Overview of Residential Energy Feedback and Behavior-based Energy Efficiency

Prepared for the Customer Information and Behavior Working Group of the State and Local Energy Efficiency Action Network

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Energy+Environmental Economics

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1 Summary

This report provides an overview of residential customer information and behavior (CIB) energy efficiency programs. The report was written in February 2011 for policy makers seeking to better understand how lessons from behavioral science may apply to real-world energy efficiency applications, with a focus on customer information/feedback. Note that this report does not reflect any changes in the industry or policy-environment that have occurred post-February 2011. This report also identifies some of the key challenges to increasing the penetration of CIB programs across the country and recommends solutions to these challenges.

+ Section 2 addresses the question: what is CIB and how does it yield energy savings? Thus, this section lays the contextual foundations for the rest of the report.
+ Section 3 offers an overview of the industry. It answers the question: who are the major players in the provision of CIB programs?
+ Section 4 answers the question: how are energy efficiency savings from CIB programs measured, and what level of savings are reported in the literature? Thus, this section informs policy makers of the evaluation challenges for, and potential efficiency gains from, CIB programs.
+ Section 5 answers the question: what are the key regulatory and policy challenges for CIB energy efficiency programs? This section provides

specific examples of states that are addressing these concerns through the legislative and public utility commission regulatory processes.

+ Section 6 concludes with recommendations for futures steps to successfully promote and implement CIB programs.

This independent report was commissioned by the U.S. Environmental Protection Agency (EPA) as background for the State Energy Efficiency Action (SEE Action) Network's Customer Information and Behavior (CIB) working group. The SEE Action Network is jointly led by the EPA and the Department of Energy. The CIB working group is, for the time being, focusing its efforts on residential electricity savings from improved customer information and energy feedback.

Behavior-based energy efficiency strategies exploit the fact that people's energy choices are influenced by social and psychological behavior as much as, if not more than, economic factors (e.g., prices, costs and income). Behavior-based strategies use non-economic incentives to change how people perceive their energy use, so as to affect their energy use behaviors and hence achieve energy savings. Energy feedback, a subset of the broader category of behavior-based energy efficiency, provides customers with more detailed, timely and contextual information than typical utility bills about their energy use, in order to help reduce their energy consumption.

While CIB programs and strategies have been, and continue to be, tested in pilots, they are starting to be deployed across the country by utilities and third parties. Reported energy savings from energy feedback programs on average range from 2% to 7%, depending on the frequency and type of energy information provided.

Energy feedback programs, especially comparative home energy reports, are seeing larger-scale programmatic adoption by utilities in some jurisdictions, and are expected to reach over 5% of U.S. households in 2011.[1] When compared to other forms of energy efficiency programs (e.g., appliance and lighting rebates), however, the use of behavior-based energy efficiency strategies is not yet widespread.

A key implementation question, which some state regulators are grappling with as part of regulatory proceedings, is how to protect the privacy of customers. Other thorny issues include measuring and verifying directly attributable energy savings, the persistence of these savings, and ensuring that the programs are cost-effective. Despite these challenges, many states, municipalities, utilities and public utility commissions are proceeding with the deployment of CIB programs, often in conjunction with the roll-out of smart meter investments. Currently, three U.S. states count energy feedback savings as part of utility-administered efficiency programs. Many other states and utilities are testing energy feedback programs on a pilot basis, with over 11 states counting energy feedback as a part of utility efficiency programs on a case-by-case basis.

While there are still many unanswered questions about CIB programs, early lessons indicate that programs are most successful when they integrate several energy feedback and behavior-based intervention strategies. Changing customer energy use behaviors is a complex challenge, one that cannot be easily overcome by flooding the customer with more data. Rather, the form,

[1] Based on U.S. Census data of 120 U.S. households and industry reports of energy feedback programs.

context and delivery method of information flow appears to be just as important as the content of the information.

CIB strategies present a promising opportunity to affect customer energy use habits and patterns, beyond traditional technology- or standards-based efficiency programs. That said, effectively capturing the CIB's untapped potential benefits will require policy-makers to take the follow steps:

- Data access, data transfer and privacy rules must be clarified, especially as they pertain to smart meter data collection;
- Training in, and access to the latest results of CIB research and pilot programs is critical for localities to start adopting CIB programs;
- Funding for larger and longer-duration CIB studies and utility pilots is needed across the country; and
- Appropriate measurement and verification protocols, such as the use of experimental design, must be adopted for CIB measures.

2 Key Terms and Definitions

2.1 Definitions

Customer information and behavior energy efficiency strategies differ from traditional programs that are technology- or standards-based because they recognize that people's motivations to implement efficiency can be swayed by social, psychological, political, and moral factors (Ehrhardt-Martinez, 2008).

Robert Cialdini, Emeritus Professor of Psychology at Arizona State University, argues that, "decision-makers can focus too much on economic and regulatory factors when seeking to motivate others towards environmental goals. They would be well advised to consider, as well, what is known about social psychological motivators, such as social norms," (Cialdini & OPOWER, 2010).

Cialdini's research shows that people are influenced both by evidence of what others commonly do (descriptive norms), and what others commonly approve or disapprove of (injunctive norms). When the two norms deviate, people tend to do as others do, suggesting that informing a household of what others are doing can be effective in inducing energy saving behavior. Cialdini's research has shown that simple changes to the language of public service signs, reflecting descriptive norms, can dramatically increase compliance with environmental goals (Goldstein, Cialdini, & Griskevicius, 2008).

CIB strategies seek to apply these and other lessons from social psychology to improve energy efficiency outcomes. Abrahamse et al. (2005) divide behavior-based strategies into antecedent strategies, which occur prior to an energy consumption decision (e.g., energy saving commitments, goal setting, information and modeling), and consequence strategies which occur after consumption has taken place (e.g., feedback and rewards). In this paper, we divide CIB programs into: (a) ***education and outreach*** *programs* targeted broadly to customers independently of their specific energy use habits, and (b) ***feedback*** programs tailored energy use information provided to customers.

Education and outreach campaigns focus on providing information to consumers, through workshops, electric bill inserts, school-based efficiency lessons or traditional media such as billboards and radio ads. An example of a statewide efficiency education program is California's Flex Your Power program, which provides consumers with a comprehensive set of energy-saving strategies.[2] Other education and outreach programs directly engage consumers to set efficiency savings goals or to contribute to achieving community energy savings goals. An example is BC Hydro's Team Energy Smart program, which asks customers to set a conservation goal, track their progress towards achieving the goal, and then rewards consumers for achieving the goal (Korteland, 2009).

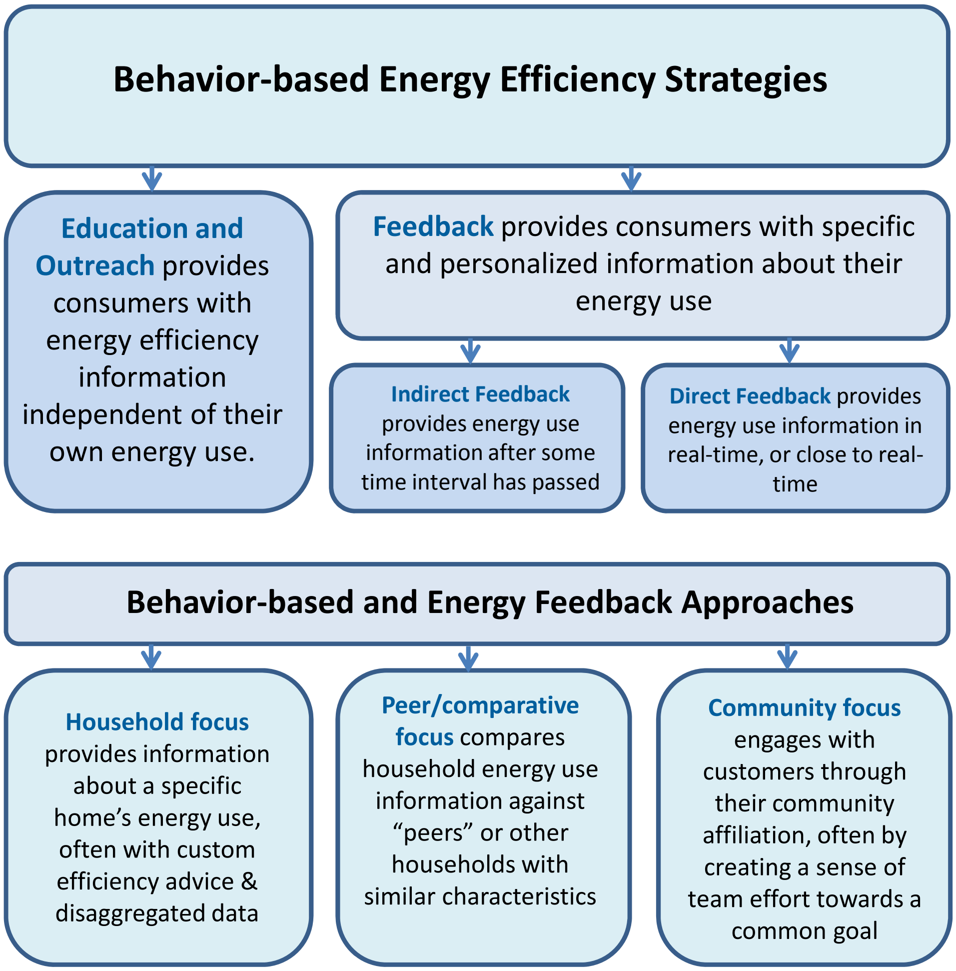
A primary focus of many CIB programs, feedback strategies seek to change consumer's energy consumption behavior by expanding the energy-related information available to the consumer. As shown in Figure 1 below, there are

[2] Flex Your Power: www.fypower.org/

two types of feedback: (a) ***direct feedback,*** which provides energy consumption information in real-time (or near real-time) through the meter or in-home display, and (b) ***indirect feedback,*** which provides energy consumption information to the customer at some later point in time (Darby, 2006). Within each feedback type, further delineation may be made based on the level of data disaggregation and frequency of energy information feedback (EPRI 2009).

Aside from the volume and frequency of information flow, the success of a feedback program critically depends on how the information is displayed and how consumers are motivated to interact with and use the information provided (Fisher, 2008). Detailed in Section 3, there are three main approaches to engage with customers to affect behavior: 1) target an individual's specific consumption habits in the home, 2) make normative comparisons with peer groups, and 3) target the community.

Figure 1. Types of behavior-based energy efficiency strategies & approaches



2.2 Types of Energy Use Behavioral Changes

Behavior affects every energy use decision that a person makes: it influences how spacious of a home one desires, what types of appliances one purchases, and how often one leaves the television or lights turned on. Thus, it is useful to categorize different types of behavior and choices in terms of what changes a household may adopt to improve its energy efficiency.

Table 1 below divides behavior changes into “investment” decisions, which require some form of capital outlay, and “habitual” decisions which are largely usage choices made after an investment choice has been made. Investment and habitual behaviors can further be classified as imposing little or no cost, or fairly high cost.

The CIB programs herein focus primarily on habitual decisions, such as turning off lights when not in use, and on low-cost or no-cost investment choices, such as weather-sealing a home. They do not consider the high-cost, one-time investments, such as the choice of whether to buy a more efficient appliance, which falls under the traditional incentive-based energy efficiency programs.

Table 1. Types of Behavior Change with Examples

	Investment One-time changes resulting from a capital outlay, non-repetitive actions	**Habitual** Recurring, repetitive or frequent actions
Low Cost/No Cost	Weather stripping Caulking More efficient light bulbs	Turn off lights, appliances, heating/cooling when not in use Cold wash clothes washing
Higher Cost	Efficient HVAC/heat pumps Efficient appliances Whole-house retrofit	Changes in habitual behaviors can occur through technology automation, including sensors, smart thermostats, smart appliances and home energy automation systems

Source: Adapted from Ehrhardt-Martinez, K. (2008). "Behavior, Energy and Climate Change: Policy Directions, Program Innovations and Research Paths," ACEEE Report Number E-087.

2.3 Barriers to Efficiency & Impacts of Feedback Programs

CIB programs present a promising source of energy savings because they can overcome some of the key barriers to energy efficiency that are difficult to address with traditional, incentive-based energy efficiency programs. Shown in Figure 2, these barriers are structural, behavioral and availability-based (McKinsey, 2009). The same figure also shows the barriers (identified in darker font) which behavioral energy efficiency strategies can help to overcome.

Figure 2. Barriers to Energy Efficiency (Behavioral Energy Efficiency Programs Can Contribute to Overcoming Barriers Shown in Darker Font)

Structural

Agency: incentives split between parties
Ownership transfer issue: Owner expects to leave before payback period
Transaction barriers: unquantifiable incidental costs of transaction. (Behavioral EE can help the customer take the first steps to motivate action.)
Pricing distortions: Regulatory, tax and other distortions

Behavioral

Risk and uncertainty: Regarding ability to capture benefits of investment (Behavioral EE can increase certainty that bill savings are achieved through more transparent billing information.)
Lack of awareness/information: About product efficiency and own consumption behavior (Energy feedback can increase awareness of energy use)
Custom and habit: Practices that prevent capture of potential efficiency (Behavioral EE can support changes to "default" practices and habits.)
Elevated hurdle rate: Similar options treated differently. (Increased awareness of energy use and choices can help overcome elevated hurdle rate.)

Availability

Adverse bundling: Combining efficiency savings with costly options
Capital constraints: Inability to finance initial outlay
Product availability: Insufficient supplies or channels to market
Installation and use: Improperly installed or operated (Energy feedback programs can help educate customer about energy use, device operation)

Source: Adapted from McKinsey and Co. (2009), "Unlocking Energy Efficiency in the U.S. Economy," available at: http://www.mckinsey.com

As shown in Figure 2, energy feedback can reduce barriers to greater efficiency by providing customers with more detailed information about their energy use patterns, thereby helping to improve their energy awareness and to change wasteful energy use habits. It can also help customers better understand the impacts of making an energy efficiency investment (e.g., energy-efficient lighting), such that they can actually "see" measureable energy savings, proving that the device is operating as expected. By making this cause and effect relationship more transparent, consumers may be more willing to invest in additional energy efficiency.

3 Residential Energy Feedback Industry

3.1 Overview

Though still relatively small, residential energy feedback is a fast-growing and fast-evolving industry. There are many third-party vendors, operating on platforms that target customers through the mail, web, mobile applications, and in-home display devices. Companies that initially used only one channel to engage its customers (e.g., traditional mail) are expanding into other channels like in-home hardware, online and mobile applications. Companies that initially provided only one type of energy use feedback, such as comparative energy use information, are now using multiple strategies like social networking and commitment setting to engage and connect with customers. This section describes some of the services and technologies that these companies provide and discusses various approaches to providing customers with energy feedback.

We identify three principle approaches to engaging the customer:

1) **Individual household**. Programs that provide energy feedback to an individual household, without benchmarking, contests or engagement of a larger community.

2) **Peer comparisons**. Programs that inform a household of its energy use relative to a benchmark based on similar households or other peer groups.

3) **Community-based programs**. Programs that encourage households to participate toward community-level savings goals, or as part of a community through social marketing and social norms or encouragement.

Within these three categories, energy feedback can occur as: one-time feedback, interval feedback and real-time feedback. Table 2 below shows examples of companies within each category. This table is only indicative because it is not a comprehensive list of all companies in this industry, and many companies are seeking to provide services across multiple categories of energy feedback listed below.

Table 2. Energy feedback types and examples of vendors by type

	One-time feedback	Interval feedback	'Real-time' feedback
Household focus	Home energy audits, RESNET Home Energy Raters, Recurve, selected Lowe's stores	Enhanced utility billing, typically provided directly by utility	Home energy displays or management systems: Control4, iControl, Tendril EnergyHub, The Energy Detective, Cisco Google PowerMeter,
Peer/ Comparative focus	Online tools with comparative focus: Yardstick, EnergySavvy, Microsoft Hohm	OPOWER, Efficiency 2.0	Microsoft Hohm, OPOWER, with selected utilities
Community/ Commitments/ Social marketing focus	Community energy challenges, typically provided directly by utility or community. Rothsay, MN Community Energy Challenge, BC Hydro "Team Power Smart" Online feedback and social networking components: Stickk, EarthAid		Efficiency 2.0

Note: Companies categorizations are approximate; company approaches are constantly evolving and may cover multiply categories. This is not an exhaustive list.

3.2 Household Energy Feedback

3.2.1 ONE TIME FEEDBACK – HOME ENERGY AUDITS

Many companies across the country offer home energy audits, providing individual homeowners with a one-time assessment of home energy use and energy savings opportunities. Energy audits are designed to increase a building owner's investments in energy efficiency, rather than to change habitual energy behaviors. Some examples include Home Energy Raters certified through RESNET (residential energy services network), Recurve, and selected Lowe's stores. Audits are generally offered on a fee-for-service basis; even though follow-on services may also be offered. Recurve, for example, offers full, turn-key home performance retrofitting, including identification and fulfillment of incentive programs offered by utilities and other entities. Fuller et al (2010) further detail several case studies of exemplary home energy audit and retrofit programs, including Bonneville Power Administration's home weatherization program, Washington D.C.'s "Weatherize D.C." program, and Houston's Residential Energy Efficiency Program.

3.2.2 INTERVAL FEEDBACK – ENHANCED UTILITY BILLING

Some utilities have begun offering energy information on monthly customer bills, beyond basic billing determinants and dollar amounts. Utilities generally provide this additional information with the intent of encouraging customers to become more energy efficient. Pacific Gas and Electric (PG&E) in California, for example, provides not only the current month's gas and electric usage, but also the usage for the same billing period from the previous year. This gives customers some insight into their energy usage trends over time.

3.2.3 REAL-TIME FEEDBACK - HOME ENERGY DISPLAYS & HOME ENERGY MANAGEMENT SYSTEMS

Home energy displays provide real-time, or near real-time, energy use information to the household, typically through a stand-alone device in the house. Pilot programs of real time energy feedback show a wide range of savings, from 0% to 13% according to recent meta-analyses (See Faruqui et al., 2010, and EPRI, 2010).

These displays vary greatly in complexity and display format. At their simplest, a device may report only the total instantaneous energy demand of the household. More complex displays may show changing electricity rates or demand response events, energy use disaggregated by household appliance, historical energy use data, and projections of monthly energy use and expenditures.

Home energy displays are often enabled by smart meters, but some can also directly “read” or measure energy use from electric wires or meters without smart meter technology. Home energy displays may have an online component that offers energy savings tips, and may overlap with “peer comparison” strategies by providing comparisons to neighbors’ energy use patterns.

Home energy management systems extend the capabilities of home energy displays, offering automation and control of end-uses such as the HVAC system or lighting. Home energy management systems often utilize data from smart meter installations. Although millions of smart meters have been installed nationwide, less than one percent are equipped with home energy displays or home energy management systems (Neichin et al., 2010).

Seeking to enter this emerging market of home energy displays and home energy management systems are companies like Google’s PowerMeter, Tendril, EnergyHub, The Energy Detective, Energy Aware, iControl, Control4, and Cisco. Display or management systems may be offered directly to consumers, or may be sold to utilities for use in their efficiency programs. The costs vary widely, from under $100 per unit to upwards of $1,000 per unit depending on the services provided, but these costs are expected to decline over time. Some offerings, such as Google Powermeter, are web-based energy monitoring services, with some delay between energy consumption and the display of the data. Google Powermeter is offered free of charge in areas where utilities support the program (Neichin et al., 2010).

3.3 Peer-based Comparative Feedback

3.3.1 ONE-TIME FEEDBACK

Another form of energy feedback compares an individual's energy usage to the average energy use in similar buildings in the community/peer group. Comparative energy feedback helps individuals put their energy use habits into context, and may encourage individuals to stay within the "norm" or to improve their energy consumption relative to their neighbors.

Two notable examples are the EPA's ENERGY STAR "Home Energy Yardstick" and Microsoft Hohm, both are online tools that allow individuals to compare their home energy use to "typical homes in the area." Another example is EnergySavvy, a web-based company that provides a self-reported online energy audit and connects homeowners with contractors who can provide energy efficiency retrofit services. The company's website also puts each home's estimated energy use on a scale from 1 to 100, as a comparison point against which customers can gauge their energy efficiency.

3.3.2 INTERVAL FEEDBACK

Interval feedback is often done by quarterly or monthly mailings to customers, and/or via web-based applications. It may be more effective in inducing energy savings because of its more frequent information supply to households. These programs rely on the power of social norms to encourage people to reduce their energy use to be in-line with their more efficient neighbors.

Some utilities offer online energy comparison reports without utilizing the services of a third-party vendor like OPOWER. For example, Duke Energy's online bill-pay also allows customers to compare their energy bill to their average "neighbor", take a home-energy audit, or view an estimate of which appliance contributes most to their bill. As another example, the municipal utility in Gainesville, Florida is testing an online portal which allows residents to compare their annual energy usage patterns and levels to their neighbors.[3]

The largest comparative, interval feedback program in U.S is operated by OPOWER. As of early 2011, OPOWER was sending reports to approximately 2 million customers, with over 6 million customers contracted to receive reports (approximately 5% of all U.S. households). In early 2011, OPOWER estimated the average cost of their program at $10/household per year, depending on the types of services included in the contract and the size of the deployment (personal interview, OPOWER). At this price, we estimate that at least $60 million (= $10/houshold/year * 6 million households) will be spent in 2011 on energy feedback programs. Scaling up an energy feedback program to every household in the U.S. would cost approximately $1.3 billion/year by 2020. Utility-based pilot programs using OPOWER's comparative energy use mailings or bill inserts show energy savings of 2% on average (Ayres et al., 2009).

[3] See Gainesville Green: http://gainesville-green.com/

3.3.3 REAL-TIME FEEDBACK

Comparative, real-time energy feedback is an emerging and rapidly-evolving field. Some companies, like OPOWER and Microsoft Hohm, are seeking to integrate comparative energy feedback and real-time feedback into home energy displays that are linked to smart meter deployments.

Through a partnership with Blue Line, Hohm offers nearly real-time energy consumption data that can be viewed at hourly or minute intervals. Based on the energy use characteristics of a residence, the program provides a "Hohm Score" indicating the relative energy efficiency of the house as compared to similar homes and projected potential.

Comparative energy feedback programs that utilize the detailed data gathered by smart meters raise a number of important questions around customer privacy and data access, especially when third-party vendors are involved. Many of the data access and privacy issues are currently being addressed in regulatory proceedings across the country, as discussed in Section 5.

3.4 Community, Commitments and Social Marketing

3.4.1 COMMUNITY SAVINGS TARGETS

Community-based programs engage customers through their community affiliation by creating a community-wide energy savings goal, possibly benchmarking progress against other communities. The communities may be geographically defined, such as a town or municipality, or may be "virtual," such as an affiliation of individuals forming a team for the purposes of a contest or game.

An example is the Rothsay Community Energy Challenge that has a goal to cut community-wide energy use 10 to 15% by 2015. The program is sponsored by the local utility - Otter Tail Power Company and undertaken with the cooperation of the City Council and Mayor's office.[4]

The program includes free home energy monitors, free energy audits, and community events to educate citizens and promote behavior changes, such as bill analyzer training and a community energy fair. Students from the Rothsay Public School system visited every home in the community to request pledges for energy savings, and a dedicated web-site provides updates on community energy savings progress.

Although the program includes incentives for weatherization and other efficiency measures, energy use behavior changes are a key part of the effort. The Rothsay Public School system has achieved savings of 10% based on changes in behavior alone, after excluding savings from retrofitting energy efficiency measures in the school system.

Another example is BC Hydro's Team Power Smart program.[5] Individuals commit to reduce energy consumption by a targeted amount, and may receive rewards and other incentives in return. While in many ways the program resembles the peer comparison programs discussed in Section 3.3, it also

[4] See Rothsay, MN Community Energy Challenge: http://www.energychallengeison.com/rothsay/
[5] See Team Power Smart: https://www.bchydro.com/youraccount/teampowersmart/Join.do

includes a community component: participation and savings levels are tracked by community and reported on the program web site, thus creating a sense of friendly competition and community participation. In addition, many of the incentives are locally-based rewards offered by local businesses – such as tickets to the local aquarium – helping to create a sense of community collaboration.

Other examples of community-based energy efficiency programs are described in cases studies in the Lawrence Berkeley National Laboratory report, "Driving Demand for Home Energy Improvements," including Efficiency Vermont's "Vermont Community Energy Mobilization Project," the Hood River Conservation Project in Oregon, Boston's "Energy Smackdown," and the "Marshfield Energy Challenge" in Marshfield, Massachusetts (Fuller, et al., 2010).

3.4.2 SOCIAL MARKETING

Other types of community-based programs may use community-based social marketing to induce customers to meet individual savings targets. The savings impacts of community-targeted energy efficiency programs have not been widely studied, and the results of pilots vary significantly, so it is difficult to make an assessment of the energy efficiency potential or costs of these types of programs.

These programs may encourage customers to reduce their energy use by setting public commitments, providing rewards for meeting energy savings targets, and connecting individuals online to create a virtual community interested in saving energy. Companies operating in this space include Efficiency 2.0, StickK and

EarthAid, although many more companies are seeking to incorporate social marketing components into their businesses.

EarthAid allows consumers to link electric, gas, and water bills of participating utilities to EarthAid's service. EarthAid then provides online information on monthly energy use compared to historical use, as well as comparisons to energy use by friends and family. In some communities, EarthAid provides additional incentives for consumers who can redeem points earned from energy savings to purchase goods and services provided by local businesses.

StickK is a goal-setting tool. The user selects the goal of choice – such as achieving a certain level of energy savings. The user commits to achieving the goal by a certain date and may volunteer "stakes" to go along with the goal. For example, the user may provide a credit card to StickK and instructions on what to do with the money if the goal is not achieved. An optional referee provides information about progress toward the goal. A community of friends, family, or others may be enlisted for encouragement; this group will receive updates on progress creating social pressure for the user to achieve their goal.

Efficiency 2.0 partners with utilities to provide software associated with the utilities' advanced metering hardware. The software enables customers to receive detailed real-time energy use feedback, as well as allowing customers to obtain savings information on hypothetical energy behavior changes, such as turning off a specified number of lights during peak hours, or shifting clothes washing and drying to off-peak hours.

Efficiency 2.0 offers a social media package that allows consumers to access community messaging, blogs, events, and contests, and to communicate and collaborate on strategies to meet savings goals. A point system is available to give users social status based on energy and carbon savings. Real-time, multiplayer games are designed to increase retention and engagement and build community.

3.5 Challenges Identified by Vendors

Although the CIB industry continues to grow and evolve rapidly, a number of challenges may prevent CIB programs from achieving their full potential. It is worth noting that the goal of CIB programs is not to supplant traditional efficiency programs, but rather to augment and improve existing efficiency efforts. From interviews and discussions with vendors, we identified the following barriers to CIB's wide-spread adoption and acceptance:

+ General lack of awareness on the part of policymakers, utilities and regulatory commissions regarding the efficacy, persistence and cost effectiveness of behavior-based energy savings.
+ "Hardware bias" ingrained in many energy efficiency program administrators, who see energy efficiency as primarily about technology and economics, rather than also about human behavior and psychology.
+ Bias in using engineering-based evaluation, measurement and verification (EM&V) protocols. Often, energy savings are estimated ex-ante based on the expected performance of a given technology. This may not be an appropriate approach for a CIB program, where the level of savings could vary greatly, depending on how the program is implemented and what types of customers are targeted by the program. For this reason, some CIB programs prefer to use "ex-post" assessments of energy savings, employing rigorous experimental design

testing methods, as discussed in Section 4. Ex-post assessment and experimental design evaluation are in some cases not approved by the regulatory commissions, or do not fit into utility's deployment strategies for energy efficiency programs.

+ Outstanding issues surrounding control of and access to smart meter data for real-time energy feedback technology companies, as discussed in Section 5.
+ Antiquated utility billing systems, a challenge to third-party vendors seeking to use utility billing data in their programs. Modernized data storage and transfer protocols could help to overcome this barrier.
+ Lack of coordination and consistency due to the patchwork of state and municipal regulations for energy efficiency programs across the country.

4 Research & Methods

4.1 Current Research

Residential energy use is typically measured by utilities on a monthly basis at the household, rather than at the end-use level. Specific energy use behaviors, such as when lighting is used or not, are rarely directly observed. This makes it difficult to know how specifically an energy feedback program, or CIB program, affects customer energy use behavior. Researchers instead typically focus on evaluating the aggregate impacts of a CIB program at the household level. Researchers use a number of techniques to isolate the impacts of CIB programs, with the gold standard being an experimental design composed of a test and a control group of sufficiently large sample size, over a sufficient duration of time.

Summarized below are several survey studies that suggest significant energy savings may be obtained through energy feedback. These studies also highlight that more high-quality research, and improved research design, are needed to better understand what drives energy savings and how to make achieved savings more predictable (EPRI 2010).

+ An ACEEE meta-analysis report by Ehrhardt-Martinez et al (2010) finds that of the 29 energy feedback studies they surveyed with sample sizes over 100, energy savings ranged from 0.5% to 13%. Of the 23 studies they surveyed with study duration over 6 months, the reported savings ranged from a 6% increase in energy use to a 21% decrease.

- Darby (2006) reports savings from indirect feedback of 0% to 10%, and savings from direct feedback of 5% to 15%.
- Pilot studies that focus specifically on the impact of OPOWER's home energy comparison reports find average savings between 1.2% and 2.1% (Ayres, Raseman, & Shih, 2009).
- Faruqui's (2010) meta-analysis of the impacts of in-home energy displays finds a mean savings of 7%, with a range from 3% to 13%.
- EPRI 2010 reports that recent studies that focus on the impacts of in-home energy displays have energy savings of 0% to 5%.
- Appendix A summarizes additional studies on this topic.

These wide ranges of energy savings indicate that the effect of energy feedback information on customer behavior is hard to isolate across diverse studies, and suggests that more research is needed to better understand the impacts of energy feedback on energy savings.

4.2 Evaluation Methods

In order for customer energy feedback to be incorporated into the programmatic energy efficiency toolbox, regulators and utilities must be confident that the resulting energy savings can be evaluated, measured and verified. There are two principal methods to assess the effectiveness of behavior-based efficiency programs:

- **Survey-based evaluations:** Survey-based evaluations are often used for assessing the impact of education and outreach programs. Typically an evaluator will contact a random sample of customers exposed to the program and ask a set of questions about their experience with the programs. Surveys are useful for establishing whether people are aware of programs, what they have learned from the program, and what their perceptions are about the program. It is harder however, to verify with survey techniques whether a participant's behavior or actions have changed as a result of the program. In addition, determining attribution of energy savings from educational programs is difficult, especially when education and outreach programs are undertaken in combination with economic incentives or other energy efficiency strategies.
- **Experimental design evaluations:** Experimental design evaluations rely on statistical methods to establish whether, on the whole, energy consumption of the treatment group decreased relative to the control group. Ideal experimental design includes large sample sizes of both control and treatment groups, with pre-program, during-program and post-program billing data (EPRI, 2010). While many factors can contribute to a change in an individual household's energy use during a program intervention (e.g., family size or vacation), with a large enough sample size, statistical methods can be used to determine whether the overall treatment group's energy consumption changed during the intervention when compared to the control group's.

While experimental design evaluation methods are well established in the sciences and social sciences, they are not widespread in the utility energy efficiency industry. Compared to engineering-based estimates of energy savings, experimental design evaluations may be seen by some program administrators as introducing difficult questions around program equity and fairness (if programs are offered to some customers and not others).

Experimental design may also be seen as more difficult or time-intensive, and is not yet accepted by some state utility regulators as evidence of energy savings. This is despite the fact that a properly designed experimental evaluation can result in more accurate savings estimates than engineering-based methods that use estimated utilization factors of technologies.

4.3 Areas of On-Going Research

Long-term, larger-scale studies are needed to build the knowledge base around how and why energy feedback programs work, and to build additional credibility and confidence in such programs. One area of on-going research relates to how program design affects customer energy savings. Moreover, the impact of energy feedback on different segments of the population is not well understood. For example, while energy feedback may reduce energy use on average, it may have no effect or lead to increased energy use for some customers.

The ways that energy use information and energy savings programs are communicated to customers matters. Improved understanding of different outcomes by customer type could lead to improved program design, such as through tailored messaging of energy feedback information. Other areas for research include what behaviors customers actually change in the face of energy feedback information, and why.

5 Government and Regulatory Programs and Actions

The collection of detailed energy use information, and the provision of that information to third party vendors and utility customers as a part of energy feedback programs, has raised a number of regulatory and legal questions which state legislatures and utility commissions are now working through. While many general laws protect consumer privacy and data sharing, the increased frequency and resolution of smart meter data collection has raised new privacy concerns. For example, when and under what circumstances must customers consent to having their energy use information shared with third parties? And what customer protections must be built in to smart meter data collection?

In a 2010 report, the DOE notes that the success of smart grid technologies to encourage energy savings will first require "the development of legal and regulatory regimes that respect consumer privacy, promote consumer access and choice regarding third-party use of their energy data, and secure potentially sensitive data to increase consumer acceptance of Smart Grid" (DOE, 2010). State utility commissions are the traditional regulatory body overseeing data sharing and privacy in this context.

The second requirement noted by DOE is "the development of appropriate technical standards and protocols for promoting privacy, choice, and the secure, interoperable transfer and maintenance of sensitive data." This area is being addressed at the state level and by the National Institute of Standards and Technology (NIST) (See Section 5.1) (National Institute of Standards and Technology, 2010).

There is a third requirement not noted by the DOE report, which is that utilities or third parties should only undertake programs which effectively utilize the energy data collected by the smart grid, and then must measure, monitor and verify the resulting energy savings and the costs and benefits of the programs.

Many state utility commissions currently have open proceedings to grapple with these questions in connection to customer energy data access and privacy, the effect of customer access to energy use on behavior and energy consumption, and the costs and benefits of such programs within the regulatory process. Examples include Arizona, California, Colorado, Minnesota, New York, North Carolina, Ohio, and Pennsylvania.

Currently, only California, Massachusetts and Minnesota have approved energy savings from energy feedback programs to count towards utility administered energy efficiency programs on a statewide basis. Over 11 other states are counting OPOWER's energy feedback programs as part of a utility administered program on a case-by-case basis. As of early-2011 these states included: Arizona, Arkansas, Colorado, Florida, Indiana, Maryland, Missouri, New Mexico, New York, Oklahoma, Oregon and Utah, and other states may soon be following (OPOWER, personal interview). The examples discussed in Section 5.2

demonstrate how states are beginning to integrate energy feedback programs into their utility administered energy efficiency savings targets.

5.1 Federal Smart Grid Activities Relating to Energy Feedback and Behavioral Efficiency Programs

The Energy Independence and Security Act of 2007 (Section 1305) charges the National Institute of Standards and Technology with developing smart grid protocols and standards to promote interoperability between and across technologies. When "sufficient consensus" has been reached on these standards, the Federal Energy Regulatory Commission (FERC) is required to "institute a rulemaking proceeding to adopt such standards and protocols as may be necessary to insure smart-grid functionality and interoperability in interstate transmission of electric power, and regional and wholesale electricity markets." This rulemaking is likely to impact the development and deployment of smart-meter enabled energy feedback programs.

NIST has thus far developed a framework of 75 existing standards likely to be applicable to the smart grid as well as 15 high priority gaps that need new or revised standards. Of those standards, five suites are considered ready for regulatory authorities. FERC has not ruled on whether these standards have reached the level of consensus required for adoption, but has issued a notice designating a docket for possible rulemaking (Notice of Docket Designation for Smart Grid Interoperability Standards, 2010).

The Privacy subgroup of the NIST standards development process has been considering issues of third party data access and data privacy. NIST has released a draft report which recommends that organizations charged with establishing policy in this area follow OECD Privacy Principles as well as other established privacy policy guidelines (National Institute of Standards and Technology, 2010). These guidelines suggest providing a process where consumers may view their own data, limiting use of customer information, and notifying customers prior to data collections (e.g. when data will be shared with third parties, and how long the data will be kept). Finally, the NIST subgroup recommends that customers should have the option to forego data collection and services unrelated to the utility's or organization's core service.

5.2 Status of Energy Feedback and Behavioral Efficiency Programs at the State Level

States are currently engaging in a wide range of pilot programs to provide customers with energy use information in order to influence customer behavior and thereby reduce energy consumption. However, the provision of energy use information has raised a number of regulatory and legal questions.

Despite the adoption by the National Association of Regulatory Utility Commissioners of a "Resolution Urging the Adoption of General Privacy Principles For State Commission Use in Considering the Privacy implications of the Use of Utility Customer Information" (National Association of Regulatory Utility Commissioners, 2000) there does not appear to be a consensus among utility commissions on these issues, especially as they relate to smart meter and CIB programs.

States are also determining whether behavioral energy efficiency programs shall be eligible for credit and funding in a utility's energy efficiency portfolio. A handful of states have begun establishing positions on these issues, but most have not. Key state positions on these issues are addressed below. A full summary of regulatory and legislative activities in this area can be found in Appendix B.

5.2.1 DATA ACCESS AND PRIVACY

California (California Senate Bill (SB) 1476: "Privacy Protections for Energy Consumption Data" (2010)

California requires that customers of the three major investor owned utilities have access to near real-time smart meter data through a third party by the end of 2011. Utilities may use aggregate consumption data for analysis, reporting, or program management, provided that identifying individual information is removed. Utilities may also contract with a third party to provide energy efficiency and demand response services, with proper safety protocols, provided the data is not used for a secondary commercial purpose without customer consent.

Colorado (Colorado Public Utilities Commission, Docket No. 09I-593EG)

Colorado will consider and adopt NIST standards for cyber security and interoperability as they are released in order to insure that any state standards are not redundant.

New York (New York State Public Service Commission, Case 07-M-0548, et al.)

New York allows third parties performing ratepayer funded utility functions (i.e. energy efficiency programs) to access customer data without prior consent provided proper privacy protocols are utilized. This allows for opt-out program design, like those being administered by OPOWER, to be utilized in the state.

Texas (Advanced Metering Rule: public utilities regulation – section §25.130)

Texas prohibits retail electricity providers (REP) from releasing customer data without informed consent except to the Commission or a third party acting on behalf of the retail electricity provider. Consumers are allowed to opt-out of information sharing by retail electricity providers to third-parties for marketing purposes. Additionally, a customer is allowed to authorize access to data by a third party other than their REP.

5.2.2 STATE EM&V PROTOCOLS FOR ENERGY FEEDBACK AND BEHAVIORAL EFFICIENCY PROGRAMS

Currently, only three states allow energy savings from energy feedback programs to count towards utility administered energy efficiency programs on a statewide basis: California, Massachusetts and Minnesota. A number of other states, like New York, have approved energy feedback programs to count as part of utility administered programs on a case-by-case basis, as described below.

California

The state's investor owned utilities are required by law to use comparative energy usage disclosure programs. The California legislature passed the "Energy Usage Information Act" (Senate Bill 488, Pavley) in 2009, which is the first of its kind in the country. The law requires that residential customers must have online access to their energy use information and to energy efficiency options, and further requires that investor-owned utilities must implement “comparative usage disclosure” programs. The legislation directs the California Public Utilities Commission (CPUC) to evaluate the energy savings resulting from the comparative energy use disclosure programs using experimental design methods.

As a result of this legislation, in April 2010, the CPUC issued a decision on evaluation, measurement and verification (EM&V) protocols for the investor owned utilities’ 2010 to 2012 efficiency programs. The decision included a provision that comparative usage disclosure programs may be counted towards the IOUs energy efficiency savings goals, with the provision that only ex-post savings evaluated using rigorous experimental design techniques would be credited to the utilities. In this way, comparative energy feedback programs specifically, are put on equal footing with more traditional forms of energy efficiency programs in California.

Massachusetts

In Massachusetts, EM&V methods using experimental design are approved for use by utilities. The Massachusetts Green Communities Act (Section 85 of Chapter 169 of the Acts of 2008), further requires the state’s investor owned utilities to develop pilot programs for smart meters, “that provide real time measurement and communication of energy consumption.” Comparative energy usage disclosure programs are already incorporated into many utility energy efficiency programs and represent a significant share of the state’s total electricity and natural gas efficiency savings. According to OPOWER, their programs have met 24 percent of the state's electric efficiency goals and 20 percent of the state's natural gas efficiency programs.

Minnesota

In 2007, through the "Next Generation Energy Act," Minnesota established a statewide requirement for each electric and gas utility to conserve 1.5% of average retail electric sales, starting in 2010. Utilities must file a Conservation Improvement Program (CIP) with the state Office of Energy Security (OES) for approval. The OES measurement and verification protocols include an option to use facility metering as a means of measuring energy savings from "behavioral modification programs" to count as an approved energy efficiency resource (Minnesota Office of Energy Security, 2008). As a result of the state's policy environment encouraging high levels of energy efficiency savings and innovative approaches towards achieving energy savings, at least eight Minnesota utilities have signed up with OPOWER to run comparative energy feedback programs with home energy reports. Other utilities are undertaking other forms of behavior-based energy efficiency programs, including community challenges and pilots using home energy displays.

New York

The New York State Public Service Commission (NYPSC) approved OPOWER programs for use used by two utilities, Niagara Mohawk Power and Central Hudson Gas & Electric, to meet the state's Energy Efficiency Portfolio Standard. The NYPSC also approved a Home Energy Reports demonstration project for two other utilities, NYSEG and RG&E. Energy savings are to be measured using experimental design methods: the NYPSC notes that, "The evaluation process [of the Home Energy Reports] would compare energy usage between a test population (program participants) and a control population (non-participants) drawn from the same target service area. Energy savings and costs are only attributed to the period in which they are evaluated and there would be no reported lifecycle costs" (NYPSC Case 07-M-0548, et al., November 18, 2010).

5.3 Remaining Questions

While some states are moving quickly to incorporate CIB programs as a standard part of utility energy efficiency efforts, others remain cautious. Data privacy concerns and questions surrounding data sharing protocols remain an unresolved challenge in many states. Resolving these issues will be a prerequisite to further penetration of energy feedback programs in many states. From a policy perspective, it is premature to say that any consensus has been reached on these issues. The following is a list of questions about CIB programs for policymakers to consider:

+ Are CIB programs allowed to be opt-out, or will consumers be required to opt-in?
+ If consumers do opt-out, can their data still be used for comparison purposes?
+ Are energy efficiency programs conducted by third-parties through utilities considered part of a utility's core service? Will there be tiers of privacy protection (i.e. data related to utility business functions will have set of regulations while data sold for unrelated functions will have another)?

+ Will utilities be required to provide third party access to energy data, and if so, how often and at what level of detail? How will the costs of such data provision be allocated?
+ In the event of a security breach of energy data, and unauthorized access to consumer information, how will consumers be notified? What, if any, is the liability of the utility or third party vendor?
+ Will behavioral programs be credited towards utility energy efficiency programs? If so, will savings be measured with experimental design methods or will there eventually be deemed savings levels for comparative energy reports and in-home displays?
+ How will program evaluations avoid double-counting savings from other energy efficiency programs? How will the persistence of CIB programs be measured?

6 Conclusions

Customer information and behavior programs, specifically energy feedback, appear to be a promising source of energy efficiency savings in the residential sector. While estimates of energy savings vary across studies, the comparative energy reports appear to produce savings in the range of 1.2% to 2% across a broad spectrum of all customers (Ayres et al., 2009). Real-time energy feedback and home energy displays generally show higher but also wider ranges of savings, with a mean estimate of 7% savings (Faruqui et al., 2010).

Early lessons from pilot programs indicate that real-time feedback *combined* with useful details on energy use tends to generate the highest level of savings. Simply providing customers with frequent and highly disaggregate energy data may be ineffective at inducing household energy savings to their fullest extent. Thus, energy feedback data should be presented to the customer in a compelling way, should be individually tailored, and should be combined with other motivational and behavioral approaches, including contextual information and education about energy efficiency opportunities.

Pilot programs have demonstrated success using normative comparisons of energy use, locally focused messaging, and small social groups working together to achieve goals/rewards. Games and contests for energy savings is another promising area of behavior-based energy savings, although the persistence of savings from these methods is unknown (Abrahamse, 2005).

Customer behavior and energy feedback program design is an area that will continue to evolve over time as more experience is gained with pilot programs. For example, opt-out program design is the preferred approach in many cases because it leads to higher participation rates and eliminates self-selection bias. However, opt-out programs are not practical in all cases and program designers must be cautious not to violate customer data privacy rights. Regulatory questions of when energy feedback programs can be designed as opt-out versus opt-in programs remain unresolved in many states.

Overall, additional experience with behavior-based and energy feedback programs is needed at the utility programmatic level with broader pilot programs of longer durations. To enable residential customers to benefit from the promising energy savings potential of CIB technologies and services, we offer the following recommendations for policy makers:

+ Data access, data transfer and privacy rules must be clarified, especially as they pertain to smart meter data collection;
+ Information on, and access to the latest results of CIB research and pilot programs is critical for localities to start adopting CIB programs;
+ Funding for larger and longer-duration CIB studies and utility pilots is needed across the country; and
+ Appropriate measurement and verification protocols, such as the use of experimental design, must be adopted for CIB measures.

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Appendix A: Table Summarizing the Literature

Table 3. Summary of in-home display's conservation effect on electricity consumption

Study	Description	Conservation effect	Methodology notes
ACEEE (2007)	A survey evaluation of energy savings due to in-home display	Conservation effect for a single family home is 5%, based on Hydro One pilot (p.1)	Includes an estimate of cost-effectiveness at $0.02/kWh saved.
Darby (2006)	"The literature reviewed here mostly consists of primary sources, with a few review papers. Most of it comes from the USA, Canada, Scandinavia, the Netherlands and the UK." (p.3)	"Savings are typically of the order of 10% for relatively simple displays …" (p.11)	Survey paper of other studies on energy use feedback, TOU pricing and other behavioral efficiency approaches.
Fischer (2008) citing Dobson and Griffin (1992)	Report of a field experiment testing 100 US households. The experiment involves continuous feedback on electricity consumption and cost, broken down to various appliances and time intervals.	The treatment group reported 12.9% less consumption than control groups.	The experiment occurred during a 60 day treatment period.

Study	Description	Conservation effect	Methodology notes
Fischer (2008) citing Ueno et al. (2006)	This paper is about an experiment involving 9 households in Japan. Households received a computerized interactive tool with daily feedback on consumption and cost breakdown.	The average reduction in electricity consumption by the households was 9%	Study occurred for 40 weekdays after beginning of treatment. Baseline period occurred for 40 days before beginning of treatment. There is no control group.
Faruqui et al (2010)	The paper reviews a dozen utility pilot programs in North America and abroad that focus on the energy conservation impact of in home displays (IHDs)	Finds that consumers who actively use an IHD can reduce their consumption of electricity on average by about 7 percent when prepayment of electricity is not involved. When consumers both use an IHD and are on an electricity prepayment system, they can reduce their electricity consumption by about twice that amount.	Meta-study (examines studies employing various methodologies)
Matsukawa (2004)	319 households in a Jul – Sep 1998 experiment in Japan: (a) the treatment group has 113 customers and (b) the control group has 206 customers.	No statistically significant difference in consumption between the treatment and control groups (p.9, Table 1).	Randomized experiment. Random effects statistical model using panel data
Mountain (2006)	Hydro One's July 2004-September 2005 pilot with 500 customers having real time monitor and 52 not.	"Overall, the aggregate reduction in electricity consumption (kWh) across the study sample was 6.5%" (p.3)	

Study	Description	Conservation effect	Methodology notes
Robinson and Rowlands (2008)	The Residential Feedback Study of 106 households in Milton Ontario during May-Nov 2006.	"Overall, … , it appears that the feedback did not have a large impact in terms of either encouraging shifting electricity-use from on-peak time or encouraging overall conservation." (p.1)	Weekly information about their homes' unique electricity consumption levels and patterns. In addition, the feedback included information such as an estimated breakdown of each home's specific appliance consumption levels, conservation tips, and, towards the end of the study, information regarding the air pollution and greenhouse gas impacts of each home's electricity use.
Sexton et al (1987)	SCE 22-month TOU pricing and feedback experiment that began in May 1979 with 480 customers divided into (a) a TOU treatment group (360); and (b) a control group (120). 68 in the TOU group had free monitors.	"Monitor households' total KWH usage rose relative to non-monitor house- holds in nine of the ten months with an average relative increase of 5.5 percent." (p.59)	The 1987 technology may not be comparable to modern technology. However, the focus of customers on shifting peak demand rather than overall reductions is interesting, suggesting perhaps that people respond to the issue that is being signaled as most important: peak reductions or energy conservation.
TEC (2007)	Energy Australia Strategic Pricing Study of 750 residential and 550 business customers.	Residential summer critical peak days: ***no*** incremental conservation effect based on the comparison between customers facing high CPP rates with and without display (p.36, Figure 8).	This study was primarily about TOU and CPP pricing.

Study	Description	Conservation effect	Methodology notes
Ehrhardt-Martinez (2010) citing Allen and Janda (2006)	Real-time energy feedback using The Energy Detective (TED) among consumers in Ohio.	Not significant.	60 (10 meters, 4 low income and 6 upper income)
Parker, et al. (ACEEE 2010)	Two-year pilot evaluation of home energy displays	Annual normalized electricity consumption reduced 7.4%	Used control group of utility customers (~2 million). 17 homes given home energy displays,
Ueno, et al. (2005)	Evaluation of energy monitoring displays installed in Japan	17.8% electricity reduction; 8.8% gas reduction	Control group of 9 homes. 10 homes given in-home display devices. Results not normalized to weather changes (results would be lower). Study duration only 56 weekdays (28 days before and after installation) in the winter.

Table 4. Summary of bill and online feedback conservation effect on electricity consumption

Study	Description	Conservation effect	Methodology notes
Abrahamse et al (2005)	Meta-analysis of interventions aiming to encourage households to reduce energy consumption through both antecedent strategies (i.e. commitment, goal setting, information, modeling) or consequence strategies (i.e. feedback, rewards)	Feedback appears to be an effective strategy for reducing household energy use in most studies reviewed, although some exceptions exist. Results of studies using feedback seem to suggest that the more frequent the feedback is given, the more effective it is. (p. 281)	Meta-study (examines studies employing various methodologies)

Study	Description	Conservation effect	Methodology notes
Allcott (2009)	This paper evaluates a pilot program run by Positive Energy in Minnesota (Connexus Energy utility) to mail home energy reports that compare a household's energy use to that of its neighbors and provide energy conservation information.	Estimates that the program reduces energy consumption by 1.9 percent relative to baseline. In a treatment group receiving reports each quarter, the effects appear to decay in the intervening months, suggesting that the reports successfully motivate or remind households to conserve but that this attention or motivation is not durable.	78,492 eligible households randomized into a treatment and control group. Treatment effects measured over period of January 2008 and August 2009.
Ayers et al (2009)	The paper analyzes data from two utilities, SMUD and PSE, in partnership with Positive Energy/OPOWER, which provides monthly or quarterly mailed peer feedback reports to customers.	Treatment effects lead to reductions in energy consumption of 1.2% (PSE) to 2.1% percent (SMUD), with the decrease sustained over the time of the studies.	Both utility studies implemented random-assignment field experiments. The PSE study lasted seven months and the SMUD study lasted twelve months.
Fischer (2008) citing Arvola et al. (1993)	An experiment with 696 Helsinki households. Treatment groups received an improved electricity bill with various combinations of increased frequency, historic comparison and advice.	Treatment group reported electricity consumption savings of 1-4% per year.	The baseline year was 1 year and the experimental group was compared to a control group during 2 years.
Fischer (2008) citing Dünnhoff and Duscha (2008)	4,500 German households in three experimental groups and one control group. Treatment groups received supplement to electricity bill with normative comparison and written advice.	Treatment group savings are not statistically significant.	Treatment effects were measured in year of intervention and year after intervention.

Study	Description	Conservation effect	Methodology notes
Fischer (2008) citing Mack and Hallmann (2004)	An experiment with 30 households in Germany. Treatment groups received weekly written feedback, meter readings, and interviews.	Treatment group reported electricity consumption savings of 2-4% per year.	The baseline year was 3 months and the experimental group was compared to a control group during 10 months.
Fischer (2008) citing Nielsen (1993)	Experiment with 1,500 households in three Danish regions. Various combinations of written advice, feedback on consumption and cost via monthly meter self-reading, personalized energy audit, financing audit & increased tariffs. Measuring of yearly consumption, questionnaires.	Participants in groups involving feedback but not tariff rate changes reported conservation savings of 6-9%.	Field experiment with random sampling. Study period was 3 years with a 1 year prior baseline.
Fischer (2008) citing Wilhite and Ling (1995)	An experiment with 1,450 Oslo households. Treatment groups received an improved electricity bill with various combinations of increased frequency, historic comparison and advice.	Treatment group reported electricity consumption savings of 7-10% per year.	The experiment included a control group as a baseline and the study period was 3 years.
Ehrhardt-Martinez (2010) citing Abrahamse et al (2007)	Netherlands study of impact of internet-based tool using estimated feedback of a customer's energy use.	5.1% reduction, control group used 0.7% more energy	189 participants, treatment group of 137 households, 66 households in control group
Ehrhardt-Martinez (2010) citing Benders et al (2006)	Netherlands study of impact of internet-based tool using estimated feedback of a customer's energy use.	8.5% reduction in direct energy consumption.	190 participants (137 in treatment group, 53 in control group)
Ehrhardt-Martinez (2010) citing Brandon and Lewis (1999)	UK study using daily and weekly feedback, some customers had computer-based feedback	4.3% energy savings compared to pretest and 12% reduction compared to control group.	120 households. Six experimental groups.

Appendix B: Table Summarizing State Regulatory Proceedings

Table 5. State Activity on Smart Grid Data Privacy and Access Issues

State	Legislative or Regulatory Activity	Description
California	California Senate Bill (SB) 1476: "Privacy Protections for Energy Consumption Data" (2010)	Clarifies and defines many of the questions around customer energy data access, privacy, ownership and disclosure which remain unresolved in other states. The law amends the Public Utilities Code to ensure that customers can access advanced metering data without relinquishing personally identifiable information to a third party.
California	California Public Utilities Commission, Proceeding R.08-12-009	Considers smart grid policies, identifies current IOU data collection activities, and considers whether smart grid data standards and protocols are needed.

State	Legislative or Regulatory Activity	Description
Colorado	Colorado Public Utilities Commission, Docket No. 09I-593EG	Investigates questions related to privacy concerns with smart meters and the smart grid: Do existing rules regarding disclosure of customer information to 3rd parties (by signed consent only) and to governmental agencies need to be modified? Is additional customer education required? What amount of data requests should be accommodated in the normal course of business and how should costs be recovered? What security standards should be maintained?
Maryland	Maryland Public Service Commission, Order No. 81637	Establishes minimum standards for AMI deployment in Maryland. The Public Service Commission requires, among other technical specifications, for advanced meters to have two-way communication capability and to provide non-discriminatory access to utilities as well as energy curtailment providers.
New York	New York State Public Service Commission, Cases 10–E–0285 & 09–M–0074	Investigates a number of questions related to the deployment of smart meters, including customer data access, ownership and privacy. The proceeding also will address the question of whether utilities should “be provided sole control of the potential commercial opportunities of the HAN?” And asks, “should utilities encourage new players such as home energy management device and services companies—as well as grid-enabled appliance makers—to develop and control the HAN market?"
New York	New York State Public Service Commission, Case 09-M-0074	Requires AMI systems to have the ability to provide customers with their real-time data in a non-proprietary format.

State	Legislative or Regulatory Activity	Description
New York	New York State Public Service Commission, Case 07-M-0548, et al.	Allowed the Niagara Mohawk Power Corporation and Central Hudson Gas & Electric Corporation to proceed with OPOWER behavioral modifications programs that didn't require informed consent of customers. Because OPOWER was performing a rate-payer funded utility function, there was a demonstrated need for consumer information to perform this function, and the contracts of the utilities with OPOWER contained necessary security safeguards, the Commission decided that this was not a prohibited sale of customer information.
Pennsylvania	House Bill 2200, Act 129 (2008)	Requires that smart meter technology will, "directly provide customers with information on their hourly consumption, enable time-of-use rates and real-time price programs, and effectively support the automatic control of the customer's electricity consumption by one or more of the following as selected by the customer: i) the customer, ii) the customer's utility, or iii) a third party engaged by the customer or the customer's utility."

State	Legislative or Regulatory Activity	Description
Texas	Advanced Metering Rule: public utilities regulation – section §25.130 – related to advanced metering	Utilities installing AMI (and receiving cost recovery) must submit a deployment plan that includes a timeline for web portal development. Meters must have the capability: • To provide direct, real-time access of customer usage data to the customer • Hourly data shall be transmitted to the electric utility's web portal on a day-after basis • To provide 15-minute data to customers and Retail Electric Providers (REPs) on a daily basis • To communicate with devices inside the premises based on open standards such as ZigBee or Home-Plug • "An electric utility shall provide a customer, the customer's REP, and other entities authorized by the customer read-only access to the customer's advanced meter data, including meter data used to calculate charges for service, historical load data, and any other proprietary customer information. The access shall be convenient and secure, and the data shall be made available no later than the day after it was created." (p.93) A customer may authorize its data to be available to an entity other than its REP.

State	Legislative or Regulatory Activity	Description
Texas	Order Adopting an Amendment to §25.472, Project No. 30769	An REP cannot release proprietary customer data without consent. However, such prohibitions do not apply to the release of data to: “(A) the commission in pursuit of its regulatory oversight or the investigation and resolution of customer complaints involving REPs or aggregators; (B) an agent, vendor, partner, or affiliate of the REP or aggregator engaged to perform any services for or functions on behalf of the REP or aggregator, including marketing of the REP's or aggregator's own products or services, or products or services offered pursuant to joint agreements between the REP or aggregator and a third part”

Table 6. State Activity on Behavioral EE Eligibility as a Utility Program

State	Legislative or Regulatory Activity	Description
California	California Senate Bill (SB) 488: "Energy Usage Information" (2009)	Requires IOUs that have comparative energy usage disclosure programs to report program energy savings to the California Public Utilities Commission and requires the Commission to use experimental design evaluations to determine net energy savings from these programs.
California	California Public Utilities Commission, Proceeding A.08-07-021	Allows behavior-based EE savings (i.e. "comparative energy usage disclosure programs" defined in SB 488) to count as utility program savings. The Commission committed only to crediting ex-post behavior-based savings for the 2010-2012 energy efficiency program cycle.
Massachusetts	Green Communities Act – D.P.U. 08-50	Allows energy efficiency savings from energy feedback programs to count towards utility administered efficiency programs, when evaluated using rigorous experimental design. All efficiency programs are subject to a cost-effectiveness analysis, and if found to pass, may qualify for credit towards utility savings goals.
Minnesota	Conservation Improvement Program (CIP)	Allows experimental design to be employed to demonstrate savings. This provision of the CIP M&V Protocols has allowed energy feedback programs to count towards utility program savings goals.
New York	New York State Public Service Commission, Case 07-M-0548, et al.	Approved "behavioral" modification programs to be credited towards the State's Energy Efficiency Portfolio Standard for Niagara Mohawk Power Corporation and Central Hudson Gas & Electric Corporation.

State	Legislative or Regulatory Activity	Description
Ohio	Ohio Public Utilities Commission, Case No. 09-512-GE-UNC	The PUC is soliciting comments as to what types of energy efficiency programs may count towards administered program savings. The initial draft of the manual did not include an EM&V protocol for behavior based programs.
Texas	Public Utility Commission of Texas, Project No. 37623, section §25.181	In rulemaking related to the administration of utility EE programs, the Public Utilities Commission of Texas indicated its support of the inclusion of behavioral energy efficiency measures in program portfolios, either as pilots, or with rigorous EM&V procedures.