbs. Habitual curtailment behaviors or small investments (such as lightbulb upgrades) account for the bulk of energy savings from HER programs.

Actively opting in to a HER program is also a key behavior for determining energy savings from the program (the opt-in program will not work if people do not enroll). In one program with a web-based opt-in component, residents reported that they signed up for two primary reasons: to save money spent on energy (35%), and to find out how their home

¹⁹ Nova Scotia Corporation (net peak demand savings of 3.724–3.938 MW at the generator), Southern California Edison (0.43% kW), EnergyFirst Ohio (critical peak demand impacts = ~1,460 kW), Xcel Energy Minnesota (peak savings of 1.45MW–2.22MW/year), SourceGas Arkansas (9,291.18 peak Therms), PPL (peak demand savings 1.7–2.2%), PG&E (peak demand reduction of 15.4 MW).

ranked in comparison with similar homes (32%; CRA and Econoler 2016). From this information, it can be inferred that power companies should work with their customers' specific motivations to encourage enrollment in HER and other energy-saving programs.

Advances in HERs

Specifically targeting a behavior should be the most effective way of changing that behavior. A number of programs use smart meter data, or data from other sources, to provide tailored HERs with energy tips specific to each household's characteristics. For example, some Opower programs send to homes with pools HERs that contain specific tips on how to conserve energy from pool heating, among other tailored messages (Navigant 2015b).²⁰ Ecotagious and BKi have developed HER programs (and websites) that use smart meter data to provide residents with specific information about the largest sources of energy consumption in their homes (e.g., space heating, air conditioning, or other appliances). These programs show promise, but have yet to undergo long-term, large-scale evaluation. In one small opt-in implementation coupled with direct personal appeals to customers by phone, BKi claimed electricity savings of 7.4% and gas savings of 13% per customer (Brown 2014). Ecotagious managed an average savings from their opt-out program of 2%, with a maximum of 4.2% reached when the program was completed after four months (Malatest 2014). Alameda County's Home Energy Analyzer (sometimes also considered an online energy audit program), paired with strong outreach efforts, had 8% gas and 3% electricity savings among 500 participants after five months (Stern and Bates 2014). These figures demonstrate the potential promise of using smart meter data to reduce energy consumption.

A recent evaluation of a long-running Opower program segmented the population of HER recipients according to their energy usage (Opinion Dynamics et al. 2016). Evaluators found that despite receiving reports for at least three years, a small segment of intensive energy users never changed their energy consumption. Therefore Ameren Illinois launched a target rank campaign (i.e., a competition) to encourage this segment to reduce their consumption. This program's results are not yet available, but this innovation is an interesting attempt to draw savings from participants who are unresponsive to HERs.

Some program implementers are now exporting HERs to businesses and water-saving programs as well. Two home water report programs found preliminary short-run savings estimates of 3–12% (Yolles, Gomez, and McBride 2015; Schultz et al. 2015), but these require further investigation and evaluation. Two initial business energy report programs also showed modest success (Stewart 2015; Miknaitis et al. 2014). With relatively large sample sizes (3,000 and 18,000) in randomized controlled trials, these programs report electricity savings of 0.2–0.6% in their first six to seven months. If the typical ramp-up period is required for business reports, then these savings may continue to increase.

²⁰ Some initial research suggests that houses with pools may be among the high energy savers in response to HER programs, but further research would be necessary to determine this (Ashby et al. 2012).

Rhode Island's Augmented HER Program

National Grid, in collaboration with Illume Advising and Navigant Consulting, implemented a HER program in 2013 that was augmented with three innovative additional pilot programs: special HERs for new homeowners, a rewards program, and a free programmable thermostat program (Illume and Navigant 2015; National Grid 2015; Henschel and Corsetti 2014; Dougherty and Hannigan 2014).

The Rhode Island New Movers initiative was implemented in conjunction with a HER program in a randomized controlled trial. Participants were randomly assigned to Group A, who did not receive HERs, Group B, who received HERs, or Group C, who received HERs with a special component for new residents who had just moved. According to Verplanken and Roy (2016), individuals are open to adopting new habits during periods of transition.²¹ Therefore program implementers hypothesized that special HERs directed specifically to this population segment would be particularly effective. Baseline HER program participants (Group B) saved 1% in electricity and 0.4% in gas in the first 14 months of the program. Due to a small sample size, however, participants in the new movers initiative (Group C) did not show savings over and above Group B beyond a small gas savings of 0.5% above the 1% saved by Group B, and a small increase in electricity use of 0.8% below that saved by Group B. However this initial assessment may change with a longer evaluation period and larger sample size.

The rewards program was randomly offered to a subset of HER participants and was evaluated by comparing those who participated in the program to a matched control sample. The program awarded points to participants for saving energy. The points could then be traded in for gift cards or donations to charity. This program successfully influenced participants to save an additional 1% in electricity and 0.4% (nonsignificant) in gas.

The programmable thermostat program was opt-in, and was evaluated by matching control participants (who were not offered the program) with those who chose to enroll in the program. The 112 participants who signed up received a free Honeywell Wi-Fi enabled thermostat that could be operated remotely using the Opower thermostat app. The app provided real-time energy-saving tips and feedback about household temperatures. The thermostat program saved more energy than the basic HER program. HER participants who opted to receive the thermostat saved an additional 2.3% in gas and 0.9% in electricity beyond the savings of a matched control group who received HERs alone.

Summary of Programs

Table 1 summarizes a variety of report programs.

²¹ This is called the habit discontinuity hypothesis (Verplanken et al. 2008).

Table 1. Home energy, home water, and business energy report programs

Program	Program duration at time of evaluation	Net electricity savings	Net gas savings	Notes on study
Home energy reports, electricity				
American Electric Power Ohio	3 years	0.9–2%		Included a live over-the-phone audit for evaluation. Also included an opt-in group that had much higher average per-customer savings. Used both randomized controls and matched controls
Commonwealth Edison, Illinois	6 years	2%		
Connecticut Light and Power (CL&P)	2 years	1.7–1.8%		
Duke Energy	2 years	1.2–1.6%		
Indiana Michigan Power	8 months	1%		
Indianapolis Power & Light	2 years	1%		Examined the effects of various HER delivery frequencies
Northeast Utilities	1 year	0.5–1.7%		Compared standard normative message with rewards message
Efficiency Nova Scotia Corporation	2 years	1.3–1.8%		Evaluated peak demand savings. Included an opt-in group. Separately examined high-baseline users and all users.
Ohio Edison	1 year	175.2 kWh/year/customer		Also evaluated peak demand savings
Potomac Edison & WV, Electricity	1 year	1.6%		
PPL Electric	2 years	1.6–1.7%		Also evaluated peak demand savings
Seattle City Light	4 years	0.1–5.2%		The highest-saving cohort was a small group (with wide margins of error) drawn from participants who may have also enrolled in an earlier opt-in family weatherization program.
Southern California Edison	2 years	0.8–1.3%		Savings validated by additional outside evaluator. Evaluation examined peak demand. Low savings for second wave but could be partly because many participants in treatment group mistakenly did not receive HERs.

Program	Program duration at time of evaluation	Net electricity savings	Net gas savings	Notes on study
Home energy reports, gas				
Berkshire Gas	1 year	0.5%		
CenterPoint Energy	2 years	1–2%		
Peoples Gas and North Shore Gas	8 months	0.6–0.9%		
SourceGas	3 years	438,534 Therms		Also evaluated peak demand savings
Southern California Gas Company	6 months	1%		Opt-in program
Home energy reports, dual fuel				
Ameren Illinois	5 years	0.7–1.7%	0.4–1.6%	Segmented customer population and engaged participants who never saved energy with a target rank campaign (contest)
Baltimore Gas and Electric	1 year	1%	0.3%	
Central Hudson Gas & Electric	1 year	2.4–2.5%	1.1–1.7%	Program had an unusually high opt-out rate (14%). Used a matched control group rather than randomized controls.
EverSource (NSTAR) and National Grid (Massachusetts)	3 years	1.4%	1.3%	Dual-fuel customers saved a smaller percentage of electricity than electric-only customers.
National Grid, New York	1.5 years	1.5–2.3%	0.8%	Dual-fuel customers saved a smaller percentage of electricity than electric-only customers.
National Grid, Niagara Mohawk	20 months	2%	0.6%	
National Grid, Rhode Island	14 months	1%	0.4%	HER program augmented with New Movers initiative, points/rewards program, and smart thermostat program
Pacific Gas and Electric Company, San Francisco	11 to 17 months	0.1–1.5%	0.4–0.9%	Also evaluated peak demand savings. Results verified by additional external evaluator.
Puget Sound Energy	6 years	1–3%	1.1–1.6%	Compared urban and non-urban consumers and found non-urban had nonsignificant savings. Assessed persistence using a "suspended group" of participants who stopped receiving reports.
San Diego Gas & Electric	3 years	1.9–2.6%	1.5–2%	

Program	Program duration at time of evaluation	Net electricity savings	Net gas savings	Notes on study
Vectren Energy Delivery of Indiana	3 years	1.4–1.7%		Dual fuel customers saved a smaller percentage of electricity than electric-only customers.
Xcel Energy	3 years	2.1–3.2%	0.6–0.9%	Also evaluated peak demand savings
Disaggregated-use home energy reports				
Alameda County, BKi	1 year	7.4%	13%	Program included extensive contact with customers, including personal phone calls. Used a matched control group rather than randomized controls,
Greater Sudbury Hydro Inc.	4 months	2.1%		Short program, but savings peaked in last month of program (4.2%)
Home water reports				
City of Sunnyvale, California	3 months			9–12% savings
WaterSmart	6 months			Not clear how control group was recruited. 3–5% savings.
Business energy reports				
Commonwealth Edison & Agentis Energy	7 months	0.2%		
Xcel Energy, Minnesota and Colorado	6 months	0.6%		

Sources: See Appendix C.

REAL-TIME FEEDBACK

Overall, feedback is an effective way to change behavior (Karlin, Zinger, and Ford 2015). It is particularly effective for reducing energy consumption if it is provided frequently (Ehrhardt-Martinez, Donnelly, and Laitner 2010; Karlin, Zinger, and Ford 2015; Foster and Mazur-Stommen 2012). One review that included four studies of real-time feedback combined with dynamic pricing found that peak electricity savings could be as high as 11.3% (Foster and Mazur-Stommen 2012).

The best way to maximize the effectiveness of feedback is to deliver it through an engaging medium such as an interactive computer program and in combination with additional strategies, such as incentives (Karlin, Zinger, and Ford 2015). Interestingly, one meta-analysis of peer-reviewed academic research found that feedback messages comparing participants' energy use to their goals was more effective than comparing it to other people's energy use, as is done in most HER programs (Karlin, Zinger, and Ford 2015). In addition, short or long durations for feedback programs appear to be ideal; programs lasting 3 to 12 months perform worse than those lasting less than 3 or more than 12 (Karlin, Zinger, and Ford 2015).³²

Feedback related to a consumer's goals acts as a mild form of reward or punishment (e.g., Skinner 1969) and allows for regulation of goal-directed behavior (goal-setting theory [Locke and Latham 1990]). Therefore, feedback devices that fulfill this requirement (e.g., by providing frequent goal-comparison information) are the most effective. This section will review research on real-time feedback devices such as home energy management systems, smart thermostats, and websites. In particular, it will focus on research that examines real-time feedback, exclusive of additional games, community-based campaigns, or SEM programs. We discuss SEM efforts later in this report.

Home Energy Management Systems and Smart Thermostats

Devices that sense information about residential energy use, and then either display it or act on it, are known as home energy management systems (HEMS), dashboards, or smart devices (e.g., smart thermostats). The Northeast Energy Efficiency Partnership (NEEP) published an excellent guide to available HEMS that categorizes these devices as either information-based or control-based (NEEP 2015). Information-based devices provide feedback that people must act on in order to realize energy-saving benefits. Control-based devices automatically act on the information that is collected (e.g., power strips that sense when devices are off and unplug them so that they do not use phantom power). These information-based devices save energy through both curtailment (repeated) and efficiency (one-time) behaviors, whereas control-based devices save energy strictly through efficiency (installation) behaviors. Perhaps counterintuitively, the efficiency potential of control-based

³² HER programs are included in this assessment.

devices is not clearly better (or worse) than information-based devices with regards to energy savings, cost of device, or ease of installation (NEEP 2015).³³

Previous generations of programmable thermostats were initially hailed as a useful method for saving energy but, due to human interface issues, they never realized their potential and were dropped from ENERGY STAR's list of recommended devices (ENERGY STAR 2009). Smart thermostats differ from these older devices in that they usually have a clearer and more user-friendly interface and allow users to adjust settings with Internet-enabled devices (e.g., a smart phone or computer). Some smart thermostats are capable of learning about residents' personal routines or automatically sensing when they are home in order to make adjustments. A few of the most popular HEMS and smart thermostat products are the Google Nest Thermostat, Ecobee Smart Thermostat, Honeywell Smart Thermostat, WeatherBug, and Tendril's Energize and Energy Services Management (ESM) Systems. See figure 4 for an example.



Figure 4. Google Nest. Courtesy of Nest.

In pilot studies, Google's Nest thermostat saved nearly twice as much energy as traditional programmable thermostats (NEEP 2015); more recent studies of the Nest and WeatherBug report savings from opt-in programs of approximately 4–4.7% for electricity and 7.7% for gas (Apex Analytics 2014; Brannan, Paidipati, and Cook 2016; Ali 2015).

Potential savings in an entire home are relatively similar for information-based and control-based devices. Information-based devices demonstrate approximately 1% savings, with a theoretical maximum potential of up to 15%, and control-based devices provide savings of 1% with a theoretical maximum potential of up to 17% (NEEP 2015). For HVAC systems specifically, information-based devices achieve 2–22% savings, and control-based devices

³³ Control-based devices start as low as \$75 USD for smart thermostats, which are relatively easy to install. Smart thermostats may also require monthly fees in order to connect to an external server and receive algorithms. Information-based devices such as load monitors and in-home displays can be as inexpensive as \$15 USD. We note that although control-based devices require little or no human interaction, there may be potential negative consequences for spillover or rebound effects (which are behavioral) that, as yet, have not been studied.

achieve 2–16% savings (based on pilot data from a variety of studies, summarized in NEEP 2015).

Control-based devices are clearly better than information-based devices in one domain: saving energy during peak periods. Smart thermostats that can automatically reduce air-conditioning use during peak heat event days are more effective than those that merely inform residents that they can earn rewards by reducing air-conditioning use themselves during those times (5–6.9% versus 23% during peak event days [Jiang 2015; Opinion Dynamics Corporation and DNV-GL report for California CPUC 2015]).³⁴ Similarly, time-of-use (TOU) pricing, combined with in-home displays, may only be effective for reducing consumption with nonspecific TOU pricing schemes. The combination of TOU and in-home displays for event-based pricing strategies may not work as well, but E-6 TOU pricing plus in-home display worked best, with 7.7% electricity savings in an opt-in study (Churchwell and Gupta 2015).³⁵ Furthermore, when in-home displays are combined with TOU pricing and thermostats that can be set to change temperatures during peak periods, savings during the hottest peak periods can be as high as 55% (Harding and Lamarche 2016). However, when cool days are also included, savings dip slightly, to 48% (as compared to a nonsignificant 13% for display plus TOU only, among 1,682 participants [Harding and Lamarche 2016]). Load shifting to post-peak times partially offsets these savings (in this case, increasing consumption by 22% immediately following the end of the peak heat event).

According to the NEEP review, although all categories of home energy use can benefit from HEMS (HVAC, lighting, water heating, appliance, electronics/plug load), the best areas to target are HVAC use, which consumes a large percentage of energy, and plug loads, which are growing rapidly as a source of energy consumption. While most HEMS research to date has focused on electricity savings, a Department of Energy report suggests that gas savings could be substantially increased with the use of smart thermostats and usage alerts (Kerr and Tondro 2012).

A study by Pacific Gas and Electric that used the Honeywell Smart thermostat and Opower interface reported minimal changes in electricity or gas savings, but this might be because of a small sample (505 participants). Another study of connected thermostats (Honeywell) found that they saved about 6.6% in space heating and cooling energy use, or 2–3% of whole-home energy use, and \$116 in energy costs per home during normal weather (among 1,769 participants) (Ward, Stewart, and Jackson 2014].

A study by a California company (Bidgley) that provided real-time usage information through an in-home display, disaggregated by appliance type (combined with TOU pricing), reported an estimated 7.7% in energy savings. Disaggregation was also useful in a water feedback study in Zurich (Tiefenbeck et al. 2015). When participants attached a device

³⁴ Rewards are earned in both the automatic and information conditions.

³⁵ According to PG&E's website, E-6 TOU is a time-of-use pricing strategy that is "best for households with low monthly bills This rate is not likely to be the best option for (households that) have high total monthly usage that goes into the higher priced tiers."

to their shower head indicating how much water they were using for each shower, they reduced the electricity required for heating the shower water by 22%, or an estimated 3.3% of whole home usage, which was better than whole-home feedback studies in the same population (Tiefenbeck et al. 2015).

Human behavior can undermine the savings potential of smart thermostats (Ho 2014; Jiang 2015).³⁶ In a study of 89 households using the EnergyHub smart thermostat, users were found to reduce electricity consumption by 6% when savings were assessed during four summer months; “fiddling with the settings,” however, reduced these savings slightly (Ho 2014). In the same way, 19–20% of participants in the Oregon Nest pilot study reduced their potential savings by turning off the AutoAway function of their thermostats (Apex Analytics 2014). Determining when and why this “fiddling” occurs is an important avenue for future research.

For control-based HEMS, the critical behavioral components are (1) the decision to install the device, and (2) the efficient (but infrequent) use of the device. In the Oregon Nest pilot study, 88% of survey respondents indicated that they chose to install the device in order to save energy (Apex Analytics 2014). However many of those who installed the Nest thermostat later identified important nonmonetary benefits, and often claimed that they would be willing to purchase and install it at full price (\$250 USD), sometimes stating that they would be satisfied with it even if it saved no money (Apex Analytics 2014).³⁷ They tended to self-report increased satisfaction with their home’s temperature and with the energy savings demonstrated through bill analyses (Apex Analytics 2014). Importantly, participants also self-reported that the thermostat was easy to use and, over time, they became more satisfied with the temperature of their home, suggesting that perhaps they were learning how to better operate the device.

DTE Energy Insights Smartphone App

A series of studies that were conducted on the DTE Smartphone Insight App provide energy-use feedback (Navigant 2015a, 2016a, 2016b). This app motivates users to save energy by providing near-real-time feedback on home energy use (with a 60-second delay), and weekly challenges that can earn the user achievement badges and points to improve the appearance of their in-app avatar. The app was tested for electricity and gas savings over the course of 6 to 17 months in 3 pilot studies that used matched controls and randomized encouragement designs. In these initial studies, energy savings were estimated at 1.1–3.2% for electricity and 2.3% for gas, after adjusting for savings by other utility programs (among 7,379–8,940 users). The program is effective for saving energy and may work because of the feedback, the game, or both in combination.

³⁶ This study used the Energy Hub smart thermostat, which is not a learning thermostat like the Nest.

³⁷ Given that this was an opt-in program, participants may have provided biased responses to these questions because they were motivated to find the program useful.

AUDIT PROGRAMS

Home or business energy audits encourage energy savings because they usually provide information and guidance about how to save energy, and installation of actual energy-saving measures such as free CFLs and faucet aerators. Home energy audits benefit from the in-person interaction between auditor and resident, but some utilities also offer phone or online audit programs that have been quite successful. Precise energy savings from these programs are difficult to assess, although programs sometimes do estimate such savings. Two examples illustrate the range and magnitude of possible savings. FirstEnergy reported savings of 6,254,000 kWh from its Ohio companies' audit programs (ADM Associates 2014). National Grid reported savings of 13,242,000 kWh and 693,350 therms (National Grid 2015). The percentage of electricity savings obtained by one online program was estimated at 1.3% (Ignelzi 2015),³⁸ and a telephone-based audit reported savings of 6.5% (Southern California Edison 2013). These savings may be slightly underestimated because evaluations were conducted only one year after the audits. In the case of business audits (and most likely home audits), efficiency upgrades are not typically implemented all at once in the first year; they are usually completed within three years but often take as long as six (NYSERDA 2012).

Energy audits are effective to the degree that they lead to implementation of energy efficiency upgrades or installations. Traditionally, four positional factors have best predicted adoption of energy-saving devices at home: home ownership, socioeconomic status, ownership of home technologies, and the presence of a household member able to perform household repairs (Costanzo et al. 1986). Once these conditions are met, social-psychological factors may come into play. Potential social-psychological principles that contribute to the effectiveness of energy audits are in-person interactions, the foot-in-the-door technique (explained in the section below called The Best In-Person Strategies), and the use of tailored/customized reports, among others. For example, a customer who commits to fixing a roof (the first part of the foot-in-the-door technique) may then be more likely to also commit to investing in ceiling insulation. Hence, contractors may be particularly effective at encouraging energy efficiency upgrades during periods of major home renovations.³⁹

Active engagement with energy audit participants is vital to the success of audit programs. Participants are more likely to enroll in programs or follow up on recommendations if they are contacted more frequently and more personally. A large-scale review that examined a number of energy adviser service programs identified effective personal contact with homeowners (e.g., reviewing an assessment together) as a key success factor for converting home audits into energy-saving upgrades (Billingsley, Stratton and Fadrhonc 2016). The report suggests that energy advisers, or auditors, should be able to guide customers through information barriers by providing knowledge about rebate programs and upgrades or actions that could save energy; through decision-making barriers, for example by reviewing assessment results with the customer; and through transactional barriers, for example by

³⁸ Electricity savings for this program were estimated at 1.3% of monthly electricity use during the year in which customers received the audit report.

³⁹ This phenomenon is also explained by the concept of shopping momentum (Dahr, Huber, and Khan 2007).

helping with scheduling and paperwork. Therefore, home energy advisers should do more than simply provide information about possible energy-saving options; they must also work with the customer to facilitate each step of the home upgrade process. These interactions provide multiple opportunities to employ various social science-derived in-person or informational behavioral strategies.

In an Arkansas CenterPoint Gas survey about participation in its HVAC rebate program, 29% of respondents said they took part because their HVAC contractor recommended it. Some 64% of participants heard about the program through their contractor (Thomas et al. 2014). Despite the clear importance of the financial costs and benefits of these rebate programs, in-person interaction between home energy professional and resident appears to be a vital point of entry for program introduction.

Several home energy audit programs have demonstrated effective social science-informed strategies for encouraging home energy upgrades. Some of these are presented in the examples below, along with administrators' evaluations of energy savings, where available.

Narragansett EnergyWise

By providing no-cost in-home education to residents, Narragansett Electric Company, in Rhode Island, is able to increase the uptake of efficiency retrofit programs. The heart of its EnergyWise program is a visit by a home energy assessor to the customer's residence. In an assessment, the professional evaluates the customer's entire home and explains how certain upgrades and changes could reduce energy consumption and increase comfort. The assessor also provides energy-efficient lightbulbs, advanced power strips, and pipe insulation to achieve immediate energy savings. He or she then explains available incentives that would help achieve deeper savings through cost-effective improvements to insulation, air filtration, and air leakages. Another aspect of the initiative is a weatherization assistance program (for heating-oil customers) and a 0% interest HEAT loan program (to finance efficient space heating, water heating, and insulation). These components were well used in 2014, when 1,003 HEAT loans were procured and 482 households participated in the weatherization assistance program (reducing consumption by 127,630 therms). Overall, the program saved 13,242,000 kWh and 693,350 therms in 2014 (National Grid 2015). This type of program capitalizes on social science-derived strategies such as using the foot-in-the-door technique, increasing the attractiveness of behavioral options (through incentives), providing information, and various in-person communication techniques (described in the Social Interactions section of this report).

TVA eScoreCard

The Tennessee Valley Authority in-person energy audit program includes a report in the form of a scorecard. This eScore provides a visual answer to the consumer's question "How can I make my home more energy-efficient?" and it does so by comparing the customer's current home to his or her "best home" (Hayes 2014). Tradewind Group, which designed the scorecard, found that appropriate messaging could increase the rate of implementation following the receipt of energy assessment reports. Through traditional market research, Tradewind determined that highlighting personal benefits motivated people more than highlighting environmental benefits, and that energy and dollar savings were not as

motivating as the desire to rate a “10” on the scorecard. These subtle changes to the audit report could be the reason that the TVA’s In-Home Energy Evaluation pilot claims an installation rate of over 70% across 55,000 audits from 2009 to 2014 (Hayes 2014).⁴⁰ This program exploits the social-psychological finding that people are more likely to act in line with messages that address their specific motivations.

FirstEnergy Online and Phone Audits

Despite a lack of interpersonal influence, online and phone-based audit programs can be effective. A report prepared for three FirstEnergy companies (Ohio Edison, the Cleveland Illuminating Company, and the Toledo Edison Company) about their audit programs showed that online and phone-based audits saved a combined 6,254,007 kWh, whereas in-person audits (costing \$100) saved 1,006,179 kWh (ADM Associates 2014).⁴¹ Online audits were completed by 10,612 customers using FirstEnergy’s web-based program, Home Energy Analyzer, after learning about the program largely through their utility. Telephone audits were completed by 4,545 customers; these were usually administered after a customer called in with questions about a high bill. In both cases, audits ranged from Level 1 (basic questions resulting in stock reports comparing types of homes and generic tips for conservation) to Level 3 (specific questions about appliances and customized suggestions that explored weatherization, cooling, and other topics). Level 2 and 3 audits (completed by one-third of online participants and 97% of phone participants) were thought to result in increased savings, but program evaluators did not verify this assumption. Most of the energy savings from these programs came from curtailment (behavioral) rather than efficiency (structural) changes, and most (86–100%) persisted from the first year to the second, according to customer surveys (ADM Associates 2014). This program also used the foot-in-the-door technique (explained in the section below called The Best In-Person Strategies) to help encourage energy efficiency upgrades.

Energy Kits

Some power companies, such as Ohio Edison, implemented a program in which home energy kits containing CFLs, faucet aerators, a smart power strip, a furnace filter whistle, and LED nightlights were mailed to customers or distributed to homes via students in school, without the assistance of a home energy audit (ADM Associates 2014). In total, the company distributed 236,660 kits and estimates that the kits resulted in a savings of 94,553,937 kWh annually (gross). The behavioral component of the program—installing the devices—was assessed using a survey. The installation rates varied depending on the product. CFLs were the most likely items to be installed, at 56–70%, and faucet aerators were the least likely, at 12–18% (ADM Associates 2014).⁴² A similar, opt-in version of the program, accompanied by training workshops and active engagement by the Pennsylvania

⁴⁰ These numbers are not verified by ACEEE, and the methods used to determine installation rates are unknown to us.

⁴¹ The per-customer savings and percentage reduction in energy use are not reported.

⁴² Installation rates are presented as a range because they differed between residential and school-based distributions.

Public Utilities Commission (Cadmus 2014), found that these same devices were all installed at rates of 79–94%, thus demonstrating the power of engagement strategies to increase behavior change. This type of program may work partly because of the *reciprocity norm*. When people receive something for free (such as an energy kit), they feel obligated to repay the favor in some way. In this case, the repayment could be engagement in the requested behavior: installing devices or buying further upgrades.

One problem with this type of energy kit program, however, is that energy-saving devices do not always replace less efficient devices. For example, 70% of the recipients of kits in the Ohio Edison program installed the LED night-light that came with the kit, but 36% of the installed night-lights did not replace less efficient lights (ADM Associates 2014). Similarly, when Southern California Edison distributed energy-efficient television set-top boxes to customers, they found that the average number of boxes per customer increased from 1.3 to 2.7, relative to controls (Dunn et al. 2015). An important lesson learned from these programs is that simply providing energy-efficient products does not necessarily decrease energy consumption (and may, in some cases, increase it). When customers have the flexibility to decide what items they receive in their energy kits, they maximize their energy savings and increase their satisfaction with the kits (Castor 2014), while also possibly addressing the nonreplacement issue.

THE MOST EFFECTIVE PERSUASIVE MESSAGES

In this section we discuss a number of specific information-based strategies that can be incorporated into larger programs to reduce energy consumption. These are mostly smaller academic studies, conducted in labs or in the field, that exploit individual behavioral insights to target energy use. Administrators should consider them when creating individual elements of an information-based program.

Financial Versus Nonfinancial Appeals

Several studies of message framing for energy efficiency have examined the interesting question of whether financial appeals are the best way to motivate customers. Perhaps not surprisingly, the answer depends on who is asked. In a Japanese study conducted by economists, researchers increased peak heat or cool event electricity prices and sent accompanying messages about the increase; they found that this intervention resulted in energy savings of 15.4%. In contrast, sending messages to customers with moral arguments for reducing electricity use, with no change in price, triggered energy savings of 3.1%. The study was conducted over one summer and one winter period across 691 participants (Ito, Ida, and Tanaka 2015). The price (dis)incentive also triggered a longer persistence of savings after the intervention was stopped than the moral suasion did. This outcome is particularly surprising given that the moral argument should result in intrinsic motivation, while the price manipulation should be strictly externally motivating.⁴³

⁴³ Importantly, cultural factors may influence the effectiveness of the same messages in different countries. The messages may have different meanings, responses may be more or less likely to be extreme, and the importance of certain topics may vary (among many other issues).

Nevertheless, American studies conducted by non-economists showed that price fluctuations did not strongly affect energy consumption behavior (Jessoe, Rapson, and Smith 2013) and that economic appeals resulted in less intention to enroll in an energy efficiency program than did environmental appeals (Schwartz et al. 2015). One German utility asked its customers to state their intentions to conserve energy after presenting energy-saving tips as ways to cut costs or to reduce CO₂ emissions (Steinhorst, Klöckner, and Matthies 2015). The two appeals resulted in equal intentions to reduce energy consumption, but the environmental phrasing led to increased intentions to engage in pro-environmental behaviors not directly related to energy (e.g., eating less beef or donating money to a climate action group).⁴⁴ A similar study in North America observed the same thing: participants who received their results from a home energy calculator in terms of CO₂ emissions (rather than kWh or costs) were more likely to say they intended to engage in energy-efficient and other pro-environmental behaviors (Asensio and Delmas 2015).

In an American study of energy use (based on billing analyses over 100 days for 118 households), participants who received HERs comparing their energy use with their neighbors' in terms of "pounds of air pollutants" (health framing) conserved more electricity than others who were randomly assigned to receive the same message phrased as "dollars saved" (Asensio and Delmas 2016). Those who received the health-framed reports achieved savings of 8–10% that persisted until the end of the 100-day study. Those who received the monetary message showed a small decrease in energy use for two weeks, but this decrease had nearly disappeared by seven weeks (relative to controls).⁴⁵ In an opt-out home energy report study with 25,000 participants, a normative message (comparing a customer's energy use with others') resulted in energy savings of 1.7%, while a reward message (offering rewards for using less energy now than this time last year) brought savings of only 0.5% (Trottier 2014).

The debate regarding the best way to frame appeals to change behavior—as cost saving, healthy, or environmentally friendly—does not have a clear winner. It is likely that both monetary and nonmonetary strategies are effective. Any persuasive message is effective only if it takes into account its source, its audience, and its content (Lasswell 1948). Hence, the choice to use a monetary or nonmonetary message depends largely on a combination of those three factors. Pricing strategies can be effective for reducing energy consumption as long as consumers are well informed and able to take action (i.e., they have effective feedback about their energy use and can control it).

But perceptions also matter—and depending on the precise wording of the appeal, perceptions of the same costs can appear different to different people. Health and environmental messages might be more effective than economic appeals if the financial

⁴⁴ Intentions do not correlate perfectly with actions, but according to various studies of the theory of planned behavior, they are good predictors of actual behavior (e.g., Armitage and Connor 2001).

⁴⁵ This was an opt-in program and, therefore, participants were likely more motivated to save energy than other HER program participants.

costs are perceived as relatively insignificant (e.g., a small amount paid off over a long period) and the equivalent health or environmental costs are perceived as more significant. Wealthier customers, for example, might be more influenced by a health or environmental message because they perceive a reduction of a few dollars from their monthly bills as unimportant.⁴⁶

Selling Comfort

Environmental, health, or financial appeals may work in the context of conserving energy or reducing consumption, but when selling home energy upgrades, emphasizing comfort may be the best approach. In the final evaluation of the Better Buildings Neighborhood Program, which examined nearly 200 programs across 41 grantees, comfort was an important factor in motivating customers to enroll (Research Into Action et al. 2015). These programs found that although there was an energy efficiency benefit, one of the primary reasons that consumers purchased upgrades was to improve the thermal comfort of their residences.

Avoiding Choice Overload

Choice overload can reduce people's willingness to take action. Although customers claim they like having options, many studies—but not all—have found that those with too many options sometimes choose nothing. Overall, results of research on this topic are mixed (Scheibehenne, Greifeneder, and Todd 2010). One example of a program to reduce audit-choice overload is presented below.

ENERGY AUDIT REPORTS AND CHOICE OVERLOAD

In a joint pilot program, Franklin Energy Services and Xcel Energy reduced choice overload for households considering home upgrades and consequently achieved a small increase in the number of home upgrades undertaken. Traditionally, homeowners who received energy audits subsequently received tailored reports with many recommended actions for saving energy. In this experiment, some homeowners were randomly assigned to receive the traditional report while others received the report with an additional cover letter suggesting up to three actions that would be most effective for saving energy. One year later, the 47 participants who received this cover letter saved a mean of 3,629 kWh and total of 252,841 kWh, with 16 installed measures, whereas the 40 participants who received only the traditional report saved a mean of 1,972 kWh and a total of 97,925 kWh, with 9 installed measures. On their own, changes in wording or presentation of information are usually quite small. Therefore, with the relatively small sample size of the study, it is not entirely surprising that this difference was not statistically significant ($p = .29$), but with a larger rollout and a longer time frame, the result could become so (Syring 2014).

Prompting

Prompting is the strategy of providing relevant information directly at the point where action may be taken. Osbaldiston and Schott (2011) found that, of 10 major pro-environmental behavior change strategies, prompting was the only information-based technique that had some success; giving instructions was, on average, the least effective.

⁴⁶ This hypothesis has yet to be tested.

Signs in public restrooms reminding users to turn off the lights, saved an estimated 10.6 kWh per day across 17 restrooms (30.1% of electricity used by lights in those rooms), depending on the type of lights and size of the room, relative to controls (Sussman and Gifford 2012). When researchers used signs in office buildings asking employees to open or close their windows (an energy-efficient method of managing office temperatures), the compliance rate was 10–30% (Ackerly and Brager 2012). But signs work only when participants are already motivated to engage in the behavior and there are few barriers to action (e.g., competing priorities or inconvenience). This may be why signs are less persuasive than oral communications (Wilson and Sherrell 1993).

Changing Defaults

Changing the default option is a powerful and simple method of presenting information that can influence program participation rates. Decreased cognitive effort (e.g., Huh, Vosgerau, and Morewedge 2014) or motivation to avoid potential loss (Tversky and Kahneman 1991) may explain why most people stick with the default option they are presented. Default bias is the reason enrollment is higher in programs that participants must actively choose to opt out of, rather than opt in to (e.g., Todd 2015). It also explains why setting in-home devices' defaults to eco-mode can significantly reduce energy use. Xbox video game consoles set to power down after one hour save an estimated average of \$30 to \$100 in electricity use each year (Hittinger, Mullins, and Azevedo 2012), and when televisions are set to optimal brightness by the technicians who install them, electricity demand is also reduced (Frank et al. 2012). However in many cases, changing defaults or using opt-out designs for energy efficiency programs is not feasible because the programs require a high level of involvement (e.g., competitions). Therefore, opt-out designs are most commonly used in HER programs and in studies of smart thermostats (discussed later in this report).⁴⁷

Social Interactions

The social influence that stems from live interactions between two or more people can effectively encourage energy reduction behaviors (e.g., Gonzales et al. 2013; Mazur-Stommen and Farley 2013). These interactions allow subtle communication patterns that are not easily replicable in other forms of discourse. Behaviors such as maintaining eye contact, smiling, nodding, and leaning forward can help generate rapport between two actors and induce the speaker to like the listener more (e.g., Chaikin et al. 1978; Palmer and Simmons 1995). Similarly, individuals who are better at eliciting self-disclosure in conversations are generally better liked (Miller et al. 1983). Liking, rapport, and the sense of connection generated by in-person interactions may be part of the reason that direct verbal communication is more persuasive than other forms of interaction (Wilson and Sherrell 1993).

⁴⁷ Goldstein et al. (2008) provide an excellent and simple guide to using the default setting strategy for changing behavior.

Indeed, a myriad of subtle social cues that come into play during in-person communication are absent from written, or even verbal (telephone) interactions. Humans naturally crave social interactions and are hyper-attuned to facial expressions (e.g., Purvis, Dabbs, and Hopper 1984), body language (e.g., Chartrand and Bargh 1999), smells (e.g., Gangestad and Thornhill 1998), changes in tone of voice (e.g., Ambady et al. 2002), and other aspects of interpersonal interactions. Not surprisingly, then, when we learn about social norms through methods that are relatively devoid of emotion (such as HERs), our behavior is less affected than when we learn about others' behaviors through personal interactions. These rich and engaging communications naturally involve multiple social-influence strategies working in tandem.

In this section, we discuss and evaluate two types of programs that rely heavily on social interactions, and then we consider specific in-person social-influence strategies that can be incorporated into a number of programs. The two types of programs are:

- Competitions and games
- Community-based programs

COMPETITIONS AND GAMES

Competitions and games can be used to effectively change behavior and reduce energy consumption. According to the ACEEE paper *Gamified Energy Efficiency Programs* (Grossberg et al. 2015), energy efficiency games and competitions motivate behavior change, not only for the purpose of earning a reward (as might occur when accumulating air miles, for example), but because the process itself is fun. Simply competing, without the prospect of a reward, can make an activity more enjoyable and challenging (Deci, Koestner, and Ryan 1999), and it may motivate participants because they do not want to lose (Haran and Ritov 2014). This could be part of the reason that energy efficiency competitions in offices are effective; employees who are happier are more likely to engage in pro-environmental behavior at work (Bissing-Olson et al. 2013).⁴⁸

Vine and Jones (2015, 3) note that "at their core, competitions provide a set of rules, mechanisms to track results, and public acknowledgement (recognition) to participants for their progress in achieving a specified objective." They go on to say that the most successful games and competitions engage everyone, rather than just winners (Vine and Jones 2015). All participants receive recognition and rewards so that even those who are unlikely to win will probably try to make some changes. While energy-saving competitions usually take place between or within residential buildings, office groups, neighborhoods, or cities (Dougherty et al. 2015), they can also occur among individuals online. Among children, working with others to compete for a shared goal may increase motivation, promote continued play, enhance self-efficacy, and increase pro-social behaviors (Marker and Staiano

⁴⁸ The link between happiness and pro-environmental behavior is not necessarily causal. Office employees may be happier because they engage in pro-environmental behavior, or they may behave pro-environmentally because they are happier (or there may be a third variable causing both effects).

2015). Hence, in some cases, games requiring group cooperation may improve outcomes, relative to individual competitions.

This class of gamified programs, like many social interaction programs, works by implementing several behavior change strategies. In this case, extrinsic rewards are usually offered (e.g., money or tangible prizes) along with intrinsic rewards (e.g., social reinforcement, praise, and a sense of accomplishment). There are also goals set, commitments made, feedback provided (with comparison to others), and prompts used to encourage behavior follow-through (Vine and Jones 2016).

In our review, we found similar energy savings results as in previous reviews in this area (Grossberg et al. 2015; Vine and Jones 2015; Dougherty et al. 2015).⁴⁹ Looking at a combined total of 18 programs that included some competition or game elements and were evaluated for percent energy savings, we found that most achieved electricity savings of 5% or less. That said, some participants in some competitions were able to save as much as 14–30%; the top 10% of participating buildings in the Campus Conservation Nationals, and the winning school in Washington, DC's Sprint to Savings, for example, were able to save 30% (Donovan 2014; Vine and Jones 2015).⁵⁰ It is thus clear that both residential and commercial (e.g., workplace) competitions can produce a wide range of electricity savings (gas savings are typically not targeted or reported). Our review (in Appendix D) found that residential programs usually saved less than commercial programs. In five residential programs we found savings of 0.7–4% electricity and 0.4–10% gas, and in six commercial programs savings were 1.8–6.5% electricity.⁵¹ Dougherty et al. (2015) found similar results for both sectors (3–14% electricity in nine residential programs; 5–21% electricity in seven commercial programs). Grossberg et al. (2015) observed that large-scale programs tended to be associated with lower savings (3–6% electricity) than narrowly targeted programs (10% electricity).

Although games and competitions are among the most popular behavior change programs, they are rarely evaluated for persistence of savings (Vine and Jones 2015; Grossberg et al. 2015; Dougherty et al. 2015). Unlike other programs, such as HERs, competitions and games normally cannot run indefinitely—eventually some person or group must win (or lose) in order to motivate participants. The question of whether energy savings from games or competitions persist beyond the end of the program is, therefore, an important one. Early studies of recycling competitions suggest that behavior may return to baseline after external rewards are removed (e.g., Witmer and Geller 1976). To our knowledge, only one program, involving competitions in small Iowa communities, chose to investigate persistence after a considerable period of time (Yates 2014). This study found that initial energy savings (4%

⁴⁹ See Appendix D for a list of competitions and games that we included in our study and that were not found in other reviews.

⁵⁰ These high savings were not evaluated for persistence.

⁵¹ In our review, all five residential programs evaluated electricity savings, but only three evaluated gas savings.

electric, 10% gas) persisted for at least 1.5 years, but the degree of persistence and method of evaluation are unknown.

The key questions, as with any program, are how internally motivating the program is, and how much the program changes automatic (habitual) behavior. If participants are purely motivated by the tangible reward earned by winning the competition, and if this reward does not lead to a durable change in habits, then the extrinsic motivation may undermine the intrinsic pleasure of playing (Deci, Kostner, and Ryan 1999), and when that reward is removed, behavior may return to baseline (e.g., Symonds, 1927). Furthermore, an extreme emphasis on energy savings as the desired outcome of a program may lead to exaggerated claims of savings, and behavior that is not continued beyond the end of the program (Johnson et al. 2012). In early recycling studies, for example, campus competitions with tangible rewards (e.g., money or raffle tickets) led to behaviors that maximized the chance of winning rather than reducing waste, such as turning in multiple single sheets of paper rather than large bundles, or purchasing more drinks in recyclable containers in order to have more to recycle (Luyben and Cummings 1982; Geller, Chaffee, and Ingram 1975). If games can serve the important function of internally motivating participants and disrupting habits so that new ones can be formed, then they may theoretically lead to lasting behavior change. Frey and Rogers (2014) argue that changing how people think or changing future costs can also increase the likelihood of persistence. A few of the most successful competitions and games are highlighted below.

Cool California Challenge

This inter-community program engaged cities in California to compete against one another to determine which could most reduce greenhouse gas emissions from household energy and transportation. Participating households in each city earned points based on their self-reported energy consumption behavior relative to similar households. In addition to reducing energy consumption, participants could also earn points by sharing their stories and photos on the program website (facilitating social comparison and culture shift). The city earning the most points at the end of the program was named “Coolest California City.” Several cities attempted to improve their chances of winning by implementing their own local activities to further encourage participation in the program (e.g., Sacramento’s Cut Your Cubes). The program reduced electricity consumption in 2012–2013 by 14%, relative to a delayed control group.⁵²

Biggest Energy Saver (San Diego Energy Challenge)

San Diego Gas & Electric used this competition among individual households within a community (intra-community challenge) to encourage energy reduction in homes, especially on peak heat days. The program was unique in that it was promoted through San Diego middle schools. Participating households could win prizes either for themselves and a middle school of their choice (part 1) or for themselves alone (part 2). In part 1, participants had to opt in to the online software and join a middle school team. In part 2, San Diego Gas & Electric recruited a large sample (44,000 customers) and sent them weekly

⁵² See Vine and Jones (2015) for an excellent summary of the program.

energy reports with neighbor comparisons and energy-saving tips to facilitate competition. During this latter part, participants could earn extra points and prizes if they also opted in to the online software. Together, both parts cost \$1 million and reduced peak load by 2.2%. Over three months, part two participants who opted in to the website reduced electricity consumption by 20%, while those who received the emails alone reduced consumption by 9%.⁵³

Office Competitions in the Northwest

In a recent review of office energy-saving competitions in Seattle, Portland, Vancouver (Washington), and Boise, 70 buildings saved an average of 2% to 6% in electricity consumption annually, as self-reported using a tracking program (Ochsner, Jones, and Siong 2014). The competitions were run in conjunction with the Building Owners and Managers Association and included the Office Energy Showdown, Carbon4Square, and the Kilowatt Crackdown.⁵⁴ Building owners or operators typically implemented the office competitions and helped encourage tenant businesses to plan and carry out energy-saving programs. In some cases, program administrators also provided guidance—for example, Kilowatt Crackdown offered energy coaches—and assisted in program design and implementation. Businesses or buildings competed against one another.

CALS Green Energy

A competition program similar to the Northwest office competitions was implemented on a university campus. Five mixed-use Cornell University buildings—including offices, research facilities, and classrooms—competed against one another to conserve energy. The participating buildings reduced electricity use by 6.5%, while similar (control) buildings increased consumption during the same period by 2.4% (Dixon et al. 2015).⁵⁵ One year after the competition, the campus buildings that hosted the competition showed persistent but reduced savings.

Battle of the Buildings, Industries, and Cities

ENERGY STAR sponsors building challenges on a national scale. Its Battle of the Buildings has enrolled 100 teams in 5,500 buildings, and its Challenge for Industry has enrolled 1,150 industrial plants. Both competitions have participants from all 50 states (as well as Washington, DC, and Puerto Rico). These massive programs require buildings and industries to track their progress using ENERGY STAR Portfolio Manager, ENERGY STAR Tracking Tool for Industry, ENERGY STAR Plant Performance, or another established tracking program. On the basis of participants' self-reporting, the US Environmental

⁵³ Again, Vine and Jones (2015) offer an excellent summary.

⁵⁴ Many other, similar office competitions exist nationwide, but few have been evaluated for energy savings. BOMA Greater Minneapolis collected some statistics on savings (2014 participants saved 6.5 gigawatt hours of electricity), but there is no indication of how the statistics were calculated. The same is true of Arlington's Green Games Office Competition, where 2011 to 2012 usage reductions were reported to be 11% in water, 5% in electricity, and 22% in natural gas. A cursory list of 14 other challenges can be found here: www.boma.org/sustainability/info-resources/Documents/Kilowatt%20Crackdowns.pdf.

⁵⁵ In fact, six buildings took part in the competition, but data were available for only five of them.

Protection Agency claims that, in one year, participants in the Battle of the Buildings challenge saved a combined total of at least 2 billion kBtus of energy, with 61 of the 5,500 buildings cutting energy use by 20% (ENERGY STAR 2014). On an even larger scale, cities can compete in ENERGY STAR's Top Cities challenge by having the largest proportion of ENERGY STAR-certified buildings relative to other cities. ENERGY STAR-certified buildings use, on average, 35% less energy than noncertified buildings (ENERGY STAR 2016).

Cool Choices

This Wisconsin-based nonprofit created a game in which participants could earn points by engaging in energy-reduction activities of various levels of difficulty. In total, there are 58 actions (each on its own card) in four categories: *Step* (small repeatable actions such as "turn off light"), *Leap* (less frequent actions such as "optimize tire pressure"), *Focus* (actions such as "explore how your home uses electricity"), and *Create* (implement your own action, not otherwise listed). More difficult actions earn more points, and participants can earn bonus points for documenting and sharing their behaviors. This ready-to-go program has been implemented at a number of workplaces, usually as a competition between employees to earn points (and trade them for prizes). The Milwaukee fire department noted a 6.6% reduction in electricity consumption during the game relative to nonparticipating firehouses (a 3.1% decrease versus a 3.5% increase) (Keene and Bensch 2014). Households with children in two Wisconsin school districts reduced electricity consumption by 2.1% in the year after the game compared to the year before (Bensch 2014). Miron Construction reported estimated savings of about 4% of electricity use and less than 1% of natural gas use after the game compared to before it (Bensch 2013).

COMMUNITY-BASED PROGRAMS

Community-based energy efficiency programs involve social interactions and are customized to target specific groups (not only neighborhoods or city communities, but also communities of employees of a business, or workers in a building). Therefore each of the programs is structured differently and contains disparate components depending on the target group and behavior. A program running in the southern United States, for example, might work through trusted local partners such as churches (Mazur-Stommen, Vigen, and Farley 2013). Similarly, some groups respond best to an environmental message, whereas others respond to an economic rationale. One research group tried to tackle this issue by testing a method of segmenting small- to medium-sized businesses according to a number of factors including baseline energy consumption (codifying a unique "DNA" for each; Laurain et al. 2016).

Once again, the concepts of specificity and customization are important for effectiveness. These programs can be highly effective because, after considering their particular target audience and behavior, they use many relevant behavior change strategies and programs to instigate change. The programmers design the intervention for maximum effectiveness rather than for testability and evaluation. Recent years have seen a more widespread use of evidence-based behavior change principles to inform community-based strategies. For example, a model espousing four goals—Engage, Educate, Motivate, and Empower— influenced several programs (Petersen, Frantz, and Shammin 2014).

Combining a previous review (Dougherty et al. 2015) with our own, 19 community-based programs were examined. Of these, 7 were residential and produced gross electric savings of approximately 11–30%, and 12 were commercial, producing gross electric savings of approximately 8–31%.⁵⁶ Residential community-based programs typically involve community events, trusted messengers, marketing, and a variety of strategies to encourage active engagement with the program. Commercial programs are similar in that they also use trusted community members and a number of engagement strategies. Both residential and commercial programs sometimes include public dashboards that display the communities' aggregated energy use, and these are often combined with a contest to reduce consumption. In practice, community programs usually include many of the other program types described in this review (i.e., they use a stacked approach, described later).

The community-based programs described here include residential and commercial initiatives as well as programs targeting behind-the-scenes players (e.g., town energy committees). They frequently include strategies and outreach elements such as public commitment, marketing, prompts, training sessions, and workshops. They may also involve in-person interactions, energy champions, energy audits, competitions, social comparison information, and energy feedback (explained in the In-Person Strategies section). The fact that the intervention involves a community of people may also have the additional benefit of a support network that helps participants follow through with their intentions. In one study, when community group members came together for regular meetings, they followed through with their planned pro-environmental behaviors even two years later (Staats, Harland and Wilke 2004).

Several examples of community-based programs that demonstrate energy savings using a variety of behavior change strategies are presented below. Program administrators who are implementing their own programs might wish to use them as starting points.

Community Energy Savers

AEP Ohio's community-based residential program targeted underrepresented communities (Henderson, Dwelley, and Hubbard 2015). It used behavioral strategies such as goal setting, community-level feedback, and peer-to-peer interactions. To encourage uptake of the program, implementers used outreach strategies such as door-to-door canvassing, attending local events, and hanging posters in local businesses. Communities that met their participation goals also received a cash reward from AEP Ohio. The program increased participation in existing energy efficiency programs by 1,164 customers, saving an additional 662,704 kWh of electricity (beyond what was expected from the existing programs alone) and increasing customers' awareness of these energy efficiency programs.

Vermont Home Energy Challenge

This program, sponsored by Efficiency Vermont and the Vermont Energy Investment Corporation, targeted town energy committees. The primary focus was encouraging

⁵⁶ Net savings were not available.

committees to pledge to (and eventually follow through on) weatherizing homes within their towns. The ultimate goal was to enroll as many households as possible in the Home Performance with ENERGY STAR program. Implementers accomplished this with a large number of intervention strategies, offering prizes for soliciting homeowner pledges (and percentage of projects completed) as well as small grants for energy efficiency projects and training for volunteers. The committees then implemented extensive outreach efforts, such as door-to-door visits, telephone campaigns, and home energy parties, to enroll participants. Seventy-nine town energy committees and local partners agreed to participate, each setting a target of weatherizing 3% of homes in their communities. Organizers received 1,512 pledge cards from homeowners in 2013, and one-fourth of pledge signers committed to completing a comprehensive project. However the program was not evaluated for energy savings (Efficiency Vermont 2014).

PowerED

A prime example of the stacked approach (described below) was employed by PowerED, a program administered by McKinstry, an energy and facility services expert, in school and local government facilities (Ruiz 2014). Overall, the program focused on three elements: people (behavior), process (technical upgrades), and performance (tracking and measuring success). Programs leveraged a large number of strategies across different organizations. In a Colorado school district, for example, PowerEd included energy champions at each site as well as a district-level steering committee. The program also solicited pledges (commitments) from students, encouraged engagement through a website, and created student energy audit teams that provided fun educational opportunities. In addition, PowerED trained custodial and facility staff on energy efficiency and installed an energy feedback dashboard for them to use. These staff members were made responsible for changing certain practices, such as shutting down systems during school breaks. Overall, the behavior change intervention achieved savings greater than 20% in some facilities, with one school reducing gas and electricity use by 34%.⁵⁷

Narragansett Residential New Construction Program

Narragansett Electric Company implemented a program that targeted homebuilders and included no-cost education, analysis of plans, and in-the-field technical assistance (National Grid 2015). It also included a few innovative solutions based on social comparisons: the Pro Tour, in which builders could receive free tours of zero net energy buildings, and the posting of success stories that highlight the best energy-saving buildings. Narragansett estimates it saved 813,000 kWh and 71,150 therms through the program in 2014, which cost \$1,081,200 (cost-benefit ratio: 5.64).

Community-Based Social Marketing (CBSM)

CBSM is a systematic method for developing a practical behavior change program (McKenzie-Mohr, 2011). Program designers assess the target behavior before deciding

⁵⁷ Methods of calculating savings are not reported, and average savings across all facilities (including high and low savers) is unknown.

which empirically supported strategies would be most useful to apply to that particular behavior in that particular context. This approach creates a bridge between the highly controlled academic lab-based research on social influence and the practical realities of in-the-field behavior change programs. In particular, the five steps involved in developing a CBSM program are: (1) identifying a specific behavior to change, (2) identifying barriers and benefits of change within the target population, (3) selecting behavior change strategies and developing an intervention, (4) implementing the program, and (5) evaluating the program (e.g., McKenzie-Mohr and Schultz 2014). Geller and others have proposed similar approaches for designing and implementing behavior change programs while researching their effectiveness (e.g., the DO-RITE method; Geller 1992). Programs designed using CBSM constitute one type of community-based program.

Three recent CBSM programs have been systematically evaluated. These represent three possible methods for encouraging energy savings, but each application of CBSM is unique to its particular behavior and target population. The three programs are presented below.

PURCHASE AND INSTALLATION OF ENERGY STAR LIGHTBULBS

In one peer-reviewed study, CBSM successfully encouraged the purchase and installation of LED bulbs (Schultz, Schmitt, and Javey 2015). The program involved an in-store lighting event in North Carolina and a school-based fund-raising event in Vermont, both of which increased consumer acquisition of energy-efficient bulbs. The in-store event led to an 896% increase in sales relative to controls, but energy savings from the new lightbulbs could not be measured reliably. After the school-based fund-raiser, lightbulb sales increased and electricity use decreased 5.6% relative to controls. There was some evidence that participants in these programs were also more likely to subsequently participate in additional programs.

COLD WATER LAUNDRY

Efficiency Nova Scotia Corporation launched a CBSM-designed program to encourage residential customers to wash their laundry in cold water (Econoler 2015). It ran alongside a direct install program, in which 438 (mostly low-income) volunteers received home upgrades. During the upgrade process, installers attempted to persuade some participants to wash their laundry in cold water, providing an information brochure, requesting a pledge, and offering a prompt (a sticker to be placed on the washing machine). A follow-up survey found that, compared with controls, participants who received the persuasive message were 60% more likely to wash their clothes in cold water (an estimated net demand savings of 12 kW at the meter).⁵⁸

GREENERU WINDOW CLOSING CAMPAIGN

This campus-based program was implemented by GreenerU to discourage students living in dorms from opening their windows when their rooms were too hot and instead calling facilities management for help. The program took place in several dorms at Brown

⁵⁸ The direct install program was opt-in. Therefore, the degree of behavior change might be greater than it would be for residents who did not enroll in the direct install program.

University over three years. Opening windows was highly prevalent at the start of the study, but with the assistance of a technical upgrade to the heating system, as well as a variety of outreach efforts such as sending emails and soliciting pledges, the program resulted in significant reductions in the target behavior. These reductions were large in the first year (partly because of the upgrade, which provided a more responsive heating system), with participants using 16% less electricity than controls. In subsequent years, with the technology in place and the behavior becoming less common, the program (in four other buildings) had smaller effects. Overall, windows were left open less frequently: 1–2.1% of the time in the treatment group and 1.6–3.8% of the time in the control groups. Overall energy savings from the dorms in the second and third years of the study, however, did not significantly differ between control and treatment groups (GreenerU 2014).

THE BEST IN-PERSON STRATEGIES

Below are a few in-person strategies that have been investigated as methods of encouraging energy savings from behavior change. These are mostly based on smaller academic studies of how individual behavioral insights can be used to change energy consumption behavior. They may be helpful when considering specific design elements for any program involving in-person interaction.

Foot in the Door

One recent study examined the use of the foot-in-the-door technique to reduce energy consumption (Souchet and Girandola 2013). In this study, pedestrians in downtown Dijon, France, were randomly approached to ask if they would commit to “maximal energy savings” in their home for two weeks. They would have to keep a daily log of their energy-saving activities and then mail the log back to the lab at their own expense. Despite the rather sizable request and the fact it was made by a stranger, those who were approached complied 60% of the time (24 out of 40) if they were first asked to complete a six-question survey and to write down arguments in favor of energy efficiency. Only 30% of participants (6 out of 20) agreed to the request if it was not preceded by the two smaller requests. Impressively, participants who were approached using this procedure also actually followed through on their commitments, completing the behaviors and sending back the daily logs to prove it. Three times more participants sent back the logs if they first received the two small requests. Precise energy savings were not measured in this study, and logs were completed by self-report, but a previous study employing the foot-in-the-door technique (Katzev and Johnson 1983) found that homeowners who were asked to curb their electricity use after first completing a short questionnaire reduced consumption by 2% at follow-up, while controls increased their consumption by 6% during the same period.⁵⁹

Public Commitment

Another strategy that capitalizes on in-person interactions (although not necessarily using the interaction to make the request) is *public commitment*. When individuals publicly state an intention to engage in a behavior, they are typically more likely to follow through than if

⁵⁹ This was a small, randomized control study with only 14 to 18 homes in each group.

they set an intention only privately or not at all (e.g., Cohen et al. 1959; Stults and Meesé 1985). Therefore, encouraging people to publicly state their intention to engage in energy efficiency behaviors can be an effective method of encouraging action (Pallak, Cook, and Sullivan 1980; Shippee and Gregory 1982; Sullivan and Pallak 1976). In one early example of this effect (Pallak and Cummings 1976), researchers went door-to-door to solicit either public or private commitment from homeowners to reduce energy consumption over the coming month.⁶⁰ Residents of homes that were not approached (but were in the same region as the approached homes) increased electricity consumption by 222% during the following 29-day period.⁶¹ Those who made a private commitment increased their consumption by 216%, similar to those who were not approached.⁶² The participants who made a public commitment, believing their energy use would be published broadly in newspapers and other media, increased their consumption significantly less than the other two groups during this period (195%). Although public commitment may be solicited without interpersonal interaction, the benefits are partially realized because of anticipated interpersonal contact, cognitive dissonance, and social pressure.

Observability

Public commitment may encourage action, but are people less likely to commit if they know their behavior will be public? In fact the opposite appears to be true: people are sometimes more likely to “do good” if their actions are publicly observable. A study of residents encouraged to sign up for utility-controlled devices that throttle air-conditioning use during peak heat events recently demonstrated this effect (Yoeli et al. 2013). Researchers situated sign-up sheets for the program in easily visible public areas, such as near shared mailbox kiosks, and residents signed up using either their names and unit numbers (public) or an anonymous code (not public). The researchers did not measure energy savings from this program directly, but nearly three times as many volunteers enrolled in the program when asked to use their names as when asked to enroll anonymously. The rate was seven times higher than what the utility was achieving with its current approach of providing \$25 incentives. The utility estimated that incentives would have to be boosted to \$174 per participant to reach the same enrollment as it achieved with the publicly observable procedure.

Goal Setting

When asking for a public commitment, we recommend encouraging participants to set their own realistic goals. In one study, participants who set their own realistic goals for energy savings reduced residential consumption by approximately 11% (Harding and Hsiaw 2014). The problem, of course, is that if allowed to set their own goals, a small percentage of

⁶⁰ This experiment included a total of 65 homeowners.

⁶¹ This high-percentage increase in use was likely a result of temperature differences between the first meter reading (October 1973) and the second reading one month later (November 1973).

⁶² Those who made a private commitment did not differ significantly from those who were not approached ($p < 0.05$).

participants (about 15%) may choose not to save any energy (0%), and some (about 41%) may set overly optimistic goals, but the overall savings, when all these participants are included, is still relatively high (4.4%).⁶³ Utilities may be able to capitalize on this procedure, while avoiding the drawbacks of unrealistic goals, by allowing participants to set their own goals within a given range. This way, participants experience the sense of responsibility and ownership that comes with setting their own goals but are not allowed to choose 0% or an unrealistically high estimate.

Guided Group Discussion

When speaking to groups about energy efficiency, guiding them to come to their own conclusions about why to engage in desired actions promotes more behavior change than telling them the reasons directly (Werner et al. 2012). When guided group discussions were used to encourage classes of university students to turn off lights in unused rooms, the percentage of rooms with lights left on dropped by 34 percentage points (from 51% to 17%). Without these presentations, lights in control rooms were left on more frequently during the same period (increasing from 29% to 41%), even if posters were put up to encourage lights-off behavior.⁶⁴

Social Networks

The power of social networks can be leveraged to increase participation in energy efficiency programs. In the case of HVAC upgrades, for example, households were more likely to purchase upgrades if they were situated in neighborhoods with other households that had already upgraded (Noonan, Hsieh, and Matisoff 2013). In greater Chicago, between 1992 and 2004, homeowners' adoption of energy efficiency upgrades spread widely through geographic and social networks. Rogers (2003) observed that the homeowners within a specific neighborhood adopted rooftop solar panels in a similar way. Opinion leaders with strong social networks were best able to diffuse adoption of this innovation through their associated groups. Although energy champions may not necessarily be natural opinion leaders, those who are may be particularly effective. Therefore, recruiting opinion leaders to act as energy champions or, if possible, training energy champions to be opinion leaders (by teaching principles of social influence) could effectively leverage the power of social networks to encourage adoption of energy efficiency technology and behaviors.

Energy Champions

The energy champion, the individual within a social group who takes it upon himself or herself to be responsible for energy savings within the group, was cited as a key component of many programs within our review, including SEM programs (e.g., Cross 2014), school-based energy management programs (e.g., Ruiz 2014), office-based programs (e.g., Turnleaf

⁶³ This study used an opt-in design with matched controls; therefore the savings could be slightly exaggerated, because they may be partly affected by the characteristics of the sample population. The important point is that setting realistic goals, relatively speaking, leads to the greatest percentage of savings.

⁶⁴ Guided group discussions were more effective than no-presentation control groups, but a traditional lecture group should be included in future studies to determine the relative benefit of the guided aspect of the talk.

Consulting 2014; Flory 2014), other workplace programs (e.g., Judd 2015; Dethman, Stewart, and Thomsen 2013), and multifamily residential programs (e.g., Ross and Drehobl 2016). These are discussed in other sections of this review but are highlighted here because they all benefited from effective energy champions.

Motivated individuals, responsible for implementing and promoting energy efficiency programs on the ground, play an important role in encouraging behavior change. One meta-analysis of pro-environmental behavior intervention strategies found that using block leaders (neighborhood block representatives responsible for leading programs) was the single most effective method for encouraging behavior change (Abrahamse and Steg 2013). This may be partly because the source of a behavior change message affects the persuasiveness of that message (Wilson and Sherrell 1993). Familiar individuals and those already embedded within target social groups may appear more trustworthy, which is a key component of persuasiveness (Wilson and Sherrell 1993). One example of an effective program that relies on an in-person approach and trusted messenger is the SmartLights program.

SMARTLIGHTS

The Bay Area SmartLights program has operated for more than 10 years (Perez-Green 2014). The mandate of the program is to encourage energy efficiency upgrades by small and medium-size businesses, primarily in the areas of lighting and refrigeration equipment, by way of free energy audits. In 2013, program administrators claimed savings of 2.5 million kWh from 300 projects (\$400,000 in total customer savings) and, over the previous nine years, savings of 64 million kWh from 5,614 projects. The key to the SmartLights program's success is an interpersonal approach to enrollment. The two primary marketing channels are local outreach campaigns and referrals from other organizations. Outreach campaigns, which include door-to-door canvassing of local businesses, usually involve a SmartLights representative and a trusted messenger. The trusted messenger can be a utility representative, a city or county official, or a community member. This person's presence lends credibility to the program, increasing enrollment rates.

Education and Training

Education and training approaches may include a variety of elements from other programs but rely primarily on teaching as the vehicle for behavior change. The three types of programs described and evaluated in this section are:

- Strategic energy management (SEM) programs
- Other community training programs
- K-12 and college campus programs

SEM programs and other training programs provide information using in-person interactions. Although they incorporate information and social interactions, they have traditionally been categorized as part of this family of approaches because they also provide education (as do K-12 and campus initiatives).

STRATEGIC ENERGY MANAGEMENT

The most commonly reported type of training programs are SEM programs (sometimes also called continuous energy improvement programs), in which administrators work with industrial or commercial customers to train representatives on how they can save energy within their organizations. Savings usually come from low-cost solutions involving how equipment is used (behaviors and processes), maintenance, equipment optimization, and so on (Cross 2014). The commercial and industrial sectors have great potential for energy savings. In the hotel sector, for example, one model predicted that energy savings from behavior change programs could be as high as 25% (Dong, Hooks, and Wang 2016). SEM programs are relatively new and are not always evaluated for energy savings, but as they are growing in number, more evaluations are becoming available.⁶⁵

One of the larger proponents of SEM programs is the Northwest Energy Efficiency Alliance (NEEA). The NEEA definition of an SEM program has five parts, and organizations are said to have implemented SEM if they have met these five criteria: (1) adoption of an organization-sanctioned goal, (2) documentation of planned activities to achieve the goal, (3) allocation of resources toward the goal, including staff (such as a dedicated energy manager), training, or capital, (4) implementation of planned activities, and (5) regular management review of progress (Ochsner et al. 2015). NEEA trains energy managers using a program based on Toyota's lean system called Lean Six Sigma.

The requirement of SEM programs to allocate resources in order to move forward limits the number of businesses that can fully adopt SEM. For this reason, small food-processing organizations, for example, are far less likely to implement complete, five-component SEM programs than large organizations (0% versus 33%; Market Strategies International 2012). Generally, uptake of SEM programs is still relatively low. Although one market characterization study from the US Northwest found that at individual SEM components were implemented at rates of 38–68% (depending on the component), only 8% of business owners/managers who were interviewed had implemented all five components (Groshans et al. 2014). Experts who were consulted in the study estimated a true adoption rate of 5% in 2013 and predicted this would rise to approximately 33% in 2030. Two years earlier, none of the 175 business owners/managers in the region who were surveyed had implemented all five components, and only 20% had allocated budgets to achieving their energy-savings goals (NEEA 2012).

Another key component of SEM is the designation of energy managers or energy champions within the organizations. Management support for these individuals, and the SEM programs in general, is an important component of successful programs (e.g., NEEA 2014b). This plays out, for example, when building operations certifications are set to expire. At this point, contacting both the certificate holders and their supervisors is an effective method of encouraging recertification (Gazman 2014). Successful SEM programs often also include financial incentives for energy managers from their companies (e.g., bonuses for achieving

⁶⁵ For a review of several recent NEEA SEM programs, see Ochsner et al. 2015.

goals) and ongoing support and coaching from NEEA or similar organizations (Ochsner et al. 2015). In these ways, good SEM programs incorporate the benefits of in-person interactions, goal setting, rewards, and public commitment.

Overall, gross electric savings from approximately 13 reviewed SEM programs ranged from 0% to 22%, and gross gas savings from six programs ranged from 0% to 23% (Ochsner et al. 2015; Dougherty et al. 2015; Therkelsen and Rao 2015).⁶⁶ This includes estimates from four NEEA programs, a BC Hydro program, and a California Public Utilities program with evaluated percent electricity savings (Ochsner et al. 2015; Dougherty et al. 2015). It also includes a US Department of Energy Program called Superior Energy Performance, in which businesses could receive ISO 50001 Energy Management System Standard certification. In their review of 11 Superior Energy Performance programs, evaluators estimated combined gas and electricity savings of 4.2% (in year 1) to 11% (in year 2) attributable to the program (Therkelsen and Rao 2015).⁶⁷ Next, we present examples of programs that include SEM elements.

Bonneville Power Energy Management

This program is used to reduce industrial energy consumption by educating and training industrial energy users. In particular, the program was designed to encourage industrial customers to engage in long-term energy planning and integrate energy management into their business planning going forward. The three components of the program are (1) energy project manager co-funding (by customers and Bonneville Power), (2) help in tracking performance and improving operation and maintenance practices (called Track and Tune), and (3) training and technical support for upper management and process engineers (called High Performance Energy Management). In the first year, 17 industrial customers enrolled in the program (two of which used only Track and Tune). Gross electricity savings across all facilities averaged 4.4% of baseline consumption (13,084,000 kWh). Only two facilities tracked gas usage; for those, gas savings were quite high (63.3% and 15.2%, total of 38,736 therms).⁶⁸ The cost-benefit ratio of the program was calculated to be 1.00 (Cadmus 2013).⁶⁹

⁶⁶ Net savings were not reported. The highest reported savings come from programs cited by Illume Advising and Navigant (2015) and are based on savings from existing rebate programs rather than the SEM programs per se.

⁶⁷ The SEM programs cited here are all opt-in programs that are evaluated with pre-post measurement (rather than with control groups); therefore, savings could be slightly overestimated.

⁶⁸ In industrial processes, gas savings are generally easier to produce than electricity savings. Net savings were not reported.

⁶⁹ The cost-benefit ratio was calculated by Cadmus: total resource costs (assuming a 5-year life) were \$5,039,692 and benefits were \$5,578,005 (ratio = 1.11); assuming a 3-year life, ratio = 1.00. For more information, see Ochsner et al. 2013.

Continuous Optimization for Commercial Buildings

BC Hydro offers a program that assists commercial energy managers with retrofitting their buildings and continually maintaining them into the future.⁷⁰ The program begins with an energy audit and recommended energy efficiency measures that pay off in two years or less (usually low-cost or no-cost). Following the initial intervention, BC Hydro offers customers support for continual energy efficiency improvement through effective ongoing tracking (e.g., benchmarking and load profiling), as well as training in-house experts at each commercial building in responding to energy reports. Every three months, a representative of BC Hydro can also return to give the building a checkup, assessing progress relative to the owner's goals. The program is cost effective and has been implemented by 115 customers at 442 sites.⁷¹ On average, gross savings are approximately 7% electricity and 11% gas (84gWh/year total; Dougherty et al. 2015).⁷²

Hospitals and Healthcare Initiative

The Hospitals and Healthcare Initiative was an NEEA program in which NEEA helped hospitals adopt SEM practices by providing technical resources (including co-funded resource conservation managers) and comprehensive web-based information. The program also included E2C, an energy-saving competition among 44 hospitals using ENERGY STAR Portfolio Manager to track savings. In 2011 the competition reduced electricity consumption by 1.6% and gas consumption by 0.1% relative to 2010. In 2012, the Hospital and Healthcare Initiative reduced electricity consumption by 4.8 million kWh; the competition decreased electricity consumption by 0.45% but saw a small increase (0.35%) in gas consumption (NEEA 2014b). In 2013, the total savings were 3.7 million kWh (NEEA 2014a).

Refrigeration Operators Coaching for Energy Efficiency (ROCEE)

Idaho's ROCEE program, which saved 2,770,459 kWh in its second year (tracked by energy management software), strongly emphasized facility visits (for audits) and training workshops (Evergreen Economics 2015). The program was a partnership of Cascade Energy, which provided the workshops and site visits, and NEEA, which recruited customers with medium to large refrigeration requirements. In interviews, implementers noted that the program was impactful and effective in its first year but less so in the second year. Implementers emphasized the importance of upper management support and recruiting the right people from participating organizations; namely refrigerator operators and users (Evergreen Economics 2015).

⁷⁰ For an excellent summary of this program and other Canadian programs, see www.exec.gov.nl.ca/exec/ccee/publications/canadian_energy_efficiency_programs_part_b.pdf.

⁷¹ Cost-benefit ratios were calculated by IndEco and Hollett & Sons, Inc. Cost-benefit ratios were: 1.9 (Utility Test), 2.9 (All Ratepayers Test), and 0.7 (Non-Participant Test). See the original report for more detail: www.exec.gov.nl.ca/exec/ccee/publications/canadian_energy_efficiency_programs_part_b.pdf.

⁷² The program is available only to large commercial buildings (>50,000 ft²), and the average enrollee has 153,000 ft² of floor space. Given that large consumers of energy can typically save more energy, the selection of participants could theoretically bias the estimation of savings.

Using a Human–Building Interaction Approach in SEM

Future SEM programs could potentially be improved by promoting a human-building interaction (HBI) approach (Shen 2015). This approach centers on solving workplace design problems and structurally changing workplace settings in order to reduce energy consumption. Importantly, it relies on observation of how people use spaces, both to facilitate energy conservation and to improve satisfaction with the space. For example, some hotels in Europe and Asia require that the hotel key card be inserted into a switch before the lights can be turned on (*Hotel News Now* 2009). This saves electricity for the hotel because guests must turn off their lights when they leave their rooms, and guests appreciate this design element because it provides a convenient place to leave the key when they are not using it. Training energy managers to use this sort of HBI approach to energy savings could be a way to further building on current SEM programs.

OTHER EDUCATION AND TRAINING PROGRAMS

Two other training and education programs, both for low-income communities, are considered in this section: Pennsylvania Public Utility Commission’s E-Power Wise Program and Illinois’ iSMART Program. Both have strong educational components but are not related to schools, colleges, or businesses.

E-Power Wise

This program uses a train-the-trainer model to reduce energy consumption by low-income community residents (Cadmus 2014). The Resource Action Program Inc. (RAP) identifies community organizations serving populations that are at no more than 150% of the federal poverty level. RAP then trains key members of those organizations on issues of energy literacy, and those individuals host workshops and one-on-one sessions with members of their communities to encourage energy-efficient behaviors and to distribute home energy kits. In its fourth year, the program’s gross savings were estimated at 1,454,240 kWh/year (among 2,440 participants), with energy kit items installed at a rate of 79–94%.⁷³ The cumulative costs of the program up to and including the fourth year were \$667,000, with benefits totaling approximately \$2,698,000, for a cost-benefit ratio of 4.04.⁷⁴

iSMART

The iSMART Program is currently underway in public housing developments across Illinois (University of Illinois 2015). The program covers five housing developments that are generally similar in composition. Residents or building managers in each development will be offered systematically varied levels of energy efficiency education through workshop sessions, and some will also receive real-time feedback devices and smart thermostats directly installed in their units. Given the quasi-experimental design, including a control building, the results from this two-year study will be interesting to note and useful for

⁷³ This program was also discussed earlier in this review, in the Energy Audits section, because it included home energy kits, installed at higher rates than those not accompanied by an extensive engagement campaign.

⁷⁴ Figures include total lifetime energy benefits (\$2,555,000) and total lifetime capacity benefits (\$143,000). Total lifetime energy savings are 29,788,000 kWh. Total lifetime capacity savings are 4,000 kW. See report for more details.

determining the most effective method for encouraging energy-efficient behavior change in low-income communities.

K-12 AND COLLEGE CAMPUS PROGRAMS

Utilities and other organizations interested in energy efficiency have implemented several school- and college-based energy efficiency programs. Typically, these involve classroom education, solicitation of student commitments to save energy, and a variety of student-led initiatives to reduce consumption. For example, some programs encourage students to audit their home or school energy use. On some occasions, students are also provided energy kits to take home or are enrolled in inter-school competitions.

One excellent example of such a program is called KEEP (K-12 Energy Education Program). The Wisconsin-based nonprofit Seventhwave (formerly Energy Center of Wisconsin) launched KEEP in 1995, and it is currently one of the longest-running K-12 energy education programs in the United States (University of Wisconsin-Stevens Point 2016). In partnership with the University of Wisconsin and several local utilities, the program provides resources to K-12 schools, such as energy assessment devices for students and professional development courses for teachers, and encourages energy reduction in school and at home.

School-based programs can increase children's knowledge and concern about climate change and alter their (self-reported) behavior to mitigate it (Lee et al. 2013). These programs are likely important for changing behavior in the long term, but precise energy savings may be difficult to assess because they pay off over extended periods and in a variety of behavioral domains. Furthermore, when energy savings are estimated, the methods and details of evaluation are not reported. We had difficulty judging the quality of reported findings in this area because these programs lack systematic controlled experiments and third-party evaluations. Nevertheless, we endeavor here to report on several school-based programs that include an education component.

PowerSave, PowerED, Sprint to Savings, and Other K-12 Programs

Administrators of K-12 programs often report electricity savings of more than 20%. A recent report by the Green Building Council highlighted five school-based programs in five states (Crosby and Metzger 2014). These high-achieving schools reported saving an incredible 20-37% (electricity) over four to six years as a result of behavior change alone. The Alliance to Save Energy's PowerSave Schools program was associated with average electricity savings of 10.5% per school (Harrigan 2014). The PowerED program (Ruiz 2014), discussed earlier as a community-based approach in schools and government buildings, and the Sprint to Savings program, mentioned earlier in the competition section (Donovan 2014), reported 20%+ savings, largely due to behavior change. One school-based program, initiated by the hiring of a new school district energy manager in Massachusetts, reported a 13% reduction in electricity use (Snell, Crosby and Patton 2016). These high savings should be interpreted with caution as the methods of evaluation are largely unknown. However a meta-analysis comparing a variety of behavior interventions and target populations determined that students were among the most likely groups to change in response to various intervention strategies (Abrahamse and Steg 2013).

LiveWise Energy

One program that did undergo third-party evaluation was South Jersey Gas's LiveWise Energy Program (Resource Action Programs and Niagara Conservation 2012). However, given the design of the program, energy savings could not be measured directly. Instead, the evaluators interviewed parents of children who had been given home energy kits to learn whether elements of the kits had been installed, and teachers quizzed students to assess the knowledge they'd gained through the education components. The program included 2,500 sixth graders and saved an estimated 62 kWh of electricity and 2 therms of gas per home through energy kit installations. Student knowledge, as measured by the quiz, went from 62% before the lessons to 80% afterward.⁷⁵

Campus Programs

Programs that take place on college campuses are less likely to teach energy efficiency explicitly in classrooms. However several programs that were mentioned earlier in this review took place on campuses and often included successful student outreach. Some programs used guided group discussions in classrooms or posters in public places to encourage turning off lights (Werner et al. 2012; Sussman and Gifford 2012); a more comprehensive program aimed to decrease dorm residents' inclination to open windows rather than turn down the heat (GreenerU 2014). Intra-building office competitions among staff and lab users have been held on campus (Dixon et al. 2015), and various colleges have implemented energy-saving competitions within and between dorms (see Vine and Jones 2015 for a summary of competitions programs, including those in dorms, which reduced electricity consumption by 3.1–8%). Overall, energy reduction from these programs varies greatly, depending on the type of program, its duration, and the target behavior.⁷⁶

Stacked Approach

Program administrators frequently combine multiple programs and strategies into larger campaigns. If each program has a small effect, then stacking these approaches could conceivably increase the overall impact. The downside of this approach is that little may be learned about the relative effectiveness of each element within the campaign. These "stacked" or "multimodal" approaches are especially common in community-based programs and education programs, several of which were described earlier.

Although implementers of these campaigns attest to their effectiveness, they rarely evaluate them using experimental or quasi-experimental methods. Therefore, the relative effectiveness of these combined programs usually cannot be compared with the efficacy of simpler programs. Some evidence, presented earlier, demonstrates that a combination of

⁷⁵ These quiz results should be interpreted with caution because a certain degree of improvement would be expected from any test that is administered twice to the same population, due to practice effects.

⁷⁶ Energy savings from non-competition campus programs are difficult to compare because they are measured using non-energy metrics or non-building-level metrics. For example, Sussman and Gifford (2012) estimated that prompts in washrooms reduced energy use from lighting by 30.1%, but they could not estimate whole-building savings. In another study, guided group discussions reduced the frequency of lights being left on in unused classrooms by 34%, but the estimated energy savings were not reported.

two program elements may be more effective than each element individually (e.g., time-of-use pricing with in-home displays, HERs with rebate programs), but no study has evaluated the combination of large, complex programs relative to simpler ones. One example of a large, complex program is the community-based Rock the Watt campaign.

ROCK THE WATT

The Rock the Watt campaign was implemented by the sustainability program of the Pacific Northwest National Laboratory, an organization with 4,300 employees in four cities in Washington State. Fourteen buildings on the main campus participated in this three-month initiative in 2015. The program was customized to the users of the buildings, which included both laboratories with specialized equipment and office spaces with traditional energy usage concerns. Organizers chose different target behaviors for the different building occupants (e.g., raising deep-freeze temperatures from -80° C to -70° C or installing smart power strips). The primary method of encouraging change was to enlist sustainability champions at each building who personally promoted these behaviors. However organizers also created a competition among buildings, educated occupants, and removed barriers to action. The program resulted in 200 actions on the part of participants and savings of an estimated 117,000 kWh/year (Judd 2015).⁷⁷

Discussion

SUMMARY OF RESULTS

Our central finding is that behavior change programs have the potential to reduce energy consumption. Reported energy savings from these programs vary greatly, depending on the type of program, the target audience, and the methods of evaluation. Many studies do not report percentage savings, and among those that do, results usually cannot be accurately compared across program types because of the differences in study design and evaluation.

The highest savings reported from programs in this review appears to be just over 30%; however this percentage comes from studies of schools and businesses that do not report the methods used in their analyses, and for which persistence of savings is unknown. The highest savings from systematically validated strategies are from SEM programs and competitions, some of which have reported savings as high as 23%. These SEM programs and competitions, however, also require more data and systematic evaluation to bear out their findings. In the lower range, HERs are able to encourage savings of up to about 3% for those who are automatically enrolled in a program (with the opportunity to opt out) and up to 16% for those who actively choose to participate, or opt in (Todd 2015). Of course, the actual upper limit to potential savings from behavior programs is unknown because the field is still young and research is evolving.

Comparing behavior change programs is difficult because they include different audiences, behaviors, designs, and methods of evaluation. However we can make some comparisons.

⁷⁷ The program lasted only three months, but annualized savings were estimated after accounting for seasonal variations in temperature.

Programs that involve many strategies usually save more energy than those that involve fewer strategies. Programs that have opt-in participants often reduce consumption more than those with less-motivated opt-out participants; residential programs generally save less electricity and gas than commercial programs, which sometimes have a higher upper range; and larger consumers from all categories—residential, commercial, and industrial—often respond to interventions with larger energy savings.

Programs that use opt-out strategies for recruitment (automatic enrollment of utility customers) naturally have more participants, but these participants are less motivated than those in opt-in (optional) programs. Typically, then, opt-out programs enroll more people and have findings that can be more readily generalized, but also have lower average savings. This distinction should be kept in mind when comparing savings from opt-in and opt-out programs. In addition, many programs cannot easily be designed using an opt-out strategy. Such is the case for competitions and games, for example, in which program implementers require active and increasing participation for the program to work. Opt-in programs are more difficult for evaluators to rate because finding equivalent control groups is challenging. Consequently, opt-in programs are more likely to be evaluated with simple methods (e.g., pre-post designs) that are prone to biases and overestimates of savings.

Persistence of savings from behavioral programs is a crucial issue. Unlike hardware programs in which savings can be associated with the lifetime of the installed equipment, behavioral programs often rely on continued repetition of behaviors. Unfortunately, little is known about the persistence of savings from behavioral programs. Research from HER programs suggests that savings may decay by 11–32% annually, or an average of 20%, for two years following the cessation of a two-year program. However little is known about savings persistence for other types of programs. Clearly, more research is needed in this area.

Programs used to reduce electricity consumption are usually easily transferable to gas consumption (or water consumption, for that matter). In industrial programs, such as SEM programs, potential gas savings are often higher than electricity savings, but in residential programs, such as HERs, gas savings are typically lower than electricity savings. This may be because there are more opportunities for gas savings in industrial settings than in residential settings, where home temperatures are vital for comfort and temperature-related behaviors may be difficult to change.

Behavior change programs are conducted in widely varying climates, including those of Hawaii, northern Ontario, Southern California, Massachusetts, Washington State, Arkansas, and many others. We did not find a systematic difference in rates of behavior change or energy use reductions by region, suggesting that energy savings through behavior change programs may work in almost any climate condition. Nevertheless, cultural differences between countries affecting how messages are framed or interpreted could still influence energy savings.

ENERGY STAR plays a supporting role in several behavior change programs. For example, ENERGY STAR products are recommended as part of home energy audits (accounting for a

large proportion of savings in some cases), and the ENERGY STAR Portfolio Manager web-based benchmarking program is frequently used by businesses to track energy savings as part of competitions or goal-setting strategies. The ENERGY STAR brand is associated with energy savings, and this is a key component of its success in embedding itself in these programs.

Table 2 summarizes our findings.

Table 2. Summary of findings

Category	Description	Findings	Energy savings	Quality of evaluation
Information				
Home energy reports (HERs)	Reports intermittently sent to residential customers with feedback about energy use, energy efficiency tips, normative comparison to similar neighbors, and occasionally notes about rewards or incentives.	Savings ramp up over two years and continue for at least five years in ongoing programs. Savings from programs that are discontinued after two years persist for at least two years, with an average decay of approximately 20%/year. ^a Customers receiving more frequent reports save more energy. High-baseline users save most energy (and are targeted by most programs). Opt-out programs save more energy overall than opt-in programs (despite lower average savings per customer). Report recipients are slightly more likely to participate in other utility program offerings. The program works primarily by changing small, repeated behaviors but may also encourage participation in rebate programs. Information about disaggregated home energy use may potentially improve HERs, but this hypothesis requires additional testing.	Traditional opt-out programs save 1.2–2.2% of electricity and about 0.3–1.6% of gas by the second year. Opt-in programs may save up to 16% of electricity per customer, but for fewer people (in one study, approximately 20% of customers participated in an opt-in program; approximately 98% participated in an equivalent opt-out program). Preliminary research suggests that disaggregated energy reports for opt-out customers may save up to 4.2% of electricity, but this is from the last month of data in a four-month study. More data are required to confirm this result. ^b	High. Most results are based on third-party evaluations using randomized, controlled trials in large, representative samples.
Real-time feedback	Information about immediate energy use, provided by websites or devices including home energy management systems, feedback “dashboards” installed in workplaces, and similar devices.	Both control-based devices, which sense and automatically regulate energy use, and information-based devices, which sense energy use and provide information in a display) can save energy at home or work. Smart thermostats may achieve energy savings approximately twice as large as previous-generation programmable thermostats. Human behavior can interfere with savings potential of smart thermostats if default settings are changed.	Information-based devices can save 1–15% of electricity or gas, and control-based devices can save 1–17%. Savings range dramatically due to differences in target behavior, device, and method of evaluation. Most programs report net electricity savings in the 5–8% range using opt-in designs. In one study, peak electricity use during heat events was reduced by 48% using control-based devices, but energy use increased immediately following the events by 22%. ^c	High. Most studies use experimental or quasi-experimental designs and report net savings.

Category	Description	Findings	Energy savings	Quality of evaluation
Energy audit programs	Audits done online or in person, in which a personalized evaluation of energy use in a home or business is followed by specific recommendations for reducing consumption.	Energy audits reduce consumption by encouraging home or business energy efficiency upgrades (as well as some curtailment behavior changes). They also provide immediate reductions through direct installation of low-cost or no-cost measures. They are most effective when auditors guide customers through three types of barriers: information barriers, decision-making barriers, and transactional barriers.	Only audit programs with unconventional elements, such as online or telephone options, were included in this review. Audits reduce energy consumption primarily by encouraging participation in other programs (e.g., rebate programs). Therefore, estimates of direct energy savings from audit programs are rare. Online and phone-based audit programs may reduce net electricity consumption by 1.3–6.5%. ^d	Low. Most programs are not evaluated using control groups and typically report gross absolute savings rather than net percentage savings; often savings estimates are based on existing rebate programs rather than data taken directly from the audits.
Persuasive messages	Written communications that use behavioral insights to encourage energy conservation.	Benefits of energy conservation should be framed in financial, health, comfort, or environmental terms, depending on the audience. Messages emphasizing comfort are effective in encouraging efficiency upgrades. Reducing choice overload, using visual prompts, and changing default options could be effective strategies for reducing energy consumption. Other strategies as yet untested in the context of energy efficiency may also work.	Modifying message frames, as part of a larger program, can increase electricity savings by 1.2–8%. Installing prompts/signs reminding people to engage in certain actions can increase the frequency of those actions by 10–30%. ^e	Moderate. Most studies use strong evaluation methods but small numbers of participants; evaluations focus on changes in specific actions, such as turning off lights, rather than whole-building percentage energy savings; results may not scale up.

Category	Description	Findings	Energy savings	Quality of evaluation
Social interactions				
Competitions and games	Competitions in which participants try to achieve the highest rank compared with other individuals or groups. Games in which participants try to reach goals by reducing energy consumption.	Effective competitions use a large number of behavior strategies to motivate and engage all participants. Persistence of energy savings from competitions and games is rarely measured, but theoretically, persistence could be increased by changing habits and providing intrinsic motivation for participants.	For residential programs, gross electricity savings ranged from 0.7–14% and gas savings from 0.4–10% (only three programs included gas savings). For commercial programs, gross electricity savings ranged from 1.8–21% (no gas savings were reported). Most programs reduce electricity consumption by approximately 5% or less, but competition winners have saved more than 30%. ^f	Moderate. Some programs are evaluated using control groups or quasi-experimental methods, but they typically report gross rather than net savings.
Community-based social marketing (CBSM) and other innovative community outreach strategies. These approaches draw from a number of available behavior change tools to create tailored programs that are designed to work with specific populations.	Community-based social marketing (CBSM) and other innovative community outreach strategies. These approaches draw from a number of available behavior change tools to create tailored programs that are designed to work with specific populations.	Systematically designed programs, specifically targeting certain energy behaviors within certain populations and incorporating evidence-based behavior change strategies, can effectively change behavior, drive customers to other efficiency programs, and reduce energy use. Using many strategies within one program increases chances of success but makes evaluation of specific strategies more difficult.	Percentage of energy savings directly attributable to the program (rather than to existing retrofit programs) are usually not reported. Gross absolute savings ranged from an estimated 117,000 kWh/year (annualized) to 813,000 kWh and 71,150 therms (in one year). Estimated electricity savings from three CBSM programs was 0–16%. The biggest savers from one commercial program reduced consumption by more than 20% at several sites; one site reduced consumption by 34%). ^g	Low. Other than CBSM programs, most are not evaluated using control groups and typically report gross absolute savings rather than net percentage savings.
In-person strategies	Direct social interaction by one or more people.	Several specific in-person behavioral strategies have been recently used to effectively reduce energy consumption. These include the foot-in-the-door technique, public commitment, public observability, goal setting, guided group discussion, and energy champions. Other strategies could also be used but have not been directly tested in the context of energy consumption.	In-person strategies evaluated for energy savings were found to reduce electricity consumption by approximately 4.4% (goal setting) to 27% (public commitment) compared with controls. But these strategies also produced other important results, such as increasing—by nearly 300%—enrollment in utility programs allowing control of A/C units during heat event days, and reducing frequency of lights left on in classrooms by 34%. ^h	Moderate. Most studies use strong evaluation methods but have small numbers of participants; evaluations focus on changes in specific actions, such as turning off lights, rather than whole-building percentage energy savings; results may not scale up.

Category	Description	Findings	Energy savings	Quality of evaluation
Education				
Strategic energy management (SEM)	Utilities work with industrial and commercial customers to train energy managers and encourage curtailment and efficiency behaviors within those organizations by helping to set goals and track progress.	SEM programs have five criteria: (1) adoption of an organization-sanctioned goal, (2) documentation of planned activities to achieve the goal, (3) allocation of resources toward the goal, (4) implementation of planned activities, and (5) regular review of progress. The largest obstacle for implementing SEM in commercial businesses is allocating resources, including hiring a dedicated energy manager. Two key components for success are an effective energy manager/champion and management support for the program.	Gross electric savings are 0–22% and gross gas savings are 0–23%, but the savings from the higher end of the spectrum are calculated from existing rebate programs rather than SEM directly. ⁱ	Moderate. Some programs use strong evaluation methods but report only gross savings, and these can often include savings from existing rebate programs.
Other training programs	Non-school-based education or training programs teaching community members strategies for reducing energy consumption.	Based on the two programs included in this review, these have great potential to increase energy literacy through education and training of low-income community members, but more data are needed.	One program was evaluated, and it reported estimated gross electricity savings of 1,454,240 kWh/year among 2,440 participants. Home energy kit installation rates ranged from 79–94% per item in the kit. ^j	Moderate. One of two programs includes a strong quasi-experimental approach, but it has yet to be evaluated. The other provides gross absolute savings without a control group.
K-12 and campus programs	Programs in K-12 schools or on college campuses that involve education of students on energy efficiency.	These programs reduce consumption by teaching students about their energy use, providing hands-on activities, and (occasionally) by providing home energy kits with low-cost/no-cost upgrades.	Gross electricity savings ranged from 13–37%. Usually savings are reported to be about 20%, but the methods of evaluation are often unknown. ^k	Low. Program details and evaluation methods for many of these programs are unclear, and they typically report gross rather than net savings.

^a Khawaja and Stewart 2014. ^b Khawaja and Stewart 2014; Opower 2016; ACEEE findings (see table 2); Todd 2015; Malatest 2014. ^c NEEP 2015; Harding and Lamarche 2016. ^d Igenzi 2015; Southern California Edison 2013. ^e Asensio and Delmas 2016; Trottier 2014; Sussman and Gifford 2012; Ackerly and Brager 2012. ^f ACEEE findings (see Appendix D); Dougherty et al. 2015; Vine and Jones 2015; Donovan 2014. ^g GreenerU 2014; Schultz et al. 2015; Ruiz 2014. ^h Harding and Hsiaw 2014; Pallak and Cummings 1976; Yoeli et al 2013; Werner et al. 2012. ⁱ Ochsner et al. 2015; Dougherty et al. 2015; Therkelsen and Rao 2015. ^j Cadmus 2014. ^k Crosby and Metzger 2014; Snell, Crosby, and Patton 2016.

EVALUATION

We were pleased to find that many newer programs included at least a rudimentary evaluation, and a large minority were formally evaluated by third parties. Nevertheless, the quality of evaluations ranged from basic (a simple pre-post measurement of energy consumption without a control group) to very rigorous (e.g., a large, randomized control trial evaluated by a third party). In its first report about utility-run behavior change programs, ACEEE called for additional systematic evaluations and data regarding observed energy savings relative to controls. Program administrators have progressed in this regard, but nevertheless more information and standardization are required before we can conclusively determine the effectiveness of various strategies or rank them against one another. Although data about energy savings from behavior change programs are now more commonly available, program administrators should gather and analyze these data more systematically. Strong evaluation methods are rare, and more data are required.

The pros and cons of various methods of evaluation are discussed in the Minnesota Chamber of Commerce's 2015 review (Dougherty et al. 2015). The simple pre-post design, in which participants' energy use is measured before and after the intervention, without comparison with a control group, is the least effective method of program evaluation. Although better than nothing, the pre-post design provides the least certainty that the intervention caused a change in behavior. Rather, a change could be attributable to time passing, the pre-existing characteristics or motivations of the participants, or any number of other uncontrolled factors. Indeed, participants who enroll in a program expect it to work and are therefore motivated to report savings. Adjusting for known potential factors (such as outdoor temperatures) or using objective measures (such as energy consumption data rather than self-reports) helps improve the validity of this method, but it remains not ideal for determining the effectiveness of behavioral interventions.

A much stronger research design strategy is the randomized controlled trial with a large, representative sample. This strategy involves randomly assigning potential participants to receive or not receive a treatment. Due to the random assignment, researchers can assume that the two groups are statistically equivalent except for receiving or not receiving the treatment.⁷⁸ Therefore, differences in energy consumption between those two groups could be attributed primarily to the intervention, as opposed to other factors, and researchers could support the assumption that the intervention caused the difference between groups.

A vital aspect of this design is that participants are not systematically different from one another in the treatment and control groups. This equivalency does not exist in an opt-in behavior change program, where participants choose to enroll; researchers cannot simply compare those who choose to enroll with those who do not choose to enroll and assume the program caused the change in behavior. The two groups are systematically different from each other because those who enroll are probably more motivated to save energy.

⁷⁸ A sufficiently large sample size is also required in order to ensure that randomization produces groups that are not statistically different from one another in any baseline factor.

Researchers could attribute the difference between the two groups to the program or to the stronger pre-existing motivation of the group that opted in. A stronger research design for this type of situation could be quasi-experimental, such as a random encouragement design or a recruit-and-deny/delay scheme, both of which provide greater certainty regarding the effects of the program (see Todd et al. 2012, or Dougherty et al. 2015, for an excellent description of these methods). Often, energy efficiency programs cannot be evaluated using randomized controlled trials, in which case strong quasi-experimental methods are reasonable substitutes.

Unfortunately, with the exception of feedback and HER studies, we found few programs in our review that include rigorous evaluations conducted by third-party experts. Part of the reason is that many behavior change programs are difficult to evaluate in their current forms, especially for a macro-level end point, such as energy savings from bill analysis.⁷⁹ However energy efficiency behavior change research has also historically been characterized by many isolated behavioral projects and field studies, featuring fairly simple internally conducted evaluations. The general lack of third-party expert evaluations is an obstacle to establishing valid and reliable savings estimates for many types of behavioral programs. For this reason, many of the energy savings numbers observed in our literature review and provided in this report should be used with caution. We found that programs with the most rigorous methods and largest sample sizes often resulted in the lowest percentage savings.

Our study is not alone in noticing the variable quality of behavioral program evaluations and how evaluation quality might affect reported results. In a comprehensive meta-analysis of programs that implemented information-based strategies for the residential sector from 1975 to 2012, the University of California Center for Energy and Environmental Economics reported that “the effect differ[s] across studies depending on the rigor of the methodology used. Indeed the savings are down to 2% for the studies of the highest quality that include a control group as well as weather and demographics controls” (Delmas, Fischlein, and Asensio 2013, 4).

In terms of program types, HERs are the most notable example of robustly evaluated behavioral programs. Some of these efforts have been particularly sophisticated, allowing examination of questions such as “Does receiving a home energy report increase the likelihood of participating in other energy-saving programs in addition to changing behavior at home?” and “How long after the program is stopped do energy savings last?” With these metrics available, third-party evaluators can effectively remove the energy

⁷⁹ Energy savings are usually the last step in a series of behavioral steps triggered by behavior change programs, and detecting their effects can be tricky without large sample sizes and long sampling periods. For example, a program encouraging residents to fill their dishwashers completely before operating them may reduce hot water consumption and produce a small amount of energy savings on their monthly bills. In order to detect these energy savings through bill analysis, researchers would require a lot of data, sampled over a long period of time, because there is considerable variability in the baseline levels of behavior and the change in energy use is small. However, if they were to measure the specific behavior they targeted (filling the dishwasher completely) by taking a photo before use or completing a self-report, then detecting a change could be easier. Hence, bill analysis and energy savings may not always be the ideal end point for behavior research.

savings that are due to uplift in other programs from the energy savings attributable to HERs.

Home energy audits, competitions, and school-based programs reported high savings, and were possibly more effective than other approaches. However the evaluation methods used by these programs were often unclear and more data are needed to validate their findings.

One final point: Program administrators will often use all applicable behavior change concepts and strategies in a behavior change program. Given that each strategy alone has a small effect, combining strategies could provide a larger effect and a higher likelihood of creating a noticeable change in behavior. This is an effective approach for encouraging behavior change, but it does not allow assessment of individual strategies within the program to determine their relative usefulness. Consequently, such a program will likely save energy, but possibly at the expense of learning why. Program administrators may consider working with social science researchers, or others who are experienced with these types of behavior change strategies, to design their behavior change programs from inception, using a strategy that both saves energy and allows thorough evaluation of effectiveness.

MAXIMIZING SAVINGS

We found that targeted programs reduce energy consumption per customer more than blanket approaches. For example, utilities interested in encouraging customers to reduce residential energy use can introduce an opt-out HER program and expect a modest reduction of 1.2-2.2% per customer by the end of the second year.⁸⁰ However, with a more targeted approach, they could offer real-time feedback devices, smart thermostats, or energy audits, which could save on average at least 4-7% among a smaller group (i.e., those who opt in to the program).

Although opt-out programs usually save more energy overall, a greater individual percentage savings can be achieved with targeted opt-in programs. Achieving savings among motivated populations is more likely than among participants who are simply complacent and choose not to opt out. Residents with more positive attitudes toward the environment use less energy even without interventions and are more likely to take action to further reduce energy consumption (Sapci and Considine 2014; Baier, Kals, and Mueller 2013). Therefore, identifying and targeting these customers might be an effective means of maximizing program savings.

In general, as programs incorporate more personal contact with customers, they are more effective at enlisting participants and eliciting energy savings. Increasing personal contact, however, requires adding resources for large numbers of people.

Specificity is vital for a program to be successful. Programs that are directed to address particular behaviors (e.g., washing laundry in cold water) are more likely to work, and the

⁸⁰ Of course the sum of these savings is not so modest when aggregated across many households.

best way to determine if the program has worked is to compare participants' behavior with that of a randomly selected control group. Community-based social marketing (McKenzie-Mohr 2011) is an effective design tool to create these types of programs, although they can sometimes be difficult to scale up.

Maximum savings can be achieved by encouraging investment in energy-efficient technology (efficiency behavior) or encouraging changes in small, frequent, habitual behaviors (curtailment behavior). Beyond decisions to install energy-efficient technologies, decisions on how to use those technologies can also affect the realization of savings. For example, operators of smart thermostats can undercut their ability to save energy if they do not use them to their full potential. Creating thermostats and other energy-relevant devices that are easier to use (or perhaps motivate users) could increase the savings provided by the devices. Conversely, encouraging residents to dress warmly rather than increase the set points of their thermostats could also save energy.

INNOVATIVE BEHAVIOR CHANGE STRATEGIES THAT COULD BOOST ENERGY SAVINGS

Energy Champions

Fortunately, a wealth of potential behavior change strategies and programs are available and have yet to be implemented to their maximum potential. For example, we found that a number of programs attributed their success to block leaders or energy champions, individuals within communities, organizations, or businesses who actively promoted behavior changes within their social or professional networks. Programs are particularly likely to succeed if business owners or managers support individuals who have the power to push behavior change initiatives. In some cases, such as SEM programs, energy champions are central components, but in other cases, such as office competitions, program evaluations simply mentioned that these were helpful and useful for the program's success.

Apart from being a strategy on their own, energy champions can effectively be added to a variety of other programs. They can boost the effectiveness of competitions, school-based programs, or any initiative targeting groups of people rather than individuals.

Effective Underused Strategies

In our research, we found that a few strategies were used less commonly than others. Several that could be more frequently employed as parts of larger programs, or on their own, are

- commitment (e.g., goal setting and the foot-in-the-door technique)
- follow-through (e.g., prompts or signs)
- framing (e.g., minimizing choices, changing defaults, or presenting as avoiding loss rather than gaining benefit)
- in-person interactions (e.g., leading by example)

Other effective strategies may include increasing participants' self-efficacy (the belief that they can change their behavior and that it would not be difficult) and framing messages such that they overcome the psychological discounting effect, in which future benefits of

energy conservation or harms of climate change are given less value than immediate benefits or consequences (Iguelzi et al. 2013).

RECOMMENDATIONS

On the basis of the evidence we have reviewed here, we believe behavior change programs can effectively reduce energy consumption. However, unlike technology-based solutions, the amount of energy savings that can be derived from behavior programs vary, and therefore, these programs should be carefully designed, implemented, and evaluated.

Program administrators can reduce consumer energy demand by using a variety of behavior change programs, each having pros and cons. In order to choose the ideal program, administrators should first consider their target audience and behavior, then tailor a program to address them. Community-based social marketing is one effective model for this process, especially with smaller-scale programs.

Although there is no single best program to use in every situation, we recommend a few methods that can be used to increase the energy savings of most programs. For example, energy champions or leaders of change should be recruited for any group-based program (e.g., community, multifamily residential, and commercial). Combining multiple programs and strategies is also likely to be effective, especially for smaller, targeted programs.

Strategies using evidence-based behavioral insights should be incorporated into programs whenever possible. There are a myriad of such insights that could be the basis of effective strategies. For instance, programs could ask participants to set goals and make plans to achieve them, or could ask them to publicly commit to energy efficiency behaviors. For a summary of possible strategies, see Gonzales et al. (2013), Abrahamse et al. (2005), and Abrahamse and Steg (2013).

We recommend that program implementers focus not only on immediate results, but also on continued savings over the long term. Therefore, if a behavior change program targets small, frequent curtailment behaviors rather than installation of efficiency upgrades, it should (1) change habits, (2) provide intrinsic motivation (e.g., deriving happiness or satisfaction from doing the behavior), (3) change how people think about the behavior (giving it greater importance, for example), and (4) change the perception of future costs (making the new behavior easier and less costly to continue than to abandon). If the behavior is primarily motivated externally, such as by time-of-use pricing or rebates, and if the program does not change habits, perceptions of future costs, or how people think, then the behavior may return to baseline levels when the program is discontinued.

Last, we strongly encourage program administrators to build effective evaluation strategies into their programs from inception. These should include third-party evaluations using a mix of methods. The percentage of energy saved is one important end point that should be included whenever possible, but other measures of behavior are helpful as well, such as the frequency of specific actions (Karlin et al. 2015). Experimental or quasi-experimental methods with long-term follow-up periods provide convincing evidence of program

effectiveness, given a large, representative sample of participants. Therefore, program administrators should use the best research design that they can feasibly implement.

CONCLUSION

Behavior change programs save energy. As demonstrated by the variety of programs and strategies reviewed in this report, they can affect both curtailment and efficiency behaviors. They can encourage people to change their personal habits at home, their electricity use at work, and energy use in industrial settings. Nevertheless, this burgeoning field could benefit from additional research and effective evaluation. Undoubtedly, energy savings will continue to grow with new and innovative behavior change program designs. Several potential strategies remain untapped, and existing programs could be further optimized and improved.

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Appendix A. Research Methodology

To expand on previous research, we surveyed 296 reports, studies, and program evaluations obtained through database searches and personal communications. We also consulted program administrators, government program directors, and other experts in more than 60 personal communications. Specifically, we derived the information contained in this report from 10 resources:

- Personal communication with key experts in energy efficiency behavior change programs
- Reports by organizations concerned with energy efficiency such as the Consortium for Energy Efficiency, the Minnesota Center for Energy and the Environment, and various regional energy efficiency organizations
- Behavior-program implementers such as Opower
- Behavior-program evaluators such as Opinion Dynamics
- Academic literature searches in databases such as PsycInfo, Web of Science, and Lawrence Berkeley National Labs (2014–2016)
- Responses to online requests, including a blog post on the ACEEE website that was also posted on the ACEEE Facebook, LinkedIn, and Twitter accounts
- ACEEE reports downloaded from its website
- Conference proceedings from the Behavior, Energy and Climate Change conference (2014–2015), the ACEEE Buildings Summer Study (2014, 2016), and the Market Transformation Conference (2016)
- California Measurement Advisory Council (CALMAC) database (2014–2016)
- State and Local Energy Efficiency database (SEE Action) website (2014–2016)

The data presented in this review are publicly available or shared with the permission of the proprietary program administrators. In our initial search we found 43 evaluations of Opower programs (including five meta-reviews), 41 reports or evaluations of other behavior change programs (often drawn from utility demand-side management reports or personal communication with program implementers or evaluators), 112 conference proceedings, five reports downloaded from CALMAC, 41 papers from the CEE and ACEEE websites (search term = “behavior”), and 54 academic papers.

We excluded reports, academic studies, and program evaluations if they were conducted before 2012 or did not include a systematic evaluation. We were pleased to find that many newer programs included at least a rudimentary evaluation, and a large minority were formally evaluated by third parties. Nevertheless, the quality of evaluations ranged from low—such as a simple pre-post measurement of gross energy consumption without a control group—to high—such as a randomized controlled trial with a large representative sample evaluated by a neutral third party). Impact evaluations of home energy report (HER) programs are particularly sophisticated. When possible, we report the net adjusted energy savings from the programs we reviewed.

Much of this report also draws on other recent reviews of energy efficiency behavior change programs (e.g., Dougherty et al. 2015; Grossberg et al. 2015; Jones and Vine 2015; Ashby et

al. 2012; Ochsner et al. 2015; Abrahamse and Steg 2013; Karlin, Zinger, and Ford 2015; Schultz 2014; NEEP 2015; Allcott and Rogers 2013; Khawaja and Stewart 2014).

Appendix B. Curtailment Versus Efficiency Behaviors

An important question to examine is, What type of behavior can be targeted by a behavior change program? Stern and Gardner (1981) distinguished curtailment behaviors from efficiency behaviors, based on their differing objectives. Curtailment behaviors include regular, recurring, and potentially habitual changes in behavior, such as washing laundry in cold rather than hot water, turning off unnecessary lights, or unplugging devices when they are not in use. Efficiency behaviors include rare, or one-time, investment behaviors such as upgrading insulation or choosing to buy a zero net energy home. Infrequent behaviors, such as changing a thermostat set point (or turning the thermostat off entirely), are important targets, but because they are infrequent activities and do not require new equipment, they are not easily categorized into either group and may, therefore, require an alternative method for classification (Boudet, Flora, and Armel 2016; Karlin et al. 2014).

Ignelzi et al. (2013) propose seven categories of behavior that subdivide efficiency and curtailment behaviors into smaller groups and provide additional categories for behaviors such as recycling appliances and installing home automation devices. Newer reviews suggest that categorizing behavior as curtailment or efficiency may not be as useful as distinguishing it by duration, difficulty, or other underlying attributes (Boudet, Flora and Armel 2016; Karlin et al. 2014). Nevertheless, we use the traditional curtailment-efficiency categorization for this review because it reflects a distinction that has potential policy implications.

Identifying the types of behaviors that can be targeted is not a trivial or academic exercise; it has genuine programming consequences. Programs that target curtailment are the clearest examples of behavior change programs because human behavior is the sole cause of energy savings. If humans cease to engage in the relevant behavior, energy savings will cease as well. Behavior change programs of this nature aim to change habits and create a new normal way of doing things. Conversely, programs that target efficiency behaviors require participants to engage in one-time actions, after which energy savings are realized for years, regardless of the participants' behavior.⁸¹ This type of behavior is difficult to change, and programs targeting it usually include a variety of behavioral and monetary strategies. The goal for these is not a shift in values, attitudes, or habits, but a single decision based on long-term planning and better outcomes. Behavior change programs that successfully curtail energy-use behaviors may be a less expensive way for utilities to reach their annual efficiency targets, but the savings may not persist to the same degree as those from efficiency behaviors. Additionally, the ability of savings to stack on each other year over year may be limited.

Stern and Gardner (1981) suggest that curtailment behaviors receive the bulk of attention in social science research but that efficiency behaviors typically save more energy. Furthermore, the durability and persistence of energy savings from programs targeting

⁸¹ Behavior is not entirely meaningless. One concern for program administrators is the potential rebound effect. If an installed piece of equipment or technology that saves energy is accompanied by behavior that uses more energy, then behavior *does* matter.

curtailment behaviors are less well known than the persistence of savings from the installation of energy-saving devices. Therefore, although curtailment behavior change programs may be cheaper in the short run, efficiency behavior change programs may be more cost effective in the long run. But are efficiency behavior programs really “behavioral” if the technology, rather than people, is saving the energy?

In a practical sense, yes; both curtailment and efficiency behavior programs are typically referred to as *behavioral*, and most programs do not specifically target one or the other. Rather, they suggest a variety of actions that could be taken to reduce energy use, some of which involve curtailment and some, efficiency. However not knowing which behaviors are changed makes predicting the persistence of their savings challenging.

As commonly defined by the California investor-owned utilities and others, behavior change energy efficiency programs exclude traditional incentive and policy-based strategies (rewards and punishment), which can lead to some narrow or tricky classifications. For example, when a program encourages the installation of efficient lightbulbs by providing a refund, it is not considered behavioral (because incentives are a traditional rather than a behavioral strategy), but if it encourages the same behavior by using a cleverly worded persuasive message (e.g., by discussing social norms), then it is behavioral. Classifying a program is particularly difficult when it provides both monetary and nonmonetary strategies.

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