PY2013–2014 California Energy Efficiency and Demand Response Residential Behavior Market Characterization Study Report

Volume I

Prepared by

Opinion Dynamics Corporation
DNV-GL

For the

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Energy Division

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Opinion Dynamics

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Evaluator Contact Information

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The table below presents the various people involved in this effort.

Firm/Agency	Name	Role	Email	Phone
CPUC Energy Division	Peter Franzese	Evaluation lead at the California Public Utility Commission Energy Division (CPUC-ED)	Peter.Franzese@cpuc.ca.gov	415-703-1926
Ken Keating	Ken Keating	Consultant to the CPUC-ED during the study development period		
DNV-GL	Valerie Richardson	Overarching lead for the Residential Roadmap	valerie.richardson@dnvkema.com	510-891-0446
Opinion Dynamics	Mary Sutter	Director of this study	msutter@opiniondynamics.com	510-444-5050
Opinion Dynamics	Olivia Patterson	Project Manager of this study	opatterson@opiniondynamics.com	510-444-5050

Introduction

This is the first of two documents that comprise the results of the Energy Efficiency and Demand Response Residential Behavior Market Characterization Study. The second volume contains a suite of appendices that document detailed methodologies, findings, data collection, and additional results.

1. Executive Summary

Over a decade ago, the California Public Utilities Commission (CPUC), along with the four Investor Owned Utilities (IOUs), embarked on a substantial undertaking to reengineer and modernize the state of California's electrical grid. As part of the investment, the CPUC expected the "smart" grid to bring about several benefits to California ratepayers through the provision of Advanced Metering Infrastructure (AMI) data. The CPUC contracted with DNV-GL and Opinion Dynamics to form a study team that would characterize the market of residential energy efficiency (EE) and demand response (DR) pilots, projects, sub-activities or programs (what this report calls "efforts") that provide residential customers with information and feedback to motivate behavior change. Specifically, the CPUC wanted a data-driven approach to help them:

1) Better understand where California stands in terms of realizing the anticipated benefits from AMI investments, what can be done moving forward to realize expected investments, and what future residential behavior feedback savings potential is for California.

2) Support California's strategic EE and DR impacts and emission goals (AB 32) through consideration of targeted future behavior offerings.

This study documents IOU implementation of AMI policy decisions and characterizes the California residential behavior market to inform future policy. Within this study, we categorize California residential behavior feedback efforts and their funding sources, as well as identify any potential gaps based on a review of similar North American efforts. In addition, we examine current data tracking for key metrics and progress to date, as well as document cost-benefit assumptions across funding streams. Further, we characterize vendor efforts offering residential behavior products and services in California and any barriers they face in providing their services to customers.

Notably, many of the customer empowerment and engagement projects leverage AMI data to provide feedback to customers on their energy use. However, behavior feedback efforts do not rely solely on AMI data. There are many feedback-based behavior interventions that program administrators can employ to effect change, including in-person interactions, and community-based social marketing. However, this study does not include all of these types of activities, but instead focuses exclusively on feedback within the residential sector.

To conduct this study, our team leveraged secondary data to document Smart Meter business case decisions, summarized current California IOU and vendor behavior feedback efforts, and summarized behavior feedback efforts outside of California. Additionally, we conducted interviews with CPUC and IOU staff, vendors, and subject matter experts to gain additional insights.

Below we highlight key findings from the study.

Overview of California Accomplishments

California offers a rich array of residential behavior feedback efforts that align with efforts seen nationwide. Our team identified a combined total of 95 efforts offered by the California IOUs, Regional Energy Networks (RENs), Community Choice Aggregators, and municipal utilities that provided behavior feedback to residential customers in 2013–2014. These efforts seek to engage customers with energy feedback information. The largest effort, in terms of participation and energy impacts, is the Home Energy Report (HER) program.

California's residential behavior feedback efforts represent a complex ecosystem with broad, varied, and multifaceted offerings. The IOUs fund their efforts through a variety of sources, including AMI, DR, EE, and other funding streams. These efforts offer a variety of different products and services to either collect or

provide behavior feedback information to customers (such as smart thermostats, in-home displays, or reports) and typically leverage multiple behavior intervention strategies (the approaches employed to induce behavior change, such as feedback with rewards and social norms). The majority of the IOU-administered efforts are typically offered as sub-activities or projects, rather than full-fledged programs, and leverage a variety of data sources (such as AMI, occupancy sensor, and temperature data) to provide feedback information.

We did not find gaps in terms of the types of residential behavior feedback offerings by IOUs. That is, California has comparable feedback offerings to those offered in North America, in terms of both types of efforts and distribution of the types of efforts that leverage multiple offerings or behavior intervention strategies.

Despite low market adoption for technologies that enable residential behavior feedback efforts, a competitive market is in place for residential behavior feedback products, and vendors report a clear value proposition to bringing energy information to customers. However, the market is nascent and fast-moving, with vendor entry and exits occurring quickly; especially for software-based options. We found a complex vendor market for smart devices, products, and services, where vendors encounter barriers to entering IOU programs. Specific barriers include the amount of time it takes to enter a program and challenges to accessing AMI data.

Capturing Benefits

While there are 95 efforts in California (the IOUs offer 83), the CPUC's ability to capture energy savings benefits and oversee efforts to inform policy is hampered by a lack of data. This is consistent with nationwide findings, where there is also a general scarcity of impact findings for new behavior feedback efforts. The limited data in California hampers CPUC staff ability to make direct comparisons and prioritize program selection. Overall, 39% percent of the 83 2013–2014 IOU-administered residential feedback efforts are missing participation data, 23% are missing budget data, and 57% are missing energy impacts data. Additionally, the IOUs do not consistently capture impacts data in equivalent metrics. In these instances, it is impossible to compare relative impacts, as the units and scales are often unclear.

From the data that were available, we found substantial variation in terms of participation, budget and expenditures, and energy impacts from the identified IOU-administered efforts. For example, as of 2014, the IOUs offer the HER program to approximately 2 million (or 20%) of California residential customers. However, 75 of the 83 (90%) efforts that we reviewed represent opt in programs that tend have low customer adoption. Additionally, with close to 10 million residential households in the IOU service territories, less than 1% of customers have adopted a Home Area Network (HAN) device or similar technologies. Also, the variation in annual energy savings reported from such efforts ranges (with only 44% reporting) from 82,700 MWh for Pacific Gas & Electric's (PG&E) HER program to 16,097 kWh for Southern California Edison's (SCE) SmartConnect Field Trials—HAN Third Party Limited Launch.

Conclusion

Smart Meter infrastructure investment alone will not realize anticipated benefits; rather, interventions must couple Smart Meter data with behavioral science and products and services to attain these benefits. There appears to be an implicit assumption that simply having access to AMI data will inevitably lead to customers taking energy-efficient actions and behavior. While this can occur, efforts that leverage behavior intervention strategies and social science insights will support customers in their attempts to save energy, to go deeper, or to persist in terms of their engagement with energy-saving practices. Below we provide considerations for the CPUC to better understand where California stands in terms of realizing the anticipated benefits from AMI and in championing California's EE, DR, and greenhouse gas (GHG) emissions reduction goals through targeted future efforts. We provide recommendations associated with these considerations in Chapter 8.

In support of realizing AMI benefits, the CPUC should consider:

- **Improving data quality of behavior feedback efforts and associated benefits.** Our team was unable to draw comprehensive conclusions regarding the achievements made and anticipated benefits given the current availability of data. To make future policies regarding behavioral programs, there is a need to better understand the potential for these efforts. As such, there is a need to assure that appropriate data is collected regarding existing and future behavioral feedback efforts. This would improve assumptions and support policy guidance. Collecting additional ongoing information can work as a virtuous cycle, allowing policy makers to make more informed decisions regarding ongoing investments. However, we acknowledge that data tracking requires additional effort on the part of the IOUs, and may not be feasible for all behavioral feedback efforts (such as strategies within a program).

- **Improving the ability of CPUC staff to assess and prioritize behavior feedback efforts across funding streams.** IOU-administered residential behavior feedback efforts are funded across multiple sources that have differing reporting requirements and cost-effectiveness calculations. While this is not a problem per se, the dispersion causes difficulty when attempting to oversee California residential behavior feedback efforts and hampers a program administrator's ability to determine if the same interventions are redundant or receiving overlapping funding.

- **Reducing vendor barriers to accessing AMI data and collaborating with IOUs.** We found that vendors reported difficulties accessing AMI data, engaging with the IOUs, and aligning their work with the timelines associated with entering the IOU portfolio of programs. Without providing an environment where vendors are able to access and leverage AMI data or operate within the IOU space, it is highly possible that the state may not reach the full potential of behavior feedback efforts or that the full potential would take much longer. We acknowledge that allowing this access does not guarantee fully realizing benefits.

To better plan for and capture potential benefits from behavior efforts, the CPUC should consider:

- **Expanding the definition of behavior and revising the current framework for the EE Potential and Goals Study (PGS).** California will not fully realize the value of behavior feedback efforts with the current PGS framework incorporates benefits only from one program, the HER program, and excludes savings from other efforts, such as AMI-enabled behavior efforts, DR initiatives, and other sub-activities that could theoretically contribute additional benefits. Because the CPUC uses the PGS to set future goals and targets, if the potential from additional behavior feedback efforts are not incorporated within the PGS, these types of offerings may not be considered for the portfolio moving forward.

2. Study Overview

The California Public Utilities Commission (CPUC) asked the study team to characterize the market of residential energy efficiency (EE) and demand response (DR) pilots, projects, sub-activities, or programs (referred to as "efforts" in this study, to provide a single nomenclature for the various types of activities under way) that provide residential customers with information and feedback to motivate behavior change.[1] Specifically, the CPUC wanted a data-driven approach to help them:

1) Better understand where California stands in terms of realizing the anticipated benefits from Advanced Metering Infrastructure (AMI) investments, what can be done moving forward to realize expected investments, and what future residential behavior feedback savings potential is for California.

2) Support California's strategic EE and DR impacts and emission goals (AB 32[2]) through consideration of targeted future behavior offerings.

This study documents IOU implementation of AMI policy decisions and characterizes the California residential behavior market to inform possible future policy. Within this study, we:

- Provide background on policy decisions regarding AMI and behavior efforts to orient the reader (Chapter 3)
- Categorize California residential behavior feedback efforts and their funding sources (Chapter 4)
- Examine current data tracking for key metrics and progress to date (Chapter 5)
- Document cost-benefit assumptions across funding streams (Chapter 5)
- Describe national residential behavior feedback efforts to identify any potential gaps in California (Chapter 6)
- Characterize vendor efforts in California and the barriers they face in providing their services to residential customers (Chapter 7)
- Summarize findings to understand progress to date in terms of realizing anticipated benefits of AMI investments and to provide guidance to develop improved interventions (Chapter 8)
- Provide study appendices as a separate document (Volume II).

As mentioned above, there are a variety of efforts focused on providing residential customers with information and feedback to motivate behavior change – what we have categorized as projects, sub-activities, pilots or programs. In many cases, the type of effort aligns with funding streams – AMI and Emerging Technology Program (ETP) efforts are typically referred to as projects, while there are myriad initiatives called sub-activities offered within existing EE funded programs. However, in other cases, the effort type is less clear – an ETP project may be titled as a "pilot", or an AMI project may be titled as a "program". In this report, we identify

[1] This may include, for example, regular reports on household energy usage, access to real-time energy prices, comparisons of a customer's household energy use to their neighbors' energy use, tips for reducing energy use, or games and challenges meant to encourage customers to use less energy. These feedback and gaming interventions are specific to non-person interactions (i.e., not including face-to-face interactions). We excluded onsite audits and community-based social marketing behavioral interventions.

[2] http://www.arb.ca.gov/cc/ab32/ab32.htm.

specific efforts as pilots or programs or sub-activities where the IOUs have labeled them as such, otherwise we refer to them as efforts.

2.1. Methods

Opinion Dynamics performed six distinct tasks within this study, shown in Table 1.

Table 1: Energy Efficiency and Demand Response Behavior Market Characterization Evaluation Tasks

Evaluation Task	Description
Exploratory with IOU and CPUC staff	Conducted seven interviews with CPUC experts and staff at three California IOUs (Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E) to discuss residential behavior efforts offered by the California IOUs, to understand the CPUC/IOUs' perspectives on the performance of residential behavior efforts to date, and to highlight potential opportunities for new types of efforts in the California residential behavior market. We conducted the interviews in Q3 2014–Q1 2015.[3]
Document Smart Meter Business Case Decisions	Used secondary research (reviewed 28 documents) and four interviews with CPUC staff to document the AMI projects that have been approved by the CPUC, progress to date, how the IOUs calculate the EE and DR benefits from their AMI projects, and the status of Green Button Connect (GBC).[4] We conducted the secondary data review and interviews in Q3–Q4 2014.
Summarize Current California Residential Behavior Feedback Efforts	Used secondary research (reviewed more than 100 documents and websites), interviews with seven IOU and CPUC staff, and data requests to IOUs to develop a list of 95 California behavior efforts; used this data to summarize IOU progress to date. We conducted the secondary data review and interviews in Q4 2014–Q1 2015.
Summarize Utility Behavior Efforts Outside of California	Used secondary research (reviewed 53 documents) to compile a list of 38 residential behavior feedback efforts in other parts of North America; used to understand the market outside of California and to identify potential gaps in California's IOU efforts. We conducted the secondary data review in Q1 2015.
Vendor Interviews	Developed a list of 38 companies and organizations ("vendors") other than IOUs that offer services or technologies in California that use the behavior interventions we explored in this study; includes vendors that are affiliated or not affiliated with the California IOUs; conducted interviews with 16 vendors to better understand their products/services, barriers to participating in the California behavior market, and potential interventions from the CPUC or IOUs. We conducted the secondary data review and interviews in Q1 2015.
Subject Matter Expert Interviews	Conducted in-depth interviews with five experts in behavior energy efficiency to support our analysis of market trends and to assist in our identification of comparable efforts outside of California. We conducted the interviews in Q1 2015.

[3] This Residential Behavior Market Characterization Study primarily focused on assessing the three California IOUs (PG&E, SCE and SDG&E) that have completed their AMI implementations. Given SoCalGas is currently in the midst of its AMI rollout, which is scheduled to be complete in 2017, the study did not include a comprehensive review of SoCalGas behavior change and energy feedback offerings, which are being implemented for the most part through its in-progress AMI implementation. It should be noted however that SoCalGas is implementing behavior change conservation pilot programs and energy feedback tools commensurate with its AMI deployment.

[4] GBC is an offshoot of the GB initiative that provides utility customers the ability to automate the secure transfer of their energy usage data to an authorized third party.

We provide detailed descriptions of our approach in Volume II: Appendix A.

2.2. Limitations

Our study, by design, is narrow in focus and is limited by leveraging secondary data to summarize the California market in 2013–2014 and produce insights to inform policy. As we will note in later chapters, the primary limitation to this study was a paucity of California and national data regarding performance of residential behavior feedback efforts. Additionally, our study focuses solely on behavior feedback efforts offered during 2013–2014 time period. As such, this study provides a snapshot of activities, but does not purport to offer a cumulative summary of all California behavior feedback efforts over time.

3. Background on Building a Smart Grid and Using It to Provide Customer Feedback

More than a decade ago, the CPUC, along with the four IOUs, embarked on a substantial undertaking to reengineer and modernize the electrical grid.[5] As part of the investment, the CPUC expected this new and "smart" grid to bring about several benefits to California ratepayers. This study focuses on one purported benefit of grid modernization: reduction in energy consumption via customer empowerment and engagement projects. These projects seek to increase energy engagement by providing customers with enhanced feedback on their energy usage and empowering customers to better manage their energy use.

Below we provide background information that summarizes AMI decisions, the anticipated benefits and costs, and how these efforts fit within the larger landscape of customer feedback efforts. Figure 1 provides a chronology of the various priorities related to AMI investment, nestled within the behavior feedback space.

Figure 1: Chronology of AMI Investment Activities to Support Behavior Feedback Efforts

3.1. Installing Smart Meters

According to the *2014 CPUC Annual Report to the Governor and Legislature – California Smart Grid*, the smart grid is a "fundamental re-architecting and modernization of the existing electricity infrastructure, with the following objectives:

- Create a more secure, reliable and resilient electricity supply
- Reduce the carbon footprint and environmental impact of energy production, distribution and transmission
- Enable customers to more intelligently manage their energy use, and give them more opportunities for participation in electric markets, both as consumers and as producers
- Create more market opportunities for electric service delivery through smart markets."[6]

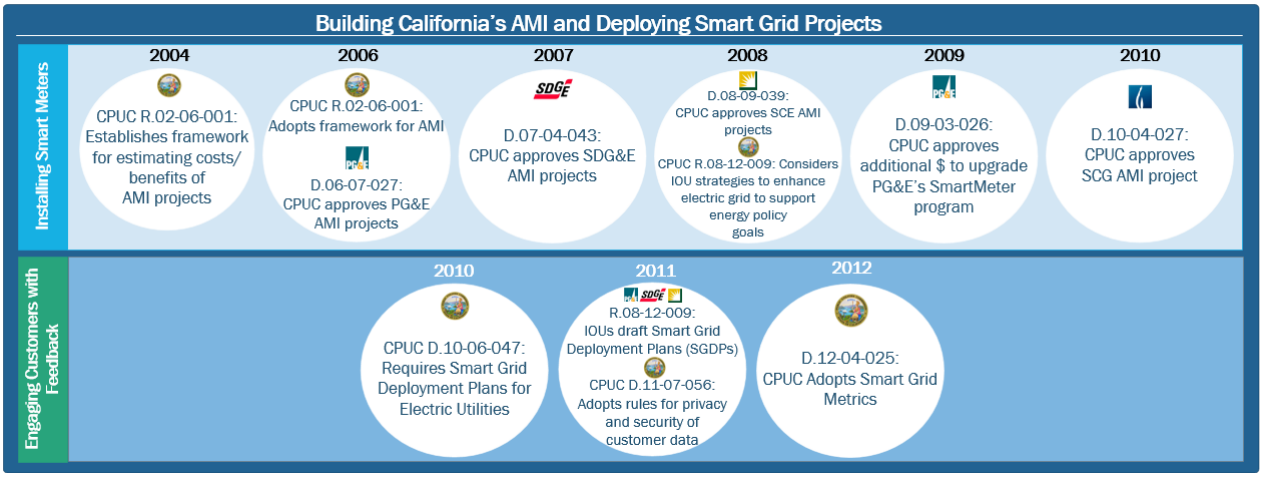
[5] D.10-04-127 also approved SCG's AMI project, however, D.10-06-047 did not require SCG to develop Smart Grid Deployment Plans.

[6] 2013 Smart Grid Report, April 2014.

To help realize this vision for the smart grid, the CPUC provided guidance to the California IOUs over a 10-year period (2004–2014).[7] Following CPUC guidance to the IOUs, we categorized efforts into two phases: Phase 1 – Installing Smart Meters and Phase 2 – Engaging Customers with Feedback.

The first phase, Installing Smart Meters, reflects early efforts (from 2004 to 2010) to build infrastructure in support of a smart grid. The second phase, Engaging Customers with Feedback, highlights later efforts (from 2010 to 2014) to leverage AMI to make utility operations, markets, and customers "smarter" about their energy use. Figure 2 provides an overview of the various decisions and documents related to each phase.[8]

Figure 2: California's Advanced Metering Infrastructure Efforts (2004–2014)



In 2004, the CPUC established a framework[9] that the IOUs used to design and implement AMI deployment efforts over the course of four years (2006–2010). Table 2 shows the progress of AMI electric meter deployment by IOU. As of October 2013, more than 90% of IOU customers had received a Smart Meter with very few customers choosing to opt out.

Table 2: AMI Deployment as of October 2013

IOU	Electric Meters Installed/Active	Electric Meters Remaining	Percent Complete	Opt Out
PG&E	5.26M/3.171M	371,000	93%	35,300
SCE	4.97M	0	100%	21,137
SDG&E	2.281M/2.278M	4,000	99.8%	2,141

Source: 2013 Smart Grid Report, April 2014.

[7] Our team reviewed 28 regulatory and utility documents during this time period. We list these documents in Volume II: Appendix E.

[8] Volume II: Appendix E provides a brief summary of each decision and document.

[9] ALJ Ruling R. 02-06-001 (July 2004) established business case analysis framework for AMI. The framework was approved in 2006.

Using the framework developed in 2004, the CPUC asked each IOU to develop a "business case" to assess the cost-effectiveness of AMI investments. Through five subsequent decisions,[10] the CPUC approved these business cases and $5.5 billion in AMI funding, while the IOUs projected more than $6 billion in benefits as a result of building the AMI infrastructure (Phase 1).[11]

3.2. Engaging Customers with Feedback

As a part of the business cases, the CPUC also asked the IOUs to design efforts to deliver benefits from leveraging the capabilities of the AMI being installed. To accomplish this, the IOUs proposed a number of customer empowerment and engagement projects that use AMI data. The IOUs estimated that the benefits from these customer empowerment and engagement projects would be more than $1 billion.[12] However, since AMI was still in the planning stages, the business cases did not base this calculation on existing projects. Rather, the IOUs incorporated a variety of assumptions to estimate the benefits of potential future projects that use AMI.

As the IOUs continued to install Smart Meters, the CPUC turned its attention toward realizing the assumed benefits from the meters. In 2010, the CPUC directed the IOUs to develop Smart Grid Deployment Plans (SGDPs) that summarize the costs and benefits from customer empowerment and engagement projects that use AMI data. Each IOU developed SGDPs in 2011, with progress updates issued annually thereafter.[13] In the SGDPs, the IOUs estimated that these projects would yield benefits of up to $1.4 billion. Table 3 provides the anticipated benefits and costs of customer engagement and empowerment projects developed by the IOUs.

Table 3: Projected AMI Customer Empowerment and Engagement Project Costs and Benefits (in Millions) [14]

Source	Cost ($ Millions)	Benefits ($ Millions)
Business Cases (2006–2010)	$191	$1,005–$1,016
Smart Grid Deployment Plans (2011)	$168–$211	$594–$1,405
Note: Given data limitations we present benefits and costs that reflect *all* customer empowerment and engagement projects, not just those that provide residential feedback, as we cannot identify the benefits and costs specific to residential efforts.		

Many of the customer empowerment and engagement projects leverage AMI data to provide feedback to customers on their energy use. However, behavior feedback efforts do not rely solely on AMI data. There are many feedback-based behavior interventions that program administrators can employ to effect change, including in-person interactions, and community-based social marketing. However, this study does not include all of these types of activities, but instead focuses exclusively on feedback within the residential sector.

[10] Decisions include D.06-07-027, D. 07-04-043, D. 08-09-039, D. 09-03-026, and D. 10-04-027.

[11] For more detail, please refer to Volume II: Appendix E.

[12] Note that the $6 billion in benefits indicated above reflects all benefits, not customer empowerment or engagement benefits

[13] D. 10-06-047 Decision Adopting Requirements for Smart Grid Deployment Plans Pursuant to Senate Bill 17 (Padilla), Chapter 327, Statutes of 2009 (June 2010).

[14] Based on the data we reviewed, it is unclear if these two amounts are cumulative or if they should be summed for a total of up to $2.4 billion in benefits.

3.3. Realizing Engagement Benefits

To capture the benefits of AMI data, demand-side management programs need to incorporate behavioral science when designing and implementing feedback efforts. The CPUC and IOUs are in the process of considering how future behavior efforts can support California's EE and DR goals. As per CPUC Decision D.12-05-015, the minimum definition and description of implementing and measuring behavior programs includes: 1) comparative energy usage and disclosure, 2) ex post measurement, 3) experimental design, and suggests a 5% target for residential households by 2014.

The IOUs recently developed a straw proposal for defining and setting parameters for EE behavior programs for 2015–2017. Under the proposal, behavior programs would[15]:

- Deploy one or more of the underused behavior intervention strategies: 1) commitment; 2) feedback; 3) follow through; 4) in-person interactions; 5) rewards or gifts; or, 6) social norms.
- May be evaluated using experimental design, quasi-experimental design, or other evaluation methods approved by the CPUC for 2015-17.
- Are typically evaluated on an ex-post basis, but may use ex-ante savings values if approved as part of evaluation methods.
- Utilizes behavioral science framing strategies.
- Omits "traditional behavior intervention strategies": financial incentives, leveraging sunk costs, and legal strategies.
- Omits "energy pricing" (as this is a demand response strategy).
- Requires use of behavioral science framing approaches across the board (appropriate for use in all EE marketing).

Currently, the EE Potential and Goals Study (PGS) is an assessment of California energy savings potential that the four IOUs could realize from EE programs. The PGS provides guidance for utilities' next EE portfolios, updates the forecast for energy procurement planning, informs strategic contributions to California's greenhouse gas (GHG) reduction targets, and sets benchmarks for shareholder incentives.[16] More specifically, the PGS provides quantitative and qualitative assessments of savings potential to help the CPUC frame and choose EE goals to meet CPUC policy objectives.

The most recent PGS study[17] incorporates one behavior-based program: the feedback-based HER program. Like the 2013 study, which estimates that HER behavior program savings range from approximately 45 to 58 GWh per year, and reflect 0.1% to 0.2% of the market potential for EE in California in any given year, the 2015 study will also include HER programs only. The study excluded savings from other efforts, such as AMI-enabled behavior efforts or DR initiatives. Because savings potential is derived from equipment, the 2013 study had difficulty disaggregating savings from equipment installation versus changes to usage-based behavior. The

[15] http://library.cee1.org/sites/default/files/library/11659/CA_IOUs_Behavior_Definition_Proposed_to_CPUC.pdf.

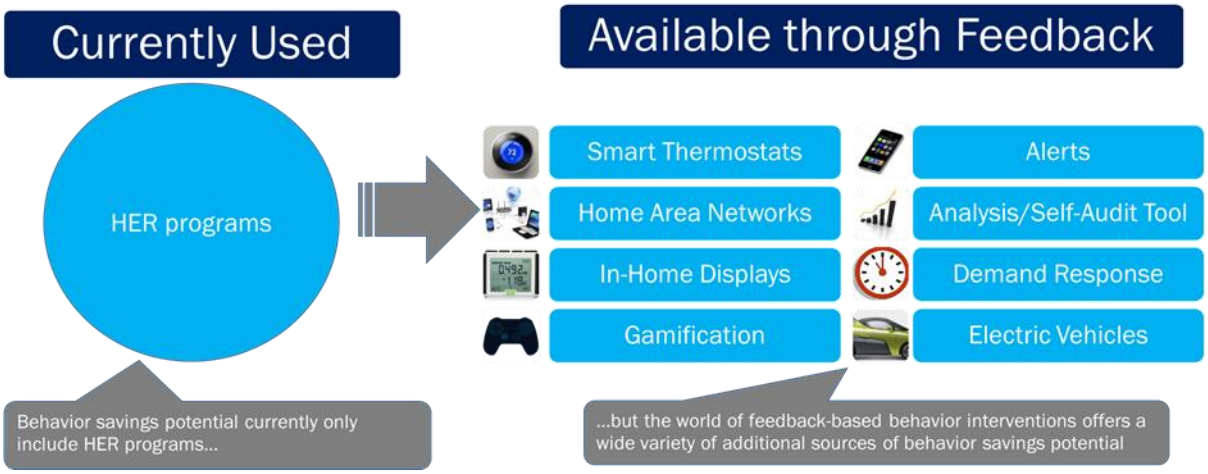
[16] http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm.

[17] Navigant Consulting and Heschong Mahone Group. March 2012. Analysis to Update Energy Efficiency Potential, Goals, and Targets for 2013 and Beyond.

study authors and CPUC staff are aware of these limitations to the PGS and plan to incorporate additional behavior-based savings within the next PGS, where possible.[18]

Figure 3 provides an illustration of the currently defined behavior program—the HER program—captured in the PGS, while on the right-hand side, there is a menu of other potential efforts that could be incorporated for claimed savings, when verified, in the future.

Figure 3: Current and Available Sources of Behavior Savings in PGS



[18] Opinion Dynamics is member of the newly scoped PGS and will bring our knowledge to support improving the behavioral component.

4. California Residential Behavior Feedback Efforts

Our team identified 83 efforts offered by the IOUs[19], 1 effort offered by the Regional Energy Networks (RENs), 2 efforts offered by Community Choice Aggregators, and 9 efforts offered by municipal utilities that provided behavior feedback to residential customers in 2013–2014 for a total of 95 efforts. These efforts seek to engage customers with energy feedback information.

Overall, California's residential feedback efforts represent a complex ecosystem with broad, varied, and multifaceted offerings. The California efforts:

- Are typically offered as sub-activities or projects, rather than full-fledged programs. This distinction can reflect the scale of adoption, as well as the stage of program design and technology assessment.
- Use a variety of data sources (such as AMI, occupancy sensor, or temperature data) to provide feedback information.
- Offer a variety of different products and services to either collect or provide feedback information to customers (such as smart thermostats, in-home displays, and reports).
- Typically leverage multiple behavior intervention strategies[20] (the approaches employed to induce behavior change, such as feedback with rewards or social norms).

4.1. Funding Sources

California residential behavior feedback efforts are funded through a variety of sources, including AMI, DR, EE, and other funding streams. Because there are a variety of funding streams, we have categorized each of the efforts by funding source across a series of figures and tables throughout this report.

Table 4: Overview of 2013–2014 California IOU-Administered Residential Behavior Feedback Funding Sources

Funding Source	Effort Count
EE	26
Emerging Technologies Program*	22
Other**	16
DR	11
AMI	8

* Only includes ETP funded under EE, does not include Integrated Emerging Technologies funded by DR. ** E.g., General Rate Case, 2009 Rate Design Windows, Shareholder funds, Operations and Maintenance funds.

To demonstrate how similar projects can be funded out of multiple funding streams, we provide a description of Home Area Network (HAN) and In-Home Display (IHD) projects administered by the IOUs. HAN and IHD efforts have a higher potential for overlapping or redundant funding as they receive funds from five different sources. Notably, efforts offered over a variety of funding streams can potentially provide challenges when determining status and allocating benefits.

[19] The IOUs included in this study are PG&E, SCE, SCG, and SDG&E.

[20] As defined in: P. Ignelzi, et al. May 2013. "Paving the Way for a Richer Mix of Residential Behavior Programs." CALMAC ID: SCE0334.01.

California IOU-Administered HAN and HEM Efforts (2013–2014)

California has 15 efforts related to HAN (e.g., ZigBee meter connectivity devices) or HEM (e.g., non-meter connected Home Energy Management efforts) (Table 5). Funding for these efforts come from multiple sources, with most coming from the Emerging Technologies Program. Notably, the IOUs differentiate between HAN projects, typically funded through AMI if they use the Zigbee protocol, and HEM efforts typically administered to develop new measures, in an effort to ensure that benefits across funding streams are not double-counted. SCE administers the largest number of HAN/HEM efforts, though the five AMI-funded efforts are technically five phases of a larger effort, the Edison SmartConnect Field Trials.

Table 5: Efforts by IOU and Funding Source

IOU	Funding Source					Total
	ETP	AMI	EE	GRC*	DR	
SCE	4	5**	0	0	0	**9**
PG&E	1**	1	0	0	1	**3**
SDG&E	1**	0	0	2**	0	**3**
SCG	0	0	0	0	0	**0**
Total	**6**	**6**	**0**	**2**	**1**	**15**

* General Rate Case funding. ** One SCE effort, 1 PG&E effort, and 2 SDG&E efforts are HEMs.

The HAN/HEM efforts in California are all in a pre-EE portfolio stage and fall on a spectrum of lab and field testing to piloting technologies with customers (Table 6). Examples of each category follow the table.

Table 6: HAN/HEM Efforts by IOU and Effort Type

Category	IOU				Total
	SCE	SDG&E	PG&E	SCG	
Customer trial	3	1	0	0	**4**
Research only	3	1	1	0	**5**
Lab and field testing	2	1	1	0	**4**
HAN infrastructure development (including a customer trial)*	1	0	1	0	**2**
Total Number of Projects	**9**	**3**	**3**	**0**	**15**

* PG&E and SCE HAN infrastructure development projects include customer trial components.

Examples demonstrate the diverse activities that the California IOUs undertake for HAN/HEM efforts:

- Customer trial: **SDG&E's Reduce Your Use IHD effort** provided 650 customers with HAN-enabled IHDs to measure the impact of IHDs on customer response to demand response events. (*GRC funding)*
- Research only: **SCE's Future Outlook for Residential Energy Management** project explored consumer and manufacturer attitudes toward energy management technology in order to understand significant changes and trends in the "connected home" market. *(ETP funding)*
- Lab and field testing: **SDG&E's Residential Load Disaggregation** project evaluated an algorithm for residential load disaggregation in 11 homes. The study compared results between leveraging Rainforest Eagle HAN devices and GBC data. *(ETP funding)*
- HAN infrastructure development: **PG&E's HAN Enablement Program** involved the development of infrastructure to allow customers to register their own HAN devices and receive real-time feedback on their energy use. This project included a customer trial of 430 IHDs. *(AMI funding)*

4.2. Categorizing Residential Behavior Feedback Efforts

To help understand the complexity of these efforts, we categorized them in four ways:

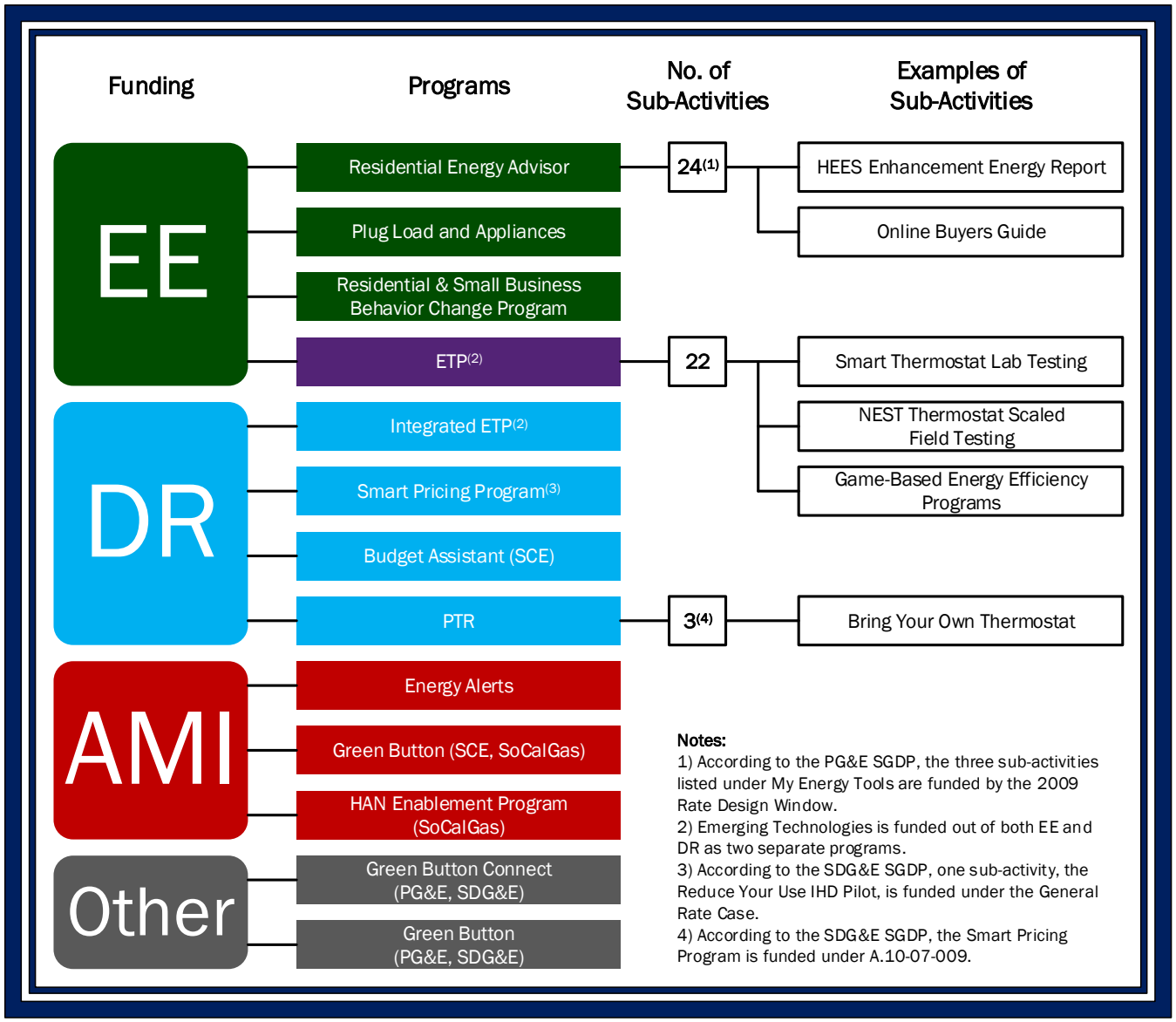
- **By effort type:** the type of programmatic effort (program, project, or sub-activity)
- **By data leveraged:** the type of data used to provide feedback to residential customers (AMI, other, etc.)
- **By offering type:** the type of product or service offered
- **By intervention strategy:** the type of approach employed to induce behavior change

For a description of offering types, refer to Volume II: Appendix C.

4.2.1. California Efforts by Effort Type

Our review of California efforts indicates that most are sub-activities or projects, rather than programs. For example, there are three EE programs that offer residential behavior feedback: the Residential Energy Advisor (REA) program, the Residential and Small Business Behavior Change Program, and Plug Load and Appliances. Within a program, there can be an array of sub-activities that offer behavior feedback, such as the HER and Universal Audit Tools within the REA program. Others, such as the Emerging Technologies Program are funded separately through EE and DR, and have multiple projects funded through the program. We also include a few time-of-use rate programs, such as PG&E SmartRate, that leverage feedback interventions in addition to price signaling via the rate. Figure 4 provides a list of the 2013–2014 IOU residential behavior feedback programs and the sub-activities associated with them.

Figure 4: 2013–2014 California IOU-Administered Residential Behavior Feedback Programs, by Funding Source



However, beyond programs, there is a proliferation of behavior feedback efforts consisting of projects and sub-activities that seek to capture smart grid investments and demonstrate a broader array of program designs. As shown in Figure 4, 49 of the 83 IOU efforts are sub-activities of larger programs. While the IOUs claim separate savings from the entire program for some sub-activities, for others they do not.

Given the number of sub-activities and projects, it appears that the IOUs recognized a need to develop efforts to identify the best approaches to capture the benefits of Smart Meter data and behavior feedback interventions, prior to rolling out full-scale programs. Notably, the AMI business cases assumed automatic benefits from installing Smart Meters; however, capturing those benefits likely requires leveraging programs

rooted in behavioral science. Importantly, some sub-activities and all ETP project efforts cannot claim savings and are not incorporated into estimates for California's EE potential or goals.

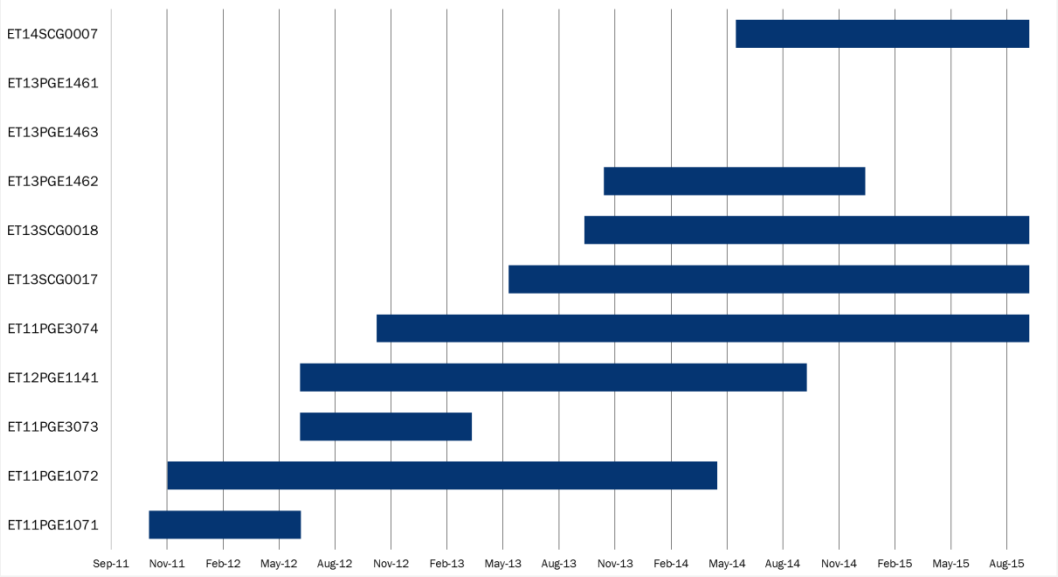
Below we provide a snapshot of one type of behavior feedback effort. This snapshot underscores that it takes time to move from the project or sub-activity to the program level, and in many cases these efforts are not transferred into the portfolio, because of issues with implementation, lack of verifiable energy savings, etc.

California IOU-Administered Smart Thermostat Efforts (2013–2014)

There are currently 13 IOU smart thermostat efforts in California.[21] The Emerging Technologies Program (ETP) conducts 11 of the 13 projects, while the remaining 2 are conducted through DR programs. ETP conducted six "Testing/Optimization" projects, which are typically lab tests or evaluation, measurement, and verification (EM&V) studies. These projects also sought to better understand customer demand for smart thermostats, how this technology could be optimized, and how it may be combined with other intervention strategies. Project results indicate that customers seem to be very interested in smart thermostats, particularly as they fit into creating networked homes and appliance and home security. ETP also conducted five "Field Assessment" projects, which study the savings potential of smart thermostats in conjunction with other feedback intervention strategies, such as normative messaging or a peak-time rebate.

Figure 5 provides a timeline of ETP projects. As illustrated, some projects began in 2011 and span up to 4 years, indicating that project efforts can take a substantial amount of time to conduct, and depending upon the results of the project, may not be incorporated as a measure into the portfolio of DSM programs.

Figure 5: Timeline of ETP Smart Thermostat Projects in 2013–2014



Two sub-activities under the Peak Time Rebate programs are "Bring Your Own Thermostat" (BYOT) efforts administered by SDG&E and SCE. Both allow participants to purchase a device from a range of thermostats, and provide a peak-time credit during peak periods. These efforts tested smart thermostat technology in the field, combining smart thermostat technology with behavior messaging, leveraging the technology in an attempt to augment the potential savings garnered from a standard peak-time rebate program.

[21] Along with these 13 projects, we found 9 other projects that included smart thermostats or programmable communicating thermostats (PCTs) in their offerings that were not included in our count of smart thermostat programs. Six of these nine projects stated explicitly that they supported smart thermostat technology; however, it was not clear to what extent, and it appeared that smart thermostats were a minor portion of the projects' overall objectives.

Table 7 provides a list of the smart thermostat ETP projects and DR programs offered, along with their project type, IOU, and status. Where savings are available, we note them. Notably, each of the ETP projects listed below reported kWh savings per unit specific to each particular study. Each of the PG&E projects estimated annual kWh savings per smart thermostat, while the three SCG projects are still active.

Table 7: Summary of 2013—2014 California IOU-Administered Smart Thermostat Projects

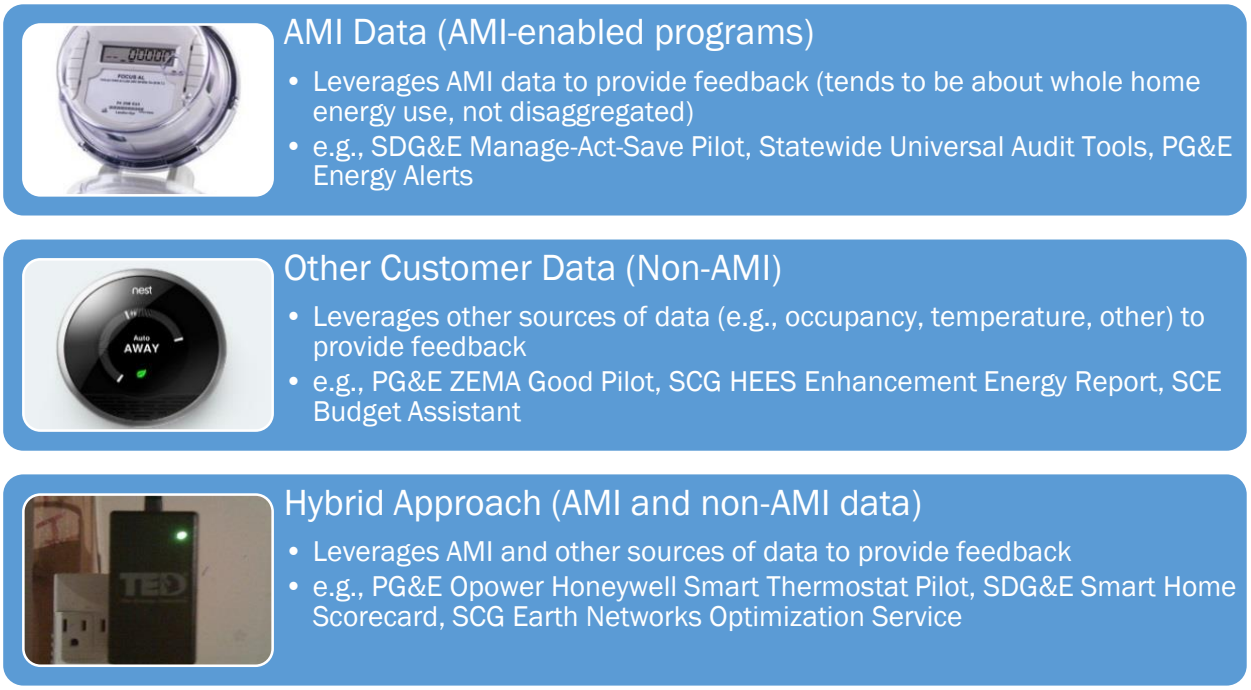
Funding	Project Type	Program Name	IOU	Status	Therm Savings (per year)	kWh Savings (per thermostat)
ETP	Testing/ Optimization	ET Home Energy Management Lab Tech Assessment Smart Thermostats	PG&E	Complete*	10	125
		Optimization/Learning Thermostat Assessment Phase 1	PG&E	Complete*	10	125
		Smart Thermostats Lab Testing	PG&E	Active	Not available	Not available
		Optimization Thermostats EM&V Study	PG&E	Stopped	Not available	Not available
		Smart/Learning Thermostats EM&V Study	PG&E	Stopped	Not available	Not available
		Earth Networks optimization service	SCG	Planning	Not available	Not available
	Field Assessment	ET Home Energy Management Field Tech Assessment Smart Thermostats	PG&E	Complete*	10	125
		ET Home Energy Management Scaled Field Placement (Phase A) Smart Thermostats	PG&E	Complete*	10	125
		ET Home Energy Management Scaled Field Placement Smart Thermostats (Phase 4)	PG&E	Complete*	12	129
		NEST Thermostat Scaled Field Testing with Portfolio of the Future Navigant	SCG	Active	Not available	Not available
		Advanced Thermostat Scaled Field Testing with EPRI	SCG	Active	Not available	Not available
DR	BYOT	Bring Your Own Thermostat (part of Peak-Time Rebate Program)	SCE	Not tracked	Not found	Not found
		Bring Your Own Thermostat (part of Peak-Time Rebate Program)	SDG&E	Not tracked	Not found	Not found

* For all completed ETP projects, none were recommended for transfer into the IOU EE portfolio. These were not recommended for three reasons: 1) there are subsequent ongoing projects testing the technologies, and 2) subsequent testing of this technology was not pursued because of the cost to test in the field was too expensive, and 3) non-positive assessment results.

4.2.2. California Efforts by Data Leveraged

There are three different types of feedback models by data source within California: those that leverage AMI data, those that use other sources, and those that use a hybrid approach (leverage both AMI and other non-AMI data). We categorize each data source in an effort to acknowledge that not all residential behavior feedback efforts use AMI data (e.g., efforts can provide monthly billing data or offer feedback related to inputs from a home energy audit or survey). However, one rationale for investing in Smart Meters was to provide feedback to customers. If efforts do not leverage AMI data, then the benefits of providing these data may go unrealized. Figure 6 provides a few examples for each type of model

Figure 6: Overview of California Residential Behavior Feedback Efforts Based on Type of Data Used to Provide Feedback



Overall, the majority (66 or 80%) of the 83 IOU-administered California residential behavior feedback efforts we identified leverage AMI. Of these, 12% (8 of 66) use GBC (for more information on GBC, see Chapter 7). The remaining efforts (17) do not use AMI or GBC data and offer a range of services from gamification efforts, HER programs, and analytical tools offered through REA sub-program activities.

- **AMI-only example – SDG&E's Manage-Act-Save Program:** According to the pilot description, Manage-Act-Save is a residential EE program that is intended to help SDG&E residential customers reduce their energy consumption. In 2013, approximately 200,000 customers participated in the pilot and an additional 200,000 were added in 2014. By providing participants with easy-to-understand and engaging information on their personal consumption, participants have the tools to manage and ultimately reduce their consumption. Additionally, the pilot encourages customers to act by providing prizes and rewards based on their actions.

- **Non-AMI example – PG&E's Zema Good Project:** According to the ETP project description, ZEMA Good is an engagement and behavior-based information technology product that uses virtual currency from

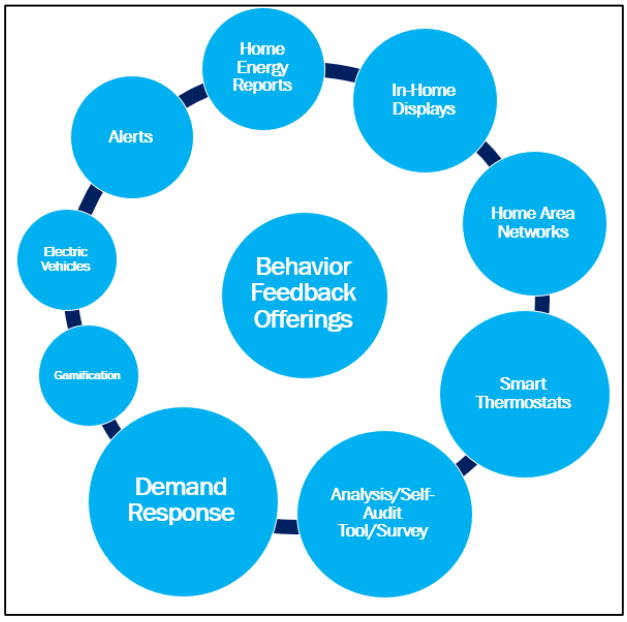
casual social games to engage, educate, and reward users for becoming more energy efficient. The goal of this project was to launch a trial with 2,000 PG&E residential customers to educate and persuade them, through incentives and tracking, to participate in energy-saving activities. Ultimately, this project was stopped given challenges for customer recruitment.

- **Hybrid example – PG&E's Opower Honeywell Smart Thermostat Project:** PG&E is conducting a Smart Thermostat project with Opower and Honeywell to evaluate the energy benefits that accrue to customers who utilize Internet-enabled thermostats, when exposed to behavior-based energy-saving messaging. This effort is an ETP project, and includes a group of approximately 500 residential customers.

4.2.3. California Efforts by Offering Type

California efforts use a variety of different offerings to either collect feedback from or provide feedback information to customers. These offerings range from paper reports to thermostats to HANs and IHDs. DR makes up the largest share of efforts, followed by analysis tools (self-audits, web portals), and thermostats. Gamification and electric vehicles make up the smallest share.

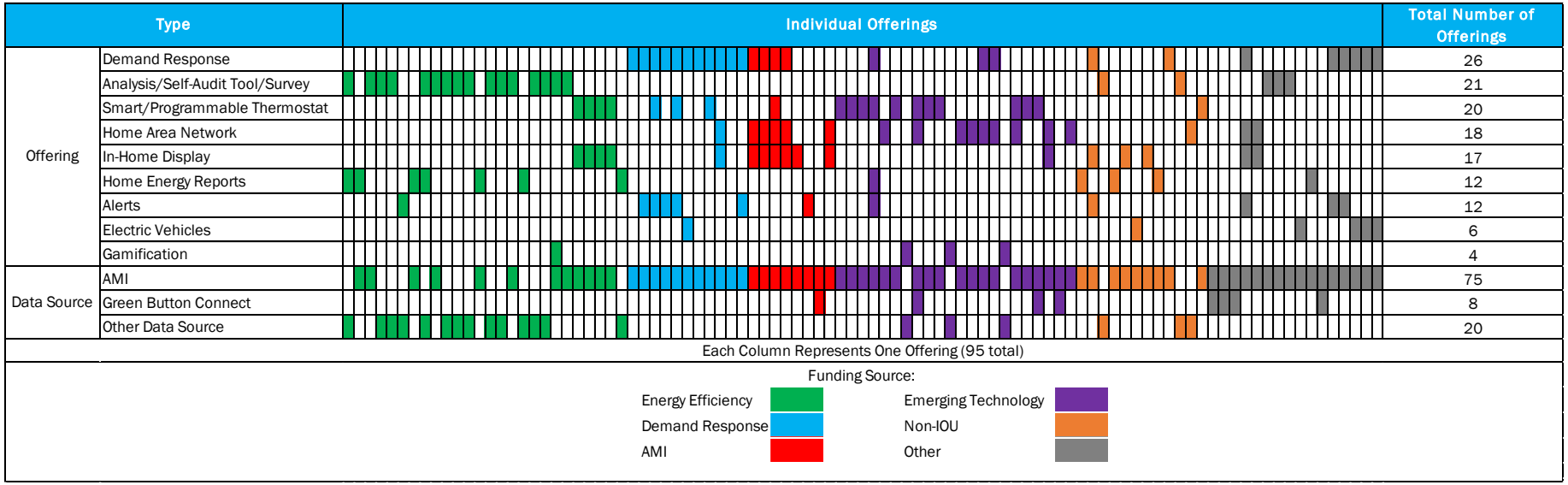
Figure 7: Menu of California Residential Behavior Feedback Services and Products Offered



Note: Circle size approximately represents the relative proportions of each service/product among the offerings in our study.

Figure 8 provides the count of efforts by offering type, data model leveraged, and color-coded funding source. In this case, we have identified four funding sources: EE, ETP (funded out of EE), DR and AMI. In the figure below, "Type" is separated into two categories. The first, "Offering", refers to the type of service; information or technology that the offerings provide. The second, "Data Source", refers to the type of customer data the offerings use. Each column under "Individual Offerings" in the figure below represents one of the 95 California efforts. On the right, we sum to total number of offerings that incorporate each "Type" category.

Figure 8: California Residential Behavior Feedback Effort Offering by Funding Source



4.2.4. California Efforts by Intervention Strategy

We categorized each of the 95 California efforts by their intervention strategies (i.e., the strategy that efforts use to influence energy-related behaviors) as defined in the IOU commissioned white paper, "Paving the Way for a Richer Mix of Residential Behavioral Programs."[22] Table 8 provides a description for each intervention strategy.

Table 8: Overview of Potential Intervention Strategies for Residential Behavior Efforts

Intervention Strategy	Description
Feedback*	Provide customers with either periodic or instantaneous feedback on their energy use (this may also include some information about the customer's energy use compared to their peers)
Commitment*	Ask people to make a commitment (first small, then larger) to another individual or group to take some energy-efficient action
Rewards or Gifts*	Offer free or low-cost EE measures or chances to win prizes or other rewards to encourage energy-efficient behavior
Competition*	Program design incorporates some sort of contest or game that sets participants against each other
Social Norms*	Activate social norms by providing comparison relative to a group others could identify with via marketing or outreach messaging, customized information, or visual cues
Financial Incentives*	Programs offer rebates, subsidies, or other monetary incentives for participating
Energy Pricing*	Offer time-differentiated pricing and electricity rates
Follow-Through	Provide prompts and reminders about the commitment or energy-efficient action that the customer committed to take
Pledging	Similar to "commitment," encourages participants to set a specific target for savings to achieve
Framing	Provide information or describe programs in such a way that emphasizes the benefits of energy-efficiency, positive social status, or self-image; reframes EE as preventing a loss, or generally changes the way that EE programs are marketed to customers
In-Person Interactions	Use interpersonal communication and a credible messenger (potentially an individual with some formal or informal authority) to encourage the desired efficient behavior
Activating Personal Norms	Triggers individual values by providing messaging, or other forms of motivation, that tap into personal codes of ethics, or help participants improve their self-image by taking recommended actions
Legal	Establish laws that require energy-efficient choices in building design and construction, land use planning, product design, and/or manufacturing
Leverage Sunk Cost	Includes programs, such as direct install, that upgrade existing equipment at no (or very low) cost to the customer in an effort to alleviate any psychological attachment to inefficient equipment that is still functioning

*Found in California efforts.

California residential behavior feedback efforts typically leverage multiple intervention strategies (including feedback, rewards, competitions, and social norms). "Feedback-only" intervention strategies make up the

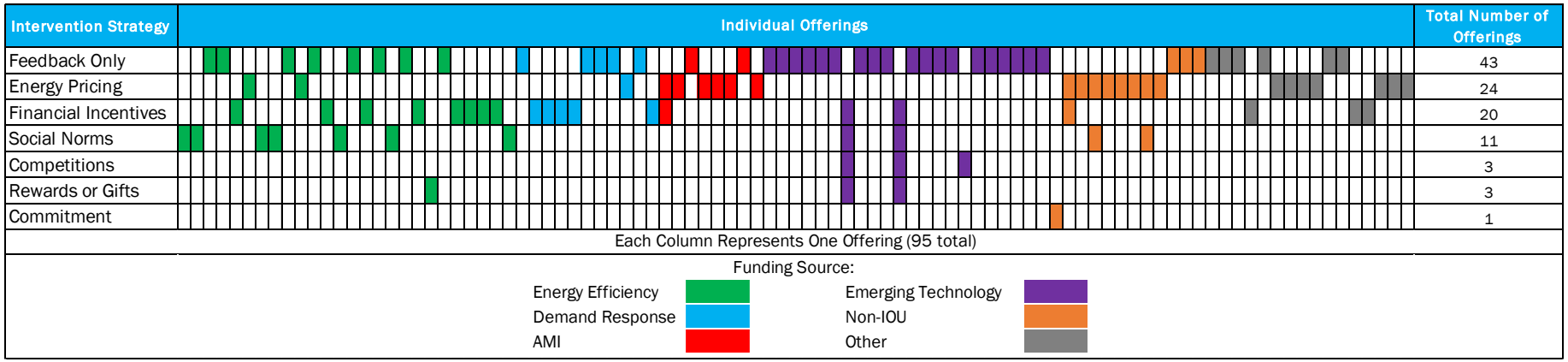
[22] P. Ignelzi et al. May 2013. "Paving the Way for a Richer Mix of Residential Behavior Programs." CALMAC ID: SCE0334.01.

largest share, followed by energy pricing and financial incentives. Competitions, rewards and gifts, and commitment make up the smallest share of intervention strategies.

The white paper recommends that programs incorporate multipronged intervention strategies to optimize program design for greater impact, and more than half of the efforts do include multiple strategies. As can be seen in Figure 9, in addition to providing information feedback, these efforts offer an array of varying intervention strategies. Figure 9 also provides a count of efforts by intervention strategy and the types of products and services offered. Notably, while low in actual effort count, gamification efforts tend to leverage the largest number of intervention strategies. Efforts that use enabling technologies, such as thermostats, IHDs, or HANs, use varying degrees of intervention strategies.

Figure 9: California Residential Feedback Efforts by Multipronged Intervention Strategies and Funding Source

Multipronged Intervention Strategy	Count	Examples of Efforts
Feedback Only	43	Universal Audit Tools, Edison SmartConnect Field Trials – HAN with Load Control, Interactive Home Energy Monitoring and Management System
Feedback + 1	46	Reduce Your Use IHD Pilot, HERs, My Energy Web Tools, PEV Submetering Pilot, Game-Based EE Programs, CEIVA Homeview Pilot
Feedback ++ 2	4	HAN RTC Pilot, SmartSacramento, BWP HERs, GWP Energy Insider
Feedback ++++ 4	2	ZEMA Good, Consumer Behavior Change with Casual Social Games



As noted earlier, the IOUs and the CPUC are in the process of expanding the definition and parameters of behavior programs (see Chapter 2).[23] These expanded definition and parameters encompass: 1) deploying multiple underused behavior intervention strategies, 2) broadening evaluation approaches beyond experimental design, 3) allowing for ex ante savings values (if approved), 4) utilizing behavioral science framing strategies, and 5) omitting traditional behavior intervention strategies.

Despite not being within our time frame (2013–2014 projects), we also reviewed SCE and SCG 2015 applications to illustrate two proposed innovative efforts that leverage underused intervention strategies (not included in our list of efforts). We also summarize a PG&E pilot that occurred in 2014-2015 and uses innovative technology that is relatively new among IOU-administered offerings. These are:

- **Energy Pledge Behavioral Pilot[24]:** This pilot will target high-energy usage residential households and specifically focuses on 10 cities with strong ethnic Chinese populations. The pilot will leverage two underused strategies: commitment and follow-through. Participants will receive bimonthly mailings that will encourage them to take low-cost/no-cost energy-savings pledges. These mailings will also provide prompts or reminders to participants about the pledges they have taken. Although some customers will have the opportunity to opt in to the pilot, SCE will also use an opt out, experimental design with a separate population in order to measure energy savings via a randomized control trial.

- **SCE/SCG 10-10-10 Multifamily Behavioral Pilot[25]:** This pilot targets multifamily complexes within joint SCE/SCG territory. The pilot will use a multipronged approach, including several underused intervention strategies: commitment, follow-through, competition, and rewards. Complexes will be asked to commit to a goal of 10% annual reduction (each) in energy, gas, and water usage. The pilot will leverage competition and rewards as motivators on multiple levels: within complex, complex to complex, and city to city. Finally, the pilot will include feedback and benchmarking by providing large complexes with information on consumption patterns using Multifamily ENERGY STAR® Portfolio Manager Software.

- **PG&E Bidgley Pilot**[26]: In late 2014 and 2015, Bidgley provided its HomeBeat and Energy Fingerprints services to 850 PG&E time-of-use customers. Bidgley's service uses smart meter data to provide two types of information to customers: real-time usage and cost information and disaggregated energy use by appliance type. According to Bidgley, the pilot achieved 7.7% energy savings per participant on average.

In the next section, we provide an overview of the data tracked and reported for California's residential behavior feedback efforts.

[23] http://library.cee1.org/sites/default/files/library/11659/CA_IOUs_Behavior_Definition_Proposed_to_CPUC.pdf.

[24] Advice 3137-E; 11/21/14.

[25] Advice 3157-E (SCE); Advice 4731-G (SCG); 12/30/14.

[26] http://www.utilitydive.com/news/how-customer-empowerment-is-helping-utilities-cut-energy-fat/379561/

5. California's Residential Behavior Feedback Data Availability and Reported Achievements

In this section, we provide a review of the data that the IOUs currently track and report by funding source, limitations with the current data, and the availability of the data. Notably, given limited data tracking, we were unable to provide a comprehensive overview of progress made in realizing benefits assumed in the AMI business cases. We also provide a brief discussion of variations in cost-benefit analysis across funding streams and implications for program oversight.

5.1. Current Data Tracking

Table 9 provides an overview of the current data tracked for residential behavior feedback programs across funding streams. As illustrated, the IOUs track a variety of metrics, including budgets, expenditures, and impacts. However, metrics are not consistently tracked across funding streams: AMI-funded reporting requirements are less rigorous than the other funding streams. We note that some EE-, DR-, and ETP-funded efforts do appear in the Smart Grid Deployment Plans, with similar data tracked for those efforts as for AMI. Additionally, efforts described in this report reflect both resource and non-resource initiatives. For example, ET projects, are by definition, non-resource programs that do not claim savings.

Table 9: Data Tracked by Funding Source

Data Category	Type of Data Tracked	AMI	EE	DR	ETP
Description	Narrative Descriptions of Efforts				
Description	IOU Administrator				
Description	Program Year/Cycle				
Description	Sector or Target Market (i.e., Residential, Commercial; where applicable)				
Description	Program Implementation Plans				
Cost	Expenditures				
Cost	Budgets				
Cost	Cost-Effectiveness (i.e., Total Resource Cost, Participant Cost Test)				
Participation	Actual Participation				
Participation	Participation Goals				
Impacts	Actual kWh/kW/Therms Savings				
Impacts	GHG Emissions Reductions				
Impacts	Cost Savings (i.e., avoided operating costs)				
Sources:		**Legend**			
AMI: SGDP Updates *EE:* EESTATS (Monthly and Annual Reports) *DR:* CPUC Demand Response Homepage (http://www.cpuc.ca.gov/PUC/energy/Demand+Response/) *ETP:* ETP Database			Tracked for every effort		
			Tracked for overall portfolio		
			Tracked for some efforts		
			Not tracked		
			Not applicable		

5.2. Limitations Exist with Current Data

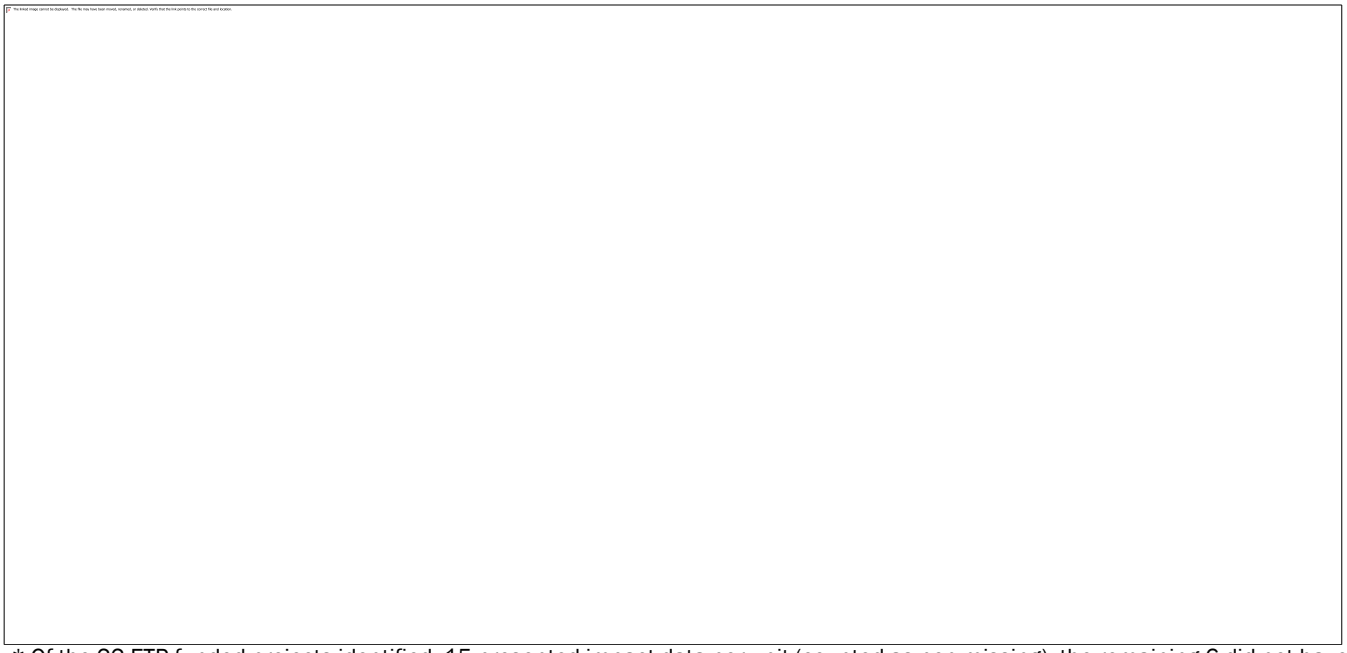
Overall, our team found it difficult to determine how the residential feedback efforts are contributing to California's EE, DR, and GHG reductions goals. This was primarily due to the lack of data that limited our ability to draw conclusions about the relative benefits and costs of these efforts. The team culled data from existing Smart Grid Annual Reports, EESTATS[27] monthly and annual reports, DR monthly reports, and the ETP database. We also submitted a data request to each IOU to provide information on key impact metrics for each of their initiatives.

There are substantial limitations in terms of data tracking for key metrics for California IOU-based efforts. Figure 10 provides a snapshot of the scale of missing data for the 83 IOU programs included in this review, underscoring a need for better tracking to help inform policy and regulatory decisions moving forward. This is important because not only is savings a good metric to track, it is required for inclusion in the EE portfolio. However, we acknowledge that for some behavioral efforts, energy savings is not the primary goal of the effort, rather efforts could be used to cross-promote other programmatic efforts or increase customer education regarding home energy management activities. Additionally, many of the efforts described are non-resource acquisition activities. To ensure a careful accounting of available data, the team removed any not applicable efforts from our review of available data. As such, tracking downstream savings, and attributing those savings to these behavioral efforts, becomes more problematic.

Overall, 39% percent of the 83 IOU-funded efforts are missing participation data, 23% are missing budget data, and 57% are missing energy impacts data. Additionally, impacts data are not consistently captured in equivalent metrics (e.g., we found impacts documented as percent per household, overall savings, savings per year). In these instances, it is impossible to compare relative impacts as the units and scales are often unclear. Missing energy impact data may be a function of the timeframe of expected effort outcomes. For example, if an effort expects to increase knowledge that will then lead to savings, not having an energy impact value is appropriate. However, we could not differentiate the efforts in this way.

[27] California Public Utilities Commission California Energy Efficiency Statistics site gives users the ability to view up-to-date savings, budgets and expenditures, and cost effectiveness of California's Energy Efficiency (EE) programs. here: http://eestats.cpuc.ca.gov/

Figure 10: Residential Behavior Feedback Efforts Missing Information, by Funding Source (n=83)



* Of the 22 ETP-funded projects identified, 15 presented impact data per unit (counted as non-missing); the remaining 6 did not have impact information available.
** The 16 listed as "Other" were either funded by the General Rate Case, 2009 rate design window, or shareholder funds, or we could not identify the funding source.
NOTE: Percentages do not include efforts where data tracking for a particular metric is not applicable.

Our team looked at all behavior feedback efforts included in the CPUC's portfolio of residential programs. In some cases, programs included a wide variety of distinct behavior interventions and activities. This necessitated looking at programs or projects at a more granular, sub-activity level. There were several cases where we found metrics for an overarching program, but not for individual sub-activities, which limited our ability to measure the effects of distinct behavior-based efforts within a program. For example, each IOU reported expenditures for its REA program at the program level. However, we were unable to break out annual expenditures for each of the 19 different sub-activities with the four IOU REA programs. The lack of impact and expenditure data at a more granular level limits the ability of program administrators to measure the cost-effectiveness of specific efforts within a program. However, we acknowledge that tracking costs at a sub-activity level can be a substantial undertaking given the number and range of activities. Tracking behavioral feedback efforts is challenging given that they comprise a variety of efforts (pilots, programs, sub-activities, and projects) as well as are oftentimes considered strategies within a program that if tracked could lead to double-counting savings.

5.3. Data Available on Key Metrics

In spite of these limitations, we can provide findings for the efforts that documented impacts. Table 10 presents a summary of impact metrics, where tracked, for IOU-funded projects in California. Participation is the most widely tracked metric, followed by annual budget. As noted above, in some cases, the metrics were reported at the overarching program level (e.g., the REA program), and our team was unable to allocate the appropriate amount to each behavioral effort (i.e., each sub-activity). As such, items listed in the table can reflect either sub-activity or overarching program level.

Table 10: 2013–2014 California IOU-Administered Residential Behavior Feedback Impact Metrics Reported
(where tracked)

Metric (n=count of non-missing, applicable efforts)	Total	Average	Max	Min
Participation				
Participants (n=42 of 70)	8,160,819	194,305	1,900,000	17
Budget & Expenditures				
Annual Budget (n=27 of 82)	$16,823,743	$623,102	$8,295,000	$3,000
Annual Expenditures (n=25 of 83)	$95,607,705	$3,824,308	$18,615,908	$10,000
Energy Impacts				
MWh Impacts (n=11 of 71)	183,093	17,116	82,700	16
MW Impacts (n=9 of 75)	726	81	347	0.430
Therm Impacts (n=17 of 73)	4,093,232	240,778	2,495,700	0.10

Note: To determine total participants, we summed participation across all efforts. This likely includes some double counting because we were unable to determine, with the data available, when a customer participated in multiple efforts.
NOTE: The count of efforts excludes not applicable activities.

In the tables that follow, we provide these metrics by funding source for the 83 California IOU programs included in this study. As shown in Table 11, there is substantial variation in participation by funding source. This is largely due to the difference in scope between many of the programs included in this review, that is, many were projects, or other studies, that had very specific participation requirements. More specifically, ETP-funded projects were a mix of field assessments or lab tests for new technology where participation is more a function of the type of study being conducted than a reflection of program scalability.

Table 11: 2013–2014 California IOU-Administered Residential Behavior Feedback Participation Data Reported by Funding Source
(where tracked)

Funding Source (n=count of non-missing)	Total Participants	Average	Max	Min
AMI (n=7 of 8)	115,054	16,436	113,000	37
DR (n=5 of 11)	2,134,244	426,849	1,207,533	1,344
EE (n=15 of 26)	3,383,919	225,595	1,200,000	4,030
ETP (n=6 of 22)	50,722	8,454	45,000	17
Other (n=9 of 16)	2,476,880	275,209	1,900,000	400

Though the IOUs have documented annual budgets and expenditure information reasonably well, as noted above, there were several cases where the IOUs reported information at a higher level than we needed for our study. We have included the available annual budget and expenditure information, by funding source, where data were tracked. In most cases where program year-to-date expenditure information was available, annual budget information was not, and vice versa. Also, for many DR and EE programs, budgetary information was reported for the entire program cycle, which may vary, and therefore makes comparison difficult year to year. For both of these reasons, the expenditure information is not directly comparable to the annual budget information reported below.

Table 12: 2013—2014 California IOU-Administered Residential Behavior Feedback Budget and Expenditures Metrics Reported by Funding Source
(where tracked)

Funding Source (n=count of non-missing)	Total	Average	Max	Min
Known Annual Budgets				
AMI (n=2 of 8)	$4,431,720	$2,215,860	$3,480,000	$951,720
DR (n=0 of 11)	not reported	not reported	not reported	not reported
EE (n=2 of 26)	$9,001,010	$4,500,505	$8,295,000	$706,010
ETP (n=22 of 22)	$2,851,013	$129,592	$886,247	$3,000
Other (n=1 of 16)	$540,000	$540,000	$540,000	$540,000
Known Annual Expenditures (these do not specifically overlap with budgets)				
AMI (n=6 of 8)	$14,700,000	$2,450,000	$9,500,000	$10,000
DR (n=8 of 11)	$16,359,599	$2,044,950	$11,940,000	$65,389
EE (n=6 of 22)	$44,949,107	$7,491,518	$18,615,908	$1,265,374
ETP (n=0 of 22)	not reported	not reported	not reported	not reported
Other (n=5 of 16)	$19,599,000	$3,919,800	$17,580,000	$100,000

Note: "Other" funding sources includes efforts funded by the General Rate Case, 2009 rate design window, or shareholder funds, or we could not identify the funding source.

Table 13 provides the reported kWh, kW, and therm savings by funding stream. Annual energy impacts represent the largest gap in data. The most common issue was missing data; however, there were also several cases, particularly for ETP-funded projects, where savings information was either reported as a percent or on a per-unit basis. In terms of kWh impacts, which was the most widely reported energy impact metric, annual savings ranged from 82,700 MWh for PG&E's HER program to 16 MWh for SCE's SmartConnect Field Trials—HAN Third Party Limited Launch.

Table 13: 2013–2014 California IOU-Administered Residential Behavior Feedback Energy Impact Metrics Reported by Funding Source
(where tracked)

Funding Source (n=count of non-missing)	Total	Average	Max	Min
Annual kWh Impacts				
AMI (n=4 of 8)	7,065,515	1,766,379	7,064,000	16,097
DR (n=1 of 11)	536,000	536,000	536,000	536,000
EE (n=5 of 26)	167,891,649	34,278,329	82,700,000	1,718,044
Other (n=1 of 16)	7,600,000	7,600,000	7,600,000	7,600,000
Annual kW Impacts				
DR (n=4 of 11)	694,722	173,680	347,000	1,000
EE (n=5 of 26)	31,110	6,222	12,300	430.44
Annual Therm Impacts				
EE (n=4 of 26)	4,092,859	1,023,215	2,495,700	118,832
ETP (n=13 of 22)	373	29	210	0.10

5.4. Data Used in Cost-Benefit Analysis

In addition to the data limitations described above, our review of the documentation identified variations in terms of the types of benefits included in the AMI and EE cost-benefit analyses (our analysis did not include DR cost-benefit analysis). Below we describe how the CPUC deems these projects cost-effective, and how they vary across the IOUs (for AMI cost-effectiveness), as well as across funding streams.

We identified a "silo effect" in the sense that each funding stream carries distinct policy rules surrounding inputs into cost-effectiveness. We begin by documenting any differences across the IOUs in calculating benefits, followed by a comparison to EE cost-effectiveness protocols.

We identified five general categories for the types of benefits calculated for AMI projects:

- **Operational:** For example, avoided energy procurement and capacity generation costs
- **DR/Conservation:** For example, energy or demand savings through changes to customer behavior, shifts in energy use from peak load, or increases to IOUs' demand response portfolio
- **Societal:** The types of benefits that fall into societal vary significantly by IOU, but include such benefits as public safety, meter accuracy, and reduced energy theft[28]
- **Reliability:** Refers to reductions in duration or avoidance of power outages, and increased service reliability
- **Environmental:** Refers to avoided GHG and other pollutant emissions

[28] SDG&E categorizes reduced energy theft and meter accuracy as operational benefits.

Variation across IOUs by AMI Proceeding

For Phase 1: Installing Smart Meters, the IOUs use a common methodology, with several common inputs and assumptions, set forth in ALJ Ruling R. 02-06-001. However, the IOUs differ in some benefits that they include. For instance, SDG&E and SCE include quantified societal benefits, while PG&E acknowledges societal benefits but does not quantify them (Table 14). This variation prevents the CPUC and other interested parties from making apples-to-apples comparisons of the IOUs' respective cost-effectiveness of AMI deployment projects.

For Phase 2: Engaging Customers with Feedback, PG&E calculates benefits using a methodology developed by the Electric Power Research Institute (EPRI) for calculating cost-effectiveness.[29] SCE uses a methodology developed by the Department of Energy's (DOE) Office of Electricity Delivery and Energy Reliability.[30] SDG&E also primarily uses the same EPRI methodology as PG&E, but with additional operational and reliability benefits estimated based on Lawrence Berkeley National Laboratories' (LBNL) Value-of-Service Reliability model.[31]

Because they use different methodologies, the IOUs vary in terms of the types of benefits included in their calculations. For instance, only PG&E and SDG&E include environmental benefits; SCE does not (Table 14).

Table 14: Types of Benefits in AMI Proceedings, by IOU

Types of Benefits Included	Installing Smart Meters(1)			Engaging Customers with Feedback(2)		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
Operational	✓	✓	✓	✓	✓	✓
DR/Conservation	✓	✓	✓	✓	✓	✓
Societal	⬢	✓	✓	×	×	✓
Reliability	⬢	✓	⬢	✓	✓	✓
Environmental	×	×	✓	✓	×	✓

Legend:
✓: Included
⬢: Included, but do not appear to be quantified
×: Not included
Notes:
(1) Based on AMI Business Case Decisions; (2) Based on Smart Grid Deployment Plans

Comparison to EE Cost-Effectiveness Protocols

For EE programs, the IOUs use the CPUC-approved Energy Environment Economic (E3) Calculator to calculate cost-effectiveness.[32] Benefits calculations for AMI efforts also use several E3 calculator inputs. However,

[29] January 2010. EPRI. Final Report No. 1020342, "Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects."

[30] While no specific citation is included in SCE's 2013 Annual Report, it seems this is the same EPRI methodology used by SDG&E and PG&E.

[31] June 2009. LBNL. Final Report No. LBNL-2132E, "Estimated Value of Service Reliability for Electric Utility Customers in the United States."

[32] https://ethree.com/.

because the overall methodologies differ, AMI differs in terms of the types of benefits included as shown in Table 15.

Table 15: Comparison of AMI and Energy Efficiency Inputs to Benefits Calculations

Types of Benefits Included	Installing Smart Meters(1)	Engaging Customers with Feedback(2)	Energy Efficiency Programs(3)
Operational	✓	✓	✓
DR/Conservation	✓	✓	✓
Societal	✓	⬢	×
Reliability	⬢	✓	×
Environmental	⬢	⬢	×

Legend:
✓: Included
⬢: Included, but do not appear to be quantified
×: Not included
Notes on Sources:
(1) Based on AMI Business Case Decisions; (2) Based on Smart Grid Deployment Plans; (3) 2013–14 E3 Calculator technical memo (https://ethree.com/)

Our review indicates that there is substantial variation in terms of the data tracked and available, as well as the cost-benefit inputs employed by the IOUs and across various funding streams. In addition to these differences, there is insufficient data tracked to support drawing any comprehensive conclusions regarding the achievements made (specifically compared to anticipated benefits from AMI investment) from these efforts.

6. National Residential Behavior Feedback Efforts

In this section, we highlight select residential behavior feedback programs offered throughout the rest of North America States to provide context to California initiatives. We reviewed behavior programs outside of California to gain a better understanding of which types of behavior modification programs have been the most widely adopted outside of California (in terms of intervention strategy and program offering) and how these programs have performed to date. Our review identified 38 programs with evaluated results. In addition to our secondary review, we conducted interviews with market experts, vendors, and IOU and CPUC staff to better understand national trends regarding residential behavior feedback programs.

Across North America, behavior programs represent a significant portion of first year EE savings goals for residential portfolios (with highs of 31% and 25% of 2012 residential portfolio impacts in Arkansas and Indiana, respectively).[33] For PG&E, the HER program now represents the largest savings measure in the residential portfolio.[34] Consequentially, this type of behavior program (HER) is primed to become a substantial driver of energy savings. Table 16 provides the top 10 states in terms of share of first year behavior program savings in a residential portfolio. Notably, these behavioral programs typically reflect opt-out Home Energy Report programs evaluated in many jurisdictions.

Table 16: Top 10 States for Behavior Program Representation in 2013 Residential Portfolio Savings[35]

Rank	State	Behavior Programs as a Percent of 2013 Residential First-Year Savings Goals
1	Indiana	28%
2	Idaho	25%
3	Rhode Island	25%
4	Illinois	22%
5	New Mexico	19%
6	California	18%
7	South Carolina	15%
8	Arizona	15%
9	Kentucky	14%
10	Colorado	13%

Note: North Carolina plans behavior programs to represent 72% of residential savings in 2014.

6.1. Summary of National Residential Feedback Initiatives and Trends

To ensure that we were able to gather information on programs throughout North America, we:

- Reviewed repositories of EM&V studies, such as the Consortium for Energy Efficiency

[33] Policy and Planning Considerations for Incorporating Behavior Programs Into Efficiency Portfolios, Illume Advising, LLC, May 2013. https://www4.eere.energy.gov/seeaction/sites/default/files/pdfs/webinar_behavioral_programs_portfolios.pdf

[34] Source: IOU 2013-2014 tracking data provided by CPUC.

[35] Ibid.

- Followed up on leads through the bibliographies of EM&V studies
- Questioned other experts in the field to see if they were aware of other feedback efforts
- Gathered studies from our internal library

We made a conscious choice to ensure that we covered the range of differing types of feedback efforts and did not specifically gather information on the numbers of efforts of each type. As such, our counts are not indicative of the frequency of offerings, rather the availability of effort types. For example, the HER program is used within many states, but we did not actively gather data from each of those efforts.

Overall, we did not find gaps in terms of California residential behavior feedback offerings, as compared to programs offered across North America. That is, the California market has comparable feedback offerings to those offered in North America, in terms of both types of efforts and distribution of the types of programs that leverage multiple offerings or behavior intervention strategies (with the exception of the Pre-pay program described below). However, additional work is required to better understand the potential for these programs as many are in the pilot stage and may not be generalizable to other populations.

There is a general paucity of impact findings for residential behavior feedback programs, hampering the ability to make direct comparisons and prioritize efforts. There are few behavior feedback programs that provide evaluated results. Within those programs, impact metrics are often tracked or reported using different measurements that cannot be disaggregated or compared.

Given the proliferation of home energy consumption data, as well as greater interest in how behavior programs can support residential portfolios, behavior feedback program design has expanded to a variety of different offerings:

- AMI data are supporting program designs seeking to reduce energy demand, as well as consumption. Market experts indicate that behavior programs are shifting from focusing on EE to focusing on DR, enabled by providing near-real-time information on energy consumption.
- Existing programs leverage behavior intervention strategies as within-program initiatives. In many regions, behavior efforts are initiatives within existing programs, allowing program administrators to assess the feasibility of new program designs and interventions, without needing to adhere to cost-effectiveness requirements.
- Barriers to providing these programs have shifted from providing infrastructure for data access to concerns regarding privacy and cost-effectiveness of technologies. As AMI data become more accessible, barriers have shifted to privacy concerns and data access, as well as to whether technology approaches to provide feedback are cost-effective (e.g., IHDs, costly web portals, developing mobile applications).

Figure 11 and Figure 12 present the 38 select U.S. program and pilot offerings reviewed for this study. The first figure presents these programs by what they offer, and the second by the intervention strategies employed. We have also included whether or not these programs leverage AMI data, as one might expect differences in terms of program offerings by access to data.

- As stated above, we found few gaps in terms of offerings and intervention strategies. North American program offerings appear to be similar to those found in California (e.g., a similar distribution of programs).

- HER programs are the most widely adopted according to market experts and existing research. While California does offer home energy reports, program administrators in California also offer a wide variety of alternative designs.
- Most programs leverage multipronged intervention strategies, consistent with recommended practice and rooted in behavioral science.
- One area that is noticeably absent from California are Pre-Pay programs, while at least two programs are in place across the nation. We understand that California has considered these types of programs. In Section 6.2, we describe nationwide Pre-Pay programs, as well as barriers to offering Pre-Pay programs in California.
- When comparing California's distribution of offering types to those offered across North America, we find that California tends to offer self-audit tools/surveys, smart thermostats and HAN more than nationwide. However, we found that nationwide there tended to be more programs that use social norming or activating personal norms than in California via HER offerings.

Figure 11: Summary of North American Efforts by Offerings (n=38), excludes California

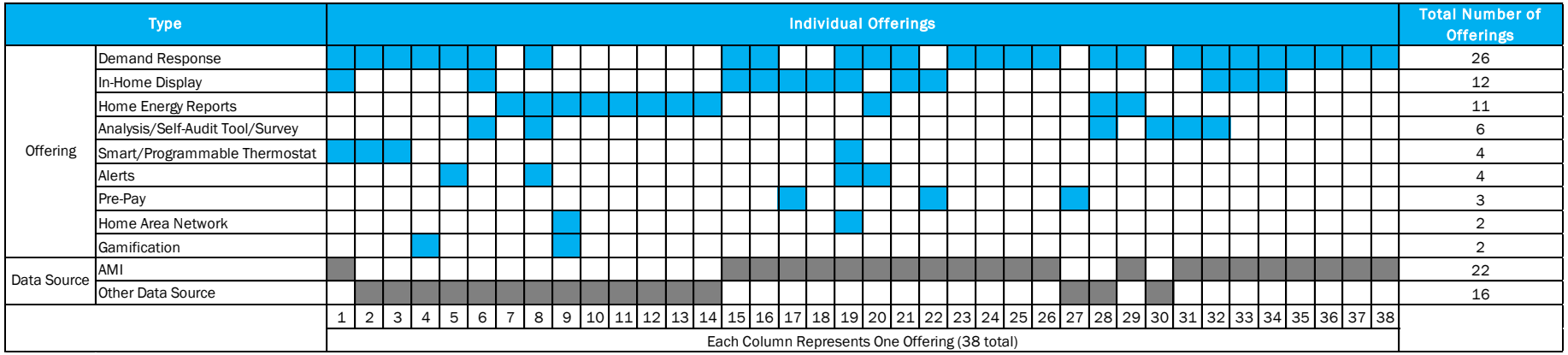
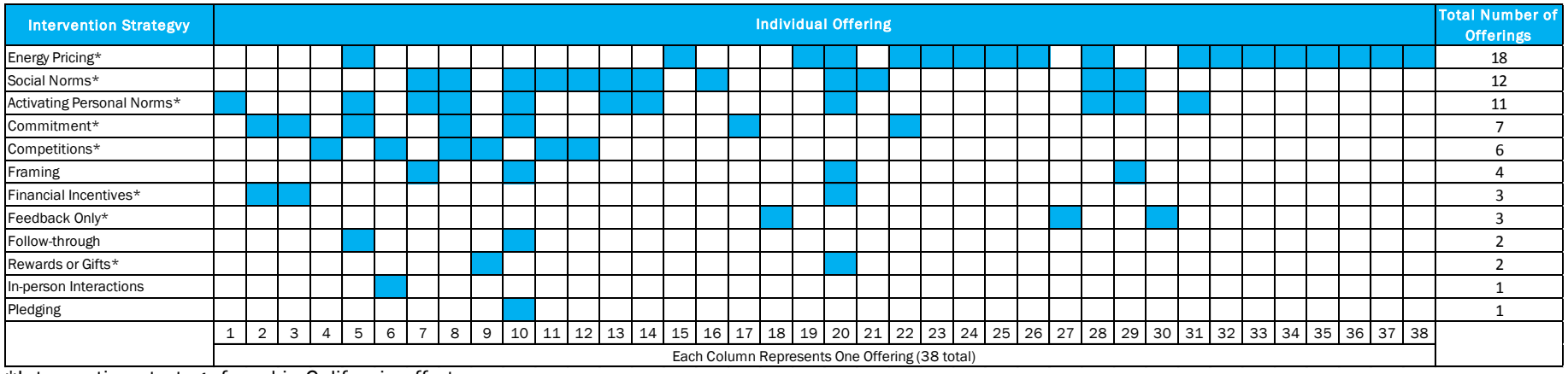


Figure 12: Summary of North American Efforts by Intervention Strategies (n=38), excludes California



*Intervention strategy found in California efforts.

6.2. Summary Snapshots Highlighting Select Innovative Efforts

The wide range of residential behavior feedback programs seen across North America is difficult to neatly compartmentalize and understand. As such, to help gain understanding about the variety of efforts, we chose five specific interventions and present snapshots of innovative programs and the factors that contributed to their development for the following innovative programs or pilots:

- Smart Thermostat Programs
- Pre-Pay Programs
- Gamification Programs
- Residential Disaggregation Software
- Time Varying Rates and Dynamic Pricing

Snapshot: Smart Thermostats Programs

As smart thermostats become more readily available in the market, utilities throughout the country are working to incorporate this technology into their current demand-side offerings. Though incidences of these types of programs are relatively low, we found efforts that use this technology, particularly for DR programs in areas where cooling represents a high percentage of homes' electricity usage.

We highlight two programs focused on the smart thermostat's ability to automate and control specific appliances (such as heat pumps) remotely. Both subsidized the purchase of specific types of smart thermostats and concentrated on the thermostat's ability to control heating and cooling devices at specific times of the year.

Table 17: Reported Metrics from Select Smart Thermostat Pilots

Program	Participants	Expenditures (millions)	Annual kWh Savings	MW
Austin Energy's Power Partner	5,819	$1.10	49,000	6.8
Energy Trust of Oregon's Nest Thermostat Heat Pump Control Pilot	177	(not reported)	781	(not reported)

- Austin Energy's Power Partner program, similar to other smart thermostat programs, aims to automate customers' air conditioning during predetermined event days over the summer months. This approach, designed to make smart thermostat technology accessible to more residential customers, provides rebates of up to $85 for the purchase of select models of connected thermostats. In return for the rebate, customers must allow Austin Energy remote access to their new thermostat during these event days for a select number of hours. The program, launched in FY2013, has been extremely successful, realizing 49,000 kWh in savings and participation approximately 380% of its initial goal. Power Partner is unique in its ability to tackle the challenges associated with high summer demand, while also providing innovative new technology to customers.
- The Energy Trust of Oregon's pilot program attempted to discern if savings could be expected by employing smart thermostat technology during the heating season in the Pacific Northwest. Its pilot focused only on the electric savings achievable in homes with air-source heat pumps. After normalizing for weather and isolating the electric savings attributable to the thermostat, the study yielded savings of approximately 4.7% (781 kWh) per year, slightly below their projected savings of 836 kWh per year.

Though incidences of utilities funding these types of initiatives are rare, another example, though relatively new, is also in Texas. Reliant Energy customers can opt into their Learn & Conserve rate plan, and are given a free Nest thermostat and guaranteed a fixed rate for 24 months. Furthermore, similar to Austin Energy's program, there are other examples of smart thermostats being used by utilities in air conditioning (AC) cycling programs. Baltimore Gas and Electric (BGE) has successfully piloted Wi-Fi-enabled thermostats in their PeakRewards HVAC program. For this program, BGE partnered with Opower to offer different levels of rebates to customers allowing different levels of cycling for specified event days. For example, a customer willing to allow BGE to reduce the runtime of his or her central AC by 50% during these event days will receive a $50 bill credit per year, while customers who allow BGE to cycle their systems off during these days will receive a $100 credit for the year.

Snapshot: Pre-Pay Programs

Pre-pay programs (also known as "Pay As You Go" programs), or those that allow customers to pay for their electricity before they use it, have been adopted in the United States, with great success. These types of programs, originally targeted at low-income ratepayers, yield savings of close to 10%, and participating customers typically report high levels of satisfaction with the service. Simply changing the way that they pay for electricity gives customers a greater sense of control over how they use electricity and over budgeting how much they spend on their bills each month. Table 18 provides key impact metrics for three sample Pre-pay efforts found around the United States. All three were offered to the general population or ratepayers; Oklahoma Electric Coop's (OEC) and DTE's pilots were offered to customers who had a history of using their online payment service.

Table 18: Reported Metrics from Pre-Pay Programs

Program Name	Participants	Percent kWh Reduced
Salt River Project's M-Power Program	77,909	12%
OEC Prepaid Account Management System	5,000	11%
DTE Energy's Smart Currents-Pay As You Go Pilot	123	11 %

Pre-Pay Program Potential for California

In 2012, the Policy and Planning Division of the CPUC released a white paper looking at the possibility of implementing Pre-pay programs in California.[36] Though Pre-pay may offer the opportunity for substantial and persistent savings through behavior change, there are several key points that would need to be addressed. These points are outlined below and are discussed at length in the CPUC white paper.

- **Limitations in how and when utilities can shut off service to customers:** Strict rules protecting customers from having their service shut off may conflict with some of the goals of Pre-pay. Presently, rules require that customers are notified via mail 10 days prior to service being shut off, and again 24–48 hours prior to service being shut off. As they currently exist, these rules, among others, would greatly complicate the administration of any Pre-pay program.
- **Customer Payment and Notification Processes:** Creating a clear process for customers to pay for their electric service, potentially through a smartphone application, is a key aspect of successfully designing a Pre-pay program. Further, it is suggested that, embedded in this process, there is a means of the utility notifying the customer of low, or negative, balances.
- **Considerations for income-qualified customers:** If California were to implement Pre-pay, considerations would need to be made for customers on special rates, specifically, those eligible for the California Alternate Rates for Energy or those on the medical baseline tariff. This group, and others that may be more prone to shut-offs, would likely require some special protections, and program administrators would need to ensure that customers with a history of delinquent payments would not be disproportionately targeted for participation.
- **Limiting when service is shut off and allowing grace periods for customers to pay negative balances:** One key consideration for Pre-pay is to limit the risk of customers losing power during non-business hours or during extreme weather events. Rules would need to be in place to prevent customers from losing power during extreme heat or cold or other storm-like scenarios. Furthermore, many Pre-pay programs in other jurisdictions have established "grace periods" where customers' service will not be shut off over the weekend or during the evening.

[36] CPUC Policy and Planning Division. *A Review of Pre-Pay Programs for Electricity Service*. July 26, 2012.

Snapshot: Gamification Programs

Games are a burgeoning new way that utilities, and other stakeholders, have begun to encourage greater energy savings. Though this is a relatively new area that North American utilities have begun to explore, there are several examples of innovative program designs that have been championed by organizations other than utilities and that have taken hold outside of North America. We have identified several examples of game-based programs; however, as many were broader in geographical scope or subject matter—that is, they focused on more than energy demand reduction—they are not included in the larger review of programs conducted for this study.

We have applied several criteria for classifying game-based EE programs for this study. First, there may be a reward component; however, winning is not guaranteed simply by participating. This is an important distinction to make between simple reward programs and those that employ competition, at least in part, as an intervention strategy. To this point, only programs with some form of competitive aspect truly qualified as games. These games could be individual or team-based, but some challenge was a central component of each.

We profile three game-based programs that exemplify different types of programs available in the market: those that offer a reward for taking some energy-saving action, challenges that reward participants based on kWh saved, and competitions focused on customer engagement through contests. This final group typically includes multiple campaigns that attempted to adjust social norms.

- **Points for Energy-Saving Actions—iChoose Pilot by Cool Choices:** Cool Choices, a Wisconsin nonprofit, partnered with Miron Construction to offer its iChoose pilot to 220 Miron employees. The game rewards participants with different levels of points (from 5 to 150) based on daily recommended energy-saving actions. Actions were broken down into different categories based on difficulty and potential energy savings that could result. Some were simple, such as asking participants to turn off unused lights, while others required a greater investment, such as air sealing or even investigating details about their energy use patterns. An independent evaluation of this pilot program estimated a reduction in electricity usage by approximately 4%.[37]

- **Reduce Usage Challenge—SDG&E's Manage-Act-Save Program:** As part of its Residential Energy Advisory program, SDG&E developed a competition that awards points to participants if they take recommended actions, similar to the iChoose pilot, but also awards points based on participants' daily reduction in energy use. This innovative pilot gives participants a daily score derived from that day's usage, measured against their historical baseline. The 2013 pilot enrolled roughly 200,000 participants and estimated an average of a 4.5% reduction in energy consumption.

- **Social Norming Contest—Palo Alto Ugliest Lighting:** The City of Palo Alto ran their "Ugliest Lighting" competition in February and March of 2012, and asked residents to send in pictures of their most outdated halogen or incandescent lighting. "Ugliness" was rated according to the number of inefficient lamps in the photo, how inaccessible their location was, how outdated the technology was, overall wattage represented in the photo, and the hours of daily use for the lamps shown. The winner of the contest was given $400 toward new LED lamps. The primary goal of the program, and similar efforts, is to raise awareness and educate participants on how they can change their behavior to reduce their energy consumption. As such, savings are difficult to calculate and were not tracked.

[37] The evaluation was conducted by the Energy Center of Wisconsin.

Snapshot: Residential Disaggregation Software

Energy disaggregation breaks down a home's energy load to analyze energy use by specific sources. This breakdown might be at the room, end-use, or potentially individual-equipment level. By analyzing energy use at this granular level, program administrators and vendors are able to provide residential customers with tailored feedback into sources of high-energy use in their home and opportunities to optimize or reduce their energy use. Of the 95 California efforts we reviewed, only two use disaggregation technology[38]:

- **SDG&E Residential Load Disaggregation[39]:** SDG&E tested four non-intrusive load monitoring algorithms (NILM) in 11 homes, each offered by a different vendor. The vendors used three different data sources: two Rainforest Gateways that pull Smart Meter data, and Green Button Connect data. Each vendor used its NILM algorithm to make daily predictions of energy usage by specific appliances. To verify the accuracy of their algorithm, the vendors then compared their predictions to appliance survey data. *(ETP funded)*
- **BayREN Residential Behavioral Pilot[40]:** This pilot was a partnership between BayREN, BKi, Home Energy Analytics, and Green Pro Network. The pilot used Smart Meter data to disaggregate participants' energy use into load categories. All participants could view their energy use via an online user interface and received bimonthly emails that included neighbor comparisons and customized recommendations. Some participants received different interventions or messaging based on their load category. For instance, 67 customers in the "high HVAC load" category were recommended to a Home Upgrade Advisor. Another 84 participants in the "high plug load (non-HVAC electricity use)" category received calls to discuss custom actions. The pilot resulted in an estimated 7.4% kWh savings per participant. (*REN program)*

While relatively few efforts in California leverage disaggregation technology, 8 of the 38 vendors we reviewed in California offer disaggregation as a part of their product or service. Of these, only two have any IOU affiliation. As we present in Table 19, most vendors provide disaggregation at the appliance or device level and most access AMI data via GBC or, more commonly, an IHD.

Table 19: California Vendors Using Disaggregation Software

Vendor ID	IOU Affiliation	Data Source				Disaggregation Level
		AMI	IHD*	GBC	Other Utility Data	
1	Yes	Yes	Yes	Yes	No	Appliance/Device
2	No	Yes	Yes	Yes	No	Appliance/Device
3	Yes	Yes	Yes	No	No	Appliance/Device
4	No	No	Yes	No	No	Appliance/Device
5	No	No	Yes	No	No	Appliance/Device
6	No	Yes	No	No	Yes	End-Use
7	No	Yes	Yes	Yes	No	Load
8	No	Yes	No	Yes	No	Load
Total	**2**	**6**	**6**	**4**	**1**	**n/a**

* For example, a HAN gateway, PCT, or monitor.

[38] Some programs that explore a wide variety of emerging technologies may include a review of disaggregation technology, but it is not specifically stated in their program descriptions. Examples include PG&E's Integrated Emerging Technology Program, SCE's Emerging Markets and Technologies Program, and SDG&E's DR Emerging Technologies Program.

[39] NegaWatt Consulting. August 2014. Residential Disaggregation Final Report. Prepared for SDG&E Project ID; ET13SDG1031.

[40] BKi. December 2014. Behavior, Energy, Climate Change Conference (BECC) Presentation: "Bringing it All Together: Design and Evaluation Innovations in the Alameda County Residential Behavior Pilot."

Snapshot: Time Varying Rates and Dynamic Pricing

Time varying rates and dynamic pricing—where the price per kWh changes in near real-time according to the current demand—is a growing strategy employed by program administrators throughout North America. These types of programs are enabled through AMI and have become a central component of some DR programs, as they have been especially effective at reducing demand over certain high usage periods. In this section, we highlight one program that has successfully paired this type of program with other feedback-based intervention strategies.

BGE Smart Energy Rewards

In 2013, BGE launched its Smart Energy Rewards program as part of its effort to educate customers about the deployment of Smart Meters. Participating customers received personalized analysis and information about their energy usage during peak times throughout the summer.

Table 20: Reported Metrics from Time Varying Rates Program

Program	Participants	Expenditures (millions)	Savings		% Savings per Household	
			MWh	MW	MWh	MW
BGE Smart Energy Rewards	315,000	$7.59	16,000	25	N/A	5%-23%*

*5% reflects MW impacts for customers without a direct load control device, while the 23% reflects those with a device.

Program Design: Eligible participants are those who opt in to the program and who have had Smart Meters installed. BGE sets roughly 5–7 event days each summer, coinciding with peak usage. Participants are sent notifications the night before an event asking that they adjust their use during specific times of the following day, after which they will receive on their bill a $1.25 per kWh saved during rebate that period. Prior to the next event, BGE works in conjunction with Opower's Behavioral Demand Response to customize messaging to each participant based on his or her performance over the course of the preceding event day. Based on Opower's analysis, BGE is able to provide customized feedback to each participant to ensure that the maximum amount of savings are realized for each event day.

Intervention Strategies and Program Performance: This innovative approach leverages AMI data in combination with a variety of intervention strategies based on social science research. In addition to energy pricing, the program uses norming strategies and provides participants with a peak-time rebate for each kWh saved over peak periods. Through the program, BGE delivers information about both how much is being saved over the same periods by similar participants in their area and custom actions that they could take to reduce their use. As of the program's launch on July 8, 2013, there were 315,000 participating customers with Smart Meters, which translated into 25 MW of savings. Typically, 82% of the 315,000 customers with Smart Meters received a bill credit in 2013.

Other Examples of Time Varying Rates

In our review, we found other examples of dynamic pricing and time-of-use (TOU) rates being tested throughout North America. TOU is in the process of being piloted in Vermont, Ontario, and Nevada, and a recent decision in Massachusetts[41] has paved the way for TOU, along with the deployment of AMI. In 2013, the Vermont Energy Investment Corporation, through the Smart Grid Investment Grant, embarked on a 2-year pilot testing a TOU rate on winter peak demand. In Nevada, NV Energy has pared its dynamic pricing rate trial with IHD technology and direct load control. Though still relatively new, and therefore with little reported impacts, employing time varying rates is clearing a growing trend in demand-side programming.

[41] Massachusetts DPU decision 14-04-C. November 5, 2014.

7. Fostering a Competitive Marketplace

In this chapter, we discuss opportunities to foster a competitive market for residential behavior feedback programs, outlining some of the barriers that currently exist, as well as recommendations for encouraging both ratepayer-funded and market-driven options. Overall, we found that:

- Current market adoption is low for technologies that enable residential behavior feedback efforts
- There is a complex vendor market for smart devices, products, and services
- Vendors encounter barriers entering IOU programs, particularly regarding the amount of time to enter a program
- Vendors also encounter barriers to accessing AMI data

As we discuss below, there is low market adoption for technologies that enable feedback to customers to reduce their energy consumption. The ability of the CPUC and IOUs to foster a robust marketplace for residential feedback efforts relies on three levers: 1) ensuring that access to AMI data (via GBC) is readily available in the market, 2) enhancing processes for building partnerships with IOUs, and 3) determining an approach to shortening the timeline for introduction into the EE portfolio that aligns with the vendors offering these products and services. Absent intervention, it is highly possible that the state could not reach the full potential of behavior feedback efforts or that the full potential would take much longer.

7.1. Low Market Adoption for Technologies that Enable Feedback

Market adoption is low for technologies that enable residential behavior feedback.[42] These technologies include, among others, HANs, IHDs, and smart thermostats. Customers who adopt these enabling technologies generally represent early adopters, who typically opt in to a given program.

There are two types of behavior programs: opt in and opt out. Most EE programs are "opt in" (meaning the program relies on marketing to encourage a customer to participate), yet opt out efforts can easily include many more participants with an intervention that a program can apply cost-effectively across full populations. The current California behavior program, the HER program, that the IOUs offer to approximately 1.5 million (or 10%) of California residential customers as of 2014 is an opt out program.[43] However, 75 of the 83 (90%) IOU efforts represent opt in programs, where, in some cases, technology adoption is required for participation (e.g., purchasing and installing a smart thermostat, HAN, or IHD). The need for a customer to purchase and install a device that is emerging in the marketplace sets additional barriers for participation.

Table 21 provides an example of the low customer adoption of a specific opt in technology (HAN) from 2012 through 2014 as reported in the SGDP Annual Updates.[44] With close to 10 million residential households in the IOU service territories, the number of customers adopting these technologies represents an extremely small proportion of residential customers (fewer than 1%). However, there appears to be potential for significantly more installing one other type of technology, smart thermostats. A "back of the envelope" analysis

[42] Pacific Gas & Electric, Characterization and Potential of Home Energy Management (HEM) Technology, January 20, 2015.

[43] Source: 2015 Potential & Goals Study estimate.

[44] Smart Grid Deployment Plan Annual Updates; Customer/Advanced Metering Infrastructure Metrics 4.

indicates that approximately 2 million households have homes with gas furnaces and nonprogrammable thermostats, while 4.5 million have homes with central air conditioning and a nonprogrammable thermostat.[45] However, given current data tracking, we cannot provide an estimate of the total number of residential customers who have installed a smart thermostat through an IOU program.

Table 21: Home Area Network or Comparable Technology Adoption

IOU	Number of Customers		
	2012	2013	2014
PG&E (Residential Only)	77	361	799
SCE (All Customers)*	0	138	567
SDG&E (Residential Only)	1,008	1,243	4,114

* SCE does not provide data on this metric by customer type.

Source: Smart Grid Deployment Plan Annual Updates; Customer/Advanced Metering Infrastructure Metrics 4.

Interviewed vendors indicate that the value proposition for the customer remains unclear. Vendors noted that oftentimes the selling point for smart devices is automation, convenience, or security, rather than energy savings, and that bundled marketing and education may be a better approach to increasing enrollment in programs. [46]

7.2. Residential Behavior Feedback Vendors Represent a Complex Market for Smart Devices, Products, and Services

There is a proliferation of vendors who offer behavior feedback products and services both within and outside of ratepayer-funded programs, many of which leverage AMI data. To help understand the trends in the marketplace, our team interviewed 16 vendors with residential behavior products and services in California and asked about key barriers and challenges, such as low market adoption, as well as opportunities to foster and develop these efforts within the California regulatory context. We identified these vendors through a

[45] CPUC, WO21: Residential On-site Study: California Lighting and Appliance Saturation Study (CLASS 2012). KEMA, Inc., November 2014.

[46] The State of California recently introduced bill AB 793 "Energy Management Technology," which proposes an energy management technology marketing campaign (targeting residential and small commercial customers) with a complementary incentive program for supporting devices. This legislation may affect future efforts. Notably, this bill has not been signed into law and as such if passed may include significant revisions. This bill seeks to support customer access to real-time or near real-time information through education and awareness, as well as to reduce the price for these technologies, to have customers make informed decisions about their energy usage, and ultimately to realize some of the customer engagement benefits from Smart Meter installations. This effort may support future adoption of technologies by reducing price barriers and increasing awareness of these technologies. However, the value proposition for these technologies, and the confirmation that providing energy consumption information leads to energy savings, still needs to be tested. Assembly Bill 793 would require IOUs to implement a plan to educate their residential and small business customers about the ability to ascertain their real-time or near real-time energy use data using energy management technologies in conjunction with their advanced or "smart" meter. Additionally, the bill would require the IOUs to implement a rebate program to reimburse residential or small business customers who purchase energy management technologies, such as an energy monitoring device, for use in their home or place of business. Lastly, AB 793 would add energy management technologies as an eligible energy conservation measure under the home weatherization program.

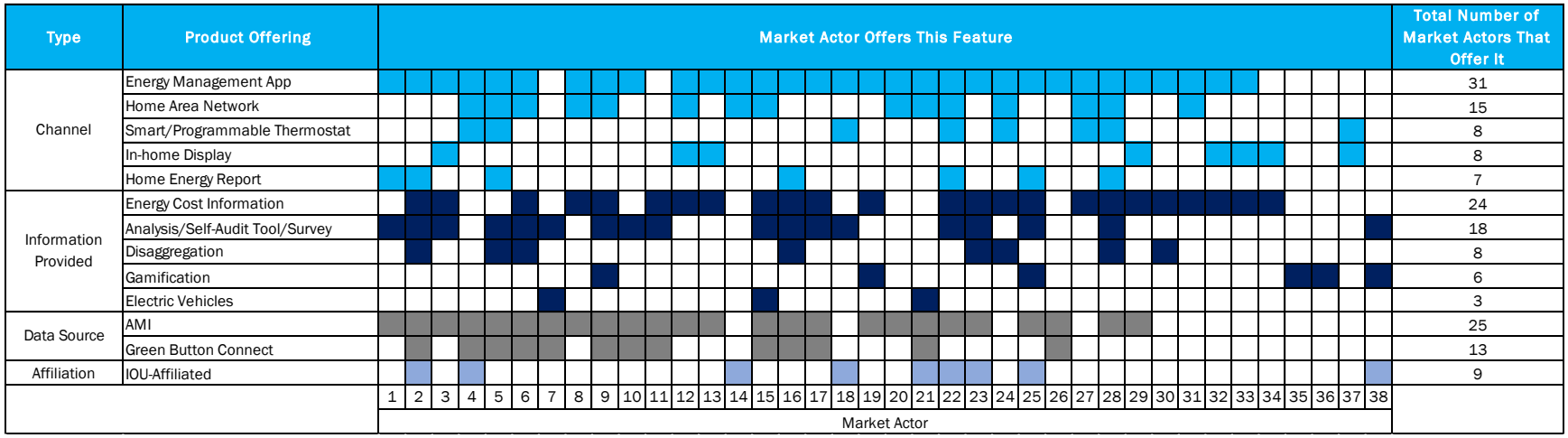
convenience sample[47] of vendors who offer products and services in California. Given our sampling approach, these results are not a comprehensive characterization of the vendor market and are not generalizable to all vendors operating in the market.

Figure 13 provides a summary of the 38 vendor products and services offered in California both through IOU programs or directly to customers in the marketplace.[48] Vendors offer an array of products and services to California customers, including gamification, disaggregation software, smart thermostats, and home energy management applications. Additionally, vendors typically bundle multiple offerings within their product (e.g., provide an energy management application with a smart thermostat). Vendors can send information to customers through multiple channels; some are hardware-based (IHDs, HANs, thermostats), while others are software-based, such as disaggregation and mobile applications. Through these channels, vendors provide a wide array of feedback information, including energy use by end uses (though disaggregation), energy costs, and customized tips and recommendations. The largest share of offerings incorporate energy management applications, followed by HAN.

[47] A nonprobability sampling technique where subjects are identified based on convenience. For this sample, it was based on identified vendors in the market place via a web search and other interviews.

[48] Many of these vendors operate both within California and across the United States.

Figure 13: California Vendor Offerings (n=38)

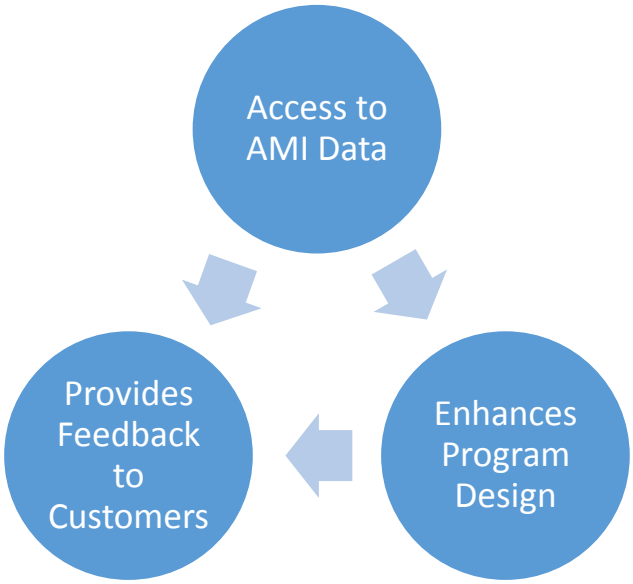


Our review indicates that there is a competitive marketplace for residential behavior products and services, with vendors seeing a value proposition to bringing energy information to customers. However, it is a nascent and fast-moving market with vendor entry and exit occurring quickly, especially for software-based options. Overall, vendor products and services tend to cover the same breadth and depth of IOU program offerings (and in many cases, they are one and the same). Further, many vendor services provide feedback through accessing and leveraging AMI data from the IOUs. Venders acknowledge low market adoption for enabling technologies and programs and services, and, in many cases, vendors seek to reduce low market adoption through access to IOU customers via pilots and programs.

7.3. Vendors Encounter Barriers Accessing AMI Data

Providing vendors with access to AMI data provides two benefits: 1) it can help vendors augment program design because they can review the data and gain insights to develop and enhance their offerings, and 2) it provides energy information that can be given as direct feedback to customers that, when coupled with behavior intervention strategies, can reduce energy usage. Figure 14 provides an overview of these benefits.

Figure 14: AMI Data Benefits

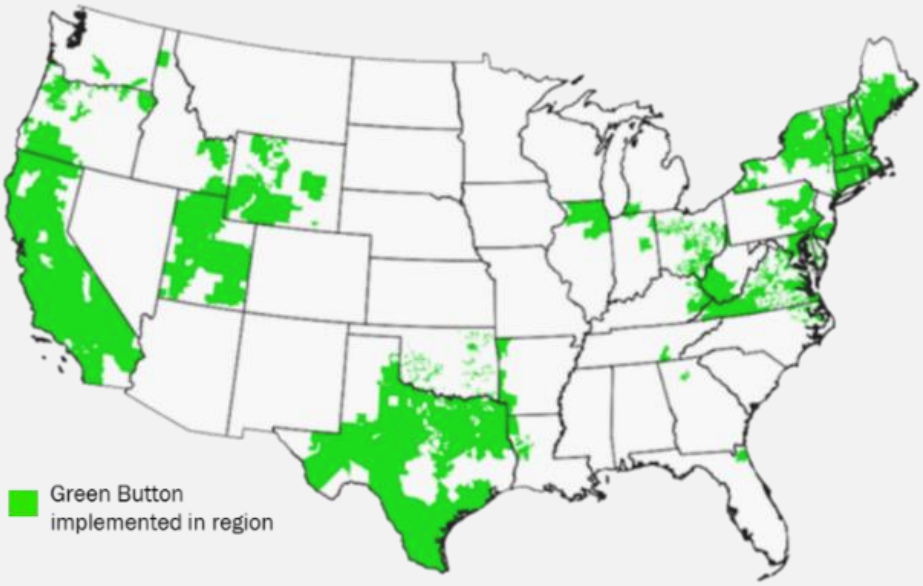


One way that vendors provide real-time or near real-time Smart Meter data to customers is through GBC, an initiative that provides utility customers with the ability to automate the secure transfer of their energy usage data to an authorized vendor. GBC is an offshoot of the original initiative called simply Green Button (GB). Compared to other regions across the country, California is pioneering the use of GB and GBC to provide access to Smart Meter data. Below we provide a snapshot of California's efforts to promote data access through offering GB and GBC.

Overview of Green Button

GB is a nationwide initiative that launched in January 2012. The initiative was in response to the White House call-to-action[49] for utility customers to have easy, secure access to their energy usage information. By clicking on the "Green Button" on their utility's website, customers have instant access to their hourly energy use and cost information.[50] PG&E and SDG&E were the first utilities to commit to implementing GB nationally.[51] Since then, according to the Department of Energy (DOE), 35 utilities and electric suppliers,[52] servicing 36 million households and businesses, have implemented GB.[53] Beyond providing access to energy data, GB also fosters a national industry standard for energy usage data (the Energy Service Provider Interface [ESPI] data standard). This standardization has the potential to enable innovative businesses and software developers to easily integrate these data to create a wide variety of applications to help customers understand and manage their energy use. Figure 15 shows the implementation of GB nationally.

Figure 15: Status of Green Button Implementation



Map Source:
http://en.openei.org/wiki/Green_Button#Green_Button_Utility_Participation_Map (last accessed 8/27/14)
Note: Map was last updated in October 2012

[49] http://www.whitehouse.gov/blog/2011/09/15/modeling-green-energy-challenge-after-blue-button.

[50] For an example of a GB report, please visit http://www.greenbuttondata.org/data/1hrLP_32Days.xml.

[51] http://www.whitehouse.gov/blog/2012/01/18/green-button-providing-consumers-access-their-energy-data.

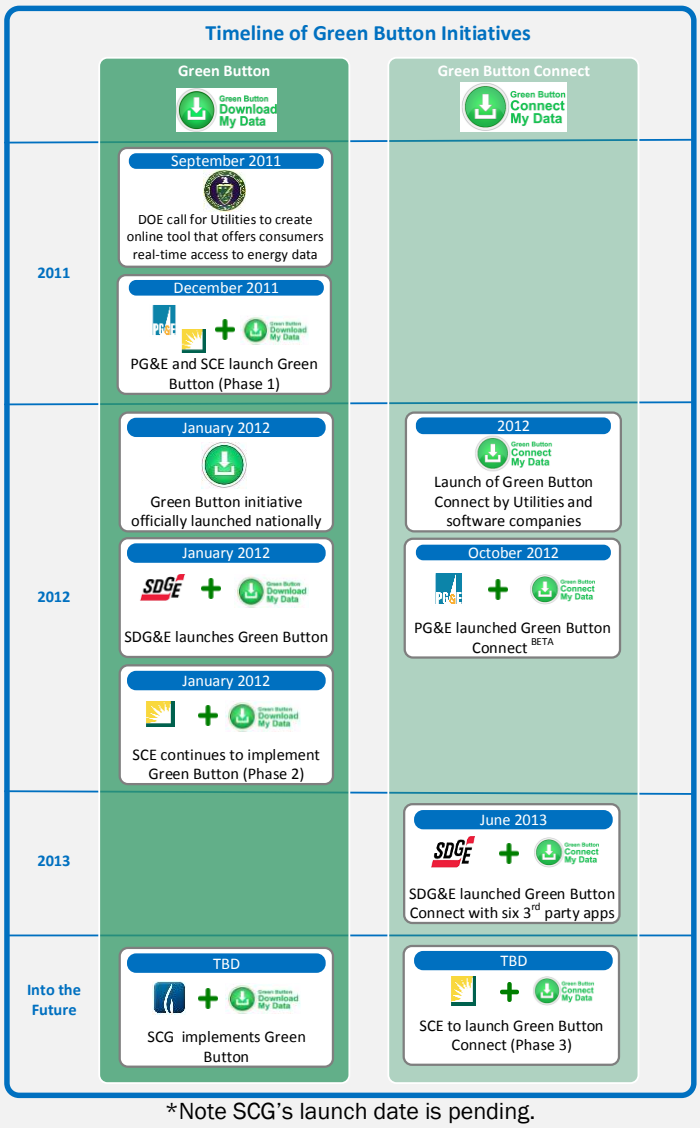
[52] Other sources indicate that as many as 41 utilities/electricity suppliers implement GB nationally; please visit http://greenbuttondata.org/ and http://en.openei.org/wiki/Green_Button#Participating_Green_Button_Utility_Providers for additional list of GB providers. Last accessed 1/27/2015.

[53] http://energy.gov/data/green-button. Last accessed 1/27/2015.

Overview of Green Button Connect

Green Button Connect (GBC) is an offshoot of the GB initiative that provides utility customers the ability to automate the secure transfer of their energy usage data to an authorized market actor. Nationally, 38 companies support or have pledged to support the use of Green Button data to develop market actor applications,[54] and these companies have developed 65 Green Button Connect applications.[55]

Figure 16: California IOU's Progress in Implementing GB and GBC



*Note SCG's launch date is pending.

[54] http://energy.gov/data/green-button. Last accessed 1/27/2015.

[55] http://en.openei.org/apps/?keyword=Green%20Button%20Apps. Last accessed 1/27/2015.

Several vendors stated that GBC provides an opportunity to access energy consumption data to support products and services (e.g., by making it easier for customers to sign up, having a data standard).

> "Green Button [Connect] is a nice way of standardizing the data access." (Vendor)
>
> "It's such great information and you can do so much with it once you have that hourly data." (Vendor)
>
> "Most customers are not motivated to [download Green Button Data]…because they are required to log-in and download it and send it off [to us]. Green Button Connect makes that a little easier because you can do it all in one step." (Vendor)

However, vendors also experienced difficulties accessing AMI data through either GBC or an alternative approach (e.g., hardware attached to meter). Although the use of AMI data within their product or service was common among the interviewed vendors, the use of GBC was much more limited (25 and 13 vendors of 38 total, respectively). This relatively low uptake of GBC may be because the IOUs have been rolling out GBC on a different timeline (e.g., PG&E[56] and SDG&E in 2012 and SCE recently offering open registration to GBC[57]) and have allowed a limited number of vendors to access GBC data. Both PG&E and SDG&E pre-verify a limited set of vendors for access to GBC, while it is unclear whether SCE limits enrollment.[58] SCG has also recently launched GBC.[59]

The interviewed vendors noted a long wait list or substantial effort to become a GBC partner. Vendors also mentioned challenges related to data quality, integrating with IOU systems, and delays in receiving data.

> "Right now we do not use Green Button Connect because it's not deemed revenue quality meter data. So for us Green Button Connect is literally worthless unless we can use it in the ISO market. What the IOUs are saying is that Green Button Connect Data is not even the same data. But if you do the statistical analysis it's within 0.1% of [revenue quality data]…." (Vendor)
>
> "The process for becom[ing] a Green Button Connect [partner] takes a little bit of work…we're on a waiting list and they tell us it's going to be anywhere from 18 months to 30 months. And that's a long time in our world [as a software company]." (Vendor)

Vendors believe that the IOUs do not market GBC sufficiently and that they cannot easily use GBC within their business models given the small number of individuals who know about it.

[56] According to PG&E's website accessed on 5/6/15, PG&E is no longer accepting vendor applications (http://www.pge.com/en/myhome/myaccount/using/thegreenbutton/connectapi/index.page)

[57] Website last visited 5/6/15 (https://www.sce.com/wps/portal/home/partners/partnerships/thirdpartylandingpage/).

[58] Notably, PG&E has shifted from its beta version in March 2015 to "Share My Data", which is available to all vendors.

[59] Based on conversations with SCG staff. Current launch date is unknown.

> "We have de-emphasized our Green Button [Connect] efforts because… we realized that Green Button is not a feasible solution because, in our opinion, the utilities are not necessarily marketing it heavily [enough] such that more users sign up and there's more awareness…it [Green Button Connect] is not very scalable…not very easy to monetize on. [The problem is] the very small level of participation you'll get from the customer base." (Vendor)

Vendors indicated that access to data and privacy concerns are driving companies to identify workarounds to using utility-provided data (specifically AMI data). Many vendors expressed that they or other companies have developed alternative approaches to collecting home energy consumption data (e.g., deploying sensors within homes, widgets that can be installed on Smart Meters) to get around some of these concerns.

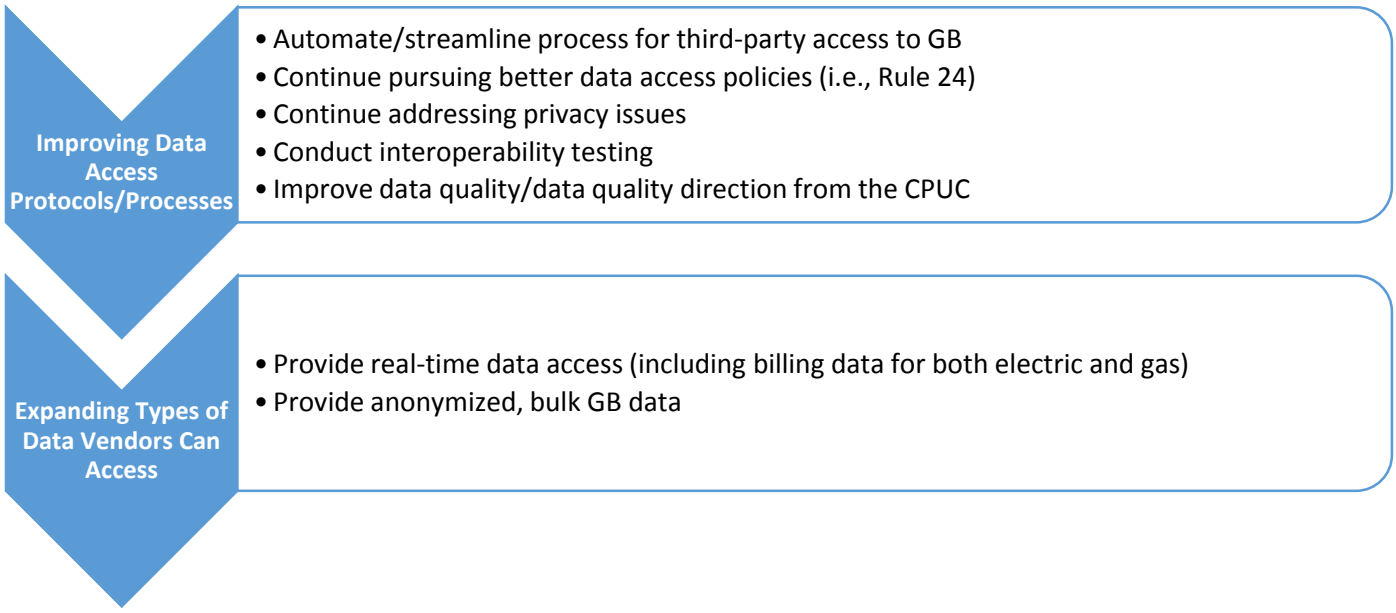
> "Regulation is not keeping up to speed with the development of technology that is making its way to consumer hands via the adoption of Smart Home solutions." (Vendor)
>
> "Increasingly, especially as companies…are facing barriers in states other than California and they are developing workarounds to the Smart Meter… I think there's a really strong chance that those products are going to continue to get better and get cheaper to the point where the AMI network…I don't know that it will become irrelevant but there might be other pathways. I would advise the Commission…to get ahead of that curve…to ensure that the AMI investment does not become irrelevant. " (Vendor)

Given these barriers, vendors recommended:

- **Improving Data Access Protocols/Processes**—continue to adopt policies and processes that make accessing AMI data easier for vendors
- **Expanding Types of Data Vendors Can Access**—make both gas and electric meter data available to vendors to potentially enhance the analyses, recommendations, and feedback they provide as a part of their services

We outline vendor specific suggestions in Figure 17 below.

Figure 17: Vendor Suggestions for Improving AMI Data Access



The CPUC has taken steps to alleviate many of these barriers. Part of ensuring that GB and GBC are available to provide usage data to customers is to ensure that the data are secure. The CPUC has been working to develop guidance on secure data access in support of leveraging AMI data. In July 2011, the CPUC issued Decision D.11-07-056 on the security and privacy of customer usage data. Within this Decision, the CPUC ordered the IOUs to submit advice letters seeking approval for new Electric Rules setting up procedures for the secure release of customer usage data to third parties (Rule 25 for PG&E, Rule 26 for SCE, and Rule 34 for SDG&E). The IOUs submitted these advice letters in March 2014.[60] In April, several stakeholders filed protests against these advice letters, and the CPUC suspended these Rules and ordered that the IOUs submit amendments to address these protests. PG&E and SDG&E submitted amendments in August 2014, followed by SCE in October 2014.[61] SDG&E and SCE have since received Advice Letters of compliance to Decision D.13-09-025 (November 2014), while PG&E received approval in December 2014 from the CPUC Energy Division.

The CPUC has been working with the California IOUs on finalizing Rules on data security. The new rules, approved by the Energy Division in late 2014 through advice letters, approve the automatic transfer of customer data to eligible third parties after customer authorization. The customer may revoke a vendor's ability to receive his or her data at any time, as can the CPUC if the market actor is deemed ineligible. In an effort to keep customer information secure, the individual IOU Rules also provide reasonable time frames (and other procedures) for third parties to retrieve usage data through a secure server, after which time data will be removed from the server. Finally, the updated Rules provide assurances to third parties that the data will be "revenue quality" and will be retransmitted in the event of billing adjustments—that is, the usage data made available to third parties, and thereby customers, will be of the highest quality and will reflect the most accurate data that the utilities have.

[60] Advice Letters 4378-E (PG&E), 3018-E (SCE), and 2586-E (SDG&E).

[61] Advice Letters 4378-E-A (PG&E), 2586-E-A (SDG&E), and 3018 E-A (SCE).

7.4. Vendors Encounter Barriers Entering IOU Programs

According to vendor interviews, there is a spectrum of engagement levels with the California IOUs. Nine of the 38 vendors partner directly with the IOUs, 3 partner with IOUs and are approved vendors for GBC applications, while another 10 are approved vendors for GBC applications only. However, while vendors must be approved by the IOUs to use GBC data, during interviews several vendors indicated that they did not consider using GBC to be a true partnership with the IOUs. Most vendors leverage AMI data to some extent, while fewer use GBC.

In addition to gaining access to IOU-provided AMI data, vendors noted that there are challenges inherent with engaging with IOUs and entering IOU portfolios. Although several vendors partner with IOU programs (5 of 16 interviewed, and 9 of the 38 identified vendors) by offering pilots to customers, many vendor respondents indicated that there are substantial barriers to participating in the IOU pilot process.[62] These barriers include a limited awareness of how to work with IOUs to develop a pilot, a lack of transparency in terms of how IOUs select vendors for programs, and a disconnect between vendor and utility pilot timelines. Examples of vendor feedback on the long time horizons required to work with the IOUs include:

> "Your [a start-up's] time horizon might be a little different [from the IOUs]…utilities aren't one to move quickly…it tends to be a very long measured, multi-step, multi-party process." (Vendor)
>
> "The sales cycles are pretty long,…and we get piloted to death…What ends up happening is there's a lot of discussion and testing…and things just drag out and you lose your opportunity." (Vendor)
>
> "From a vendor perspective…these bottlenecks and barriers…it's just not worth it. So you see people leave [the IOU partnership space] or you see people not really coming in." (Vendor)

Other examples of vendor feedback on challenges getting into IOU partnerships include:

> "One of the hardest things is to figure out…this entire RFI, RFP process, the annual funding for EE dollars and DR dollars. The truth is, early on, it was really rough to get into that. Now it's a little bit better only because I have the relationships with the IOUs. It's really hard for smaller companies because you just don't have the eyeballs to track that stuff." (Vendor)
>
> "Especially if you're a start-up, when you don't have a track record of delivering programs, it's not easy to deploy your solutions [in partnership with IOUs]…Finding the right pilot for the right type of technology can be very tough, and it's also the most critical thing…because it needs extensive validation before an IOU would consider purchasing your solution." (Vendor)
>
> "Fundamentally, I think there is this culture [at the IOUs] of just being super risk-averse." (Vendor)

In particular for vendors who offer new or emerging technologies, respondents mentioned challenges related to the risk-averse nature of the IOUs. For instance, one vendor mentioned that the IOUs are hesitant to try new technologies that are unique or not easily comparable to others. In other words, the IOUs would rather conduct studies that compare multiple offerings of the same technology (like Bring Your Own Thermostat studies where

[62] Vendors referred to working with the IOUs as pilots or programs; as such we use this terminology in this section.

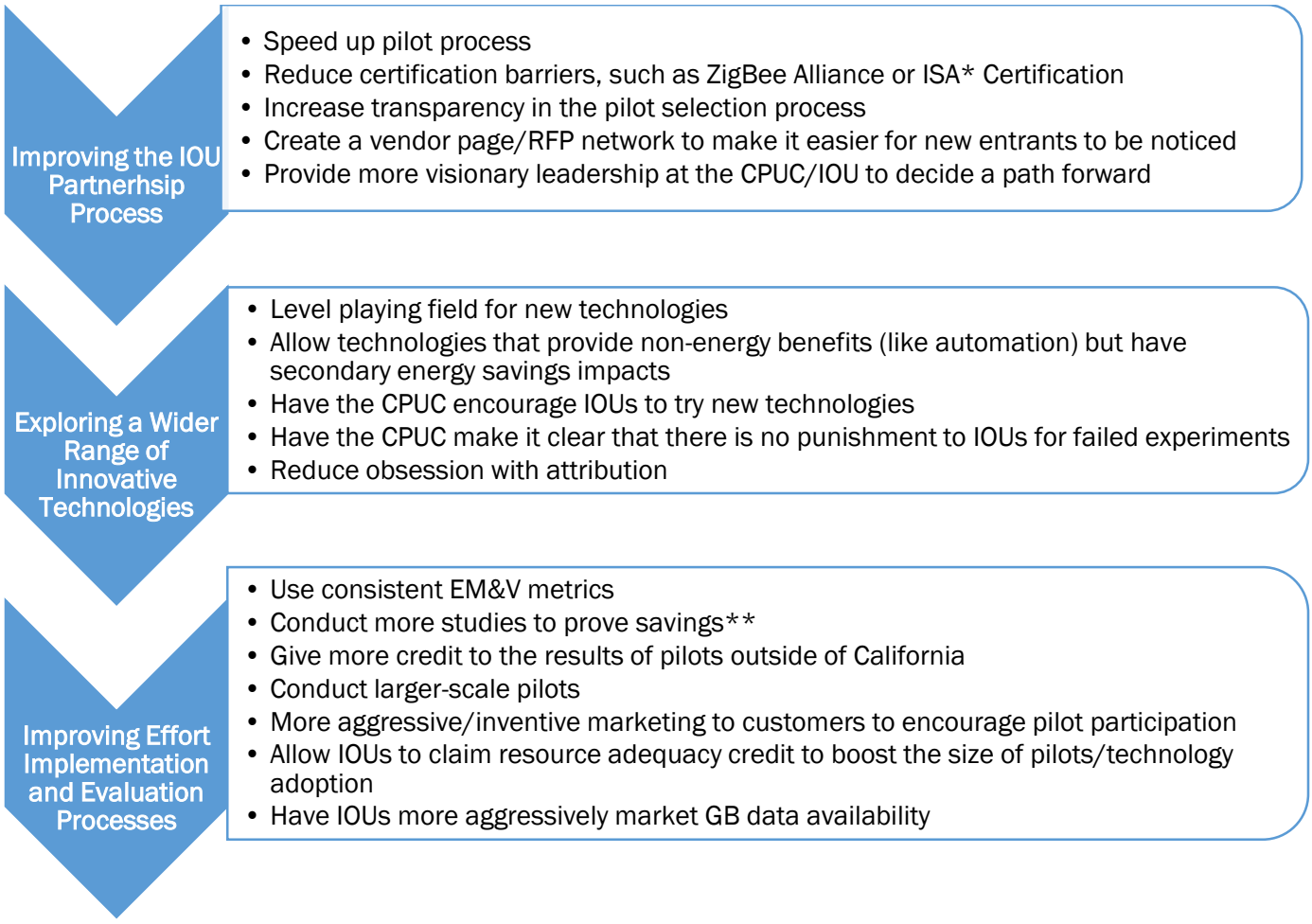
customers select from a range of thermostat devices), as opposed to evaluate single technologies with no alternatives. We acknowledge that the IOUs have limited resources to identify promising measures, and must be careful to not choose winners when working with vendors to offer products and services to customers.

Importantly, partnerships with the IOUs can help to alleviate customer and IOU concerns regarding technology feasibility and savings. Vendors suggested that the IOUs could better support helping new feedback products and services enter the market, and thereby increasing market adoption, by:

- **Improving the IOU Partnership Process**—increasing awareness of opportunities and making processes easier for starting IOU partnerships
- **Exploring a Wider Range of Innovative Technologies**—encouraging the IOUs to incorporate cutting-edge technologies into their efforts
- **Improving Effort Implementation and Evaluation Processes**—helping technologies move out of the trial phase more quickly

We outline specific vendor suggestions in Figure 18 below.

Figure 18: Vendor Suggestions for Improving IOU Partnership Processes



*ISA Certification is Instrumentation, Systems and Automation Society certification: https://www.isa.org/templates/two-column.aspx?pageid=53020#sthash.hmGDfNBU.dpuf
** While this presents a laundry list of vendor suggestions, we acknowledge that vendors are required to provide robust impact values if chosen to partner with the IOUs for efforts that anticipate energy savings.

The vendor recommendations presented above provide a relatively long list of suggestions, some of which the IOUs are currently implementing.

Vendors suggested improving the IOU partnership process, focusing on being aware of potential opportunities, as well as increasing transparency about selection processes. We acknowledge that the IOUs already offer a variety of solicitations and opportunities to engage with the IOUs. For example, the ETP holds an Open Forum four times a year for entrepreneurs to present ideas for inclusion in the ETP or directly in other IOU programs. Additionally, the ETP website (http://www.etcc-ca.com/get-involved) actively solicits new ideas with the ability of entrepreneurs to contact IOU staff through the website. Additionally, TRIP or IDEEA 365 is also available for promising emerging technologies needing assessment and approval, or for existing EE/DR programs or third party implementers to allow the IOUs to try new and innovative third-party approaches.[63] However, vendor recommendations suggest a need for a consolidated space, like the Emerging Technologies Coordinating Council website, to market these opportunities to facilitate greater awareness.

Vendors also suggested exploring a wider range of technologies. Based on our review, there are some effort designs like Bring Your Own Thermostat (as mentioned earlier) that allow the IOUs to test a variety of new technologies for their relative effectiveness.[64] Various technology agnostic models that allow customers to choose from a wide range of technologies and assess use and savings in the field can help facilitate incorporating market-based solutions, as well as limit risk.

Vendors also suggest more aggressive/inventive marketing to customers to encourage participation and broader market adoption. Moving forward, the IOUs could (continue to) incorporate marketing and education tactics to encourage adoption, as well as conduct studies to understand the barriers to program adoption. Currently, the ETP uses a suite of tactics to better understand market adoption, including market and behavioral studies, scaled field placements, and demonstration showcases, to take the temperature of market adoption, as well as to understand barriers and challenges customers or programs might encounter through offering these technologies and services.

Finally, from the pilot/project stage, there are few technologies or services that make it to the point of entering a program. For example, some smart thermostat efforts (as noted in 4.2.2) have in in the piloting stage for up to four years. Even though smart thermostats have been implemented as full-scale efforts within the DR portfolio, many are projects within the ETP program. In addition, many other projects have not been recommended for inclusion in the IOU EE portfolio (see Chapter 4). However, longer timelines may also reflect barriers to entry based on regulatory/administrative needs.

[63] http://www.cpuc.ca.gov/NR/rdonlyres/B37ED730-B2C6-4117-8381-09A4D239D766/0/CPUCWebsiteIdeationCollateral_IOUFinalDraft10172013_clean_links.pdf

[64] Notably, identifying technologies that are tested but that do not achieve claimed savings increases information within the marketplace (an overall benefit to ratepayers). However, because this space is so nascent, testing a variety of technologies, for more than energy-savings benefits, or in relation to existing programmatic efforts, may yield opportunities for future program designs.

8. Realizing AMI Investments and Guiding Future Behavior Efforts

The CPUC tasked the study team to characterize the residential behavior feedback market for two primary reasons:

1) To better understand where California stands in terms of realizing the anticipated benefits from AMI investments, what can be done moving forward to realize expected investments, and what future residential behavior feedback savings potential is for California

2) To support California's strategic EE and DR impacts and emission goals (AB 32) through consideration of targeted future behavioral program offerings.

A market failure occurs when free markets fail to allocate resources efficiently. There are different types of potential market failures, the most relevant are a missing market (there is a failure to meet a need or want for residential behavioral feedback) or an incomplete market (the market fails to produce enough products or services that provide feedback demanded by consumers). Given the information available at this time, there does not appear to be a market failure per se, as much as a lack of consumer demand for the goods within a behavioral feedback market. Generally speaking, the residential behavior market continues to have lower than expected market demand for technologies that leverage AMI data to support energy conservation, as well as a nascent market of vendors seeking to supply products and services. Further, access to AMI data is progressing, but limited with Green Button and Green Button Connect still incompletely implemented across the state. Interventions to support this market should incorporate aspects that seek to raise customer awareness and education of their energy consumption and opportunities to reduce consumption, as well as create opportunities for third party access to data to support developing and offering AMI enabled products and services.

To make future policies regarding behavioral programs, there is a need to better understand the potential for these efforts. As such, there is a need to assure that appropriate data is collected regarding existing and future behavioral feedback efforts. This would improve assumptions and support policy guidance. Collecting additional ongoing information can work as a virtuous cycle, allowing policy makers to make more informed decisions regarding ongoing investments. However, we acknowledge that data tracking requires additional effort on the part of the IOUs, and may not be feasible for all behavioral feedback efforts (such as strategies within a program).

Moving forward, we offer four major initiatives to help California realize AMI benefits and better target behavioral efforts in the future.

8.1. Realizing AMI Benefits

Smart Meter infrastructure investment alone will not realize anticipated benefits; rather, interventions must couple Smart Meter data with behavioral science and products and services to attain these benefits. The Business Cases appear to include an implicit assumption that simply having access to AMI data will inevitably lead to customers taking energy-efficient actions and behavior. While this can occur, programs that leverage behavior intervention strategies and social science insights (such as a call to action, personal relevance, or games inviting customers to engage with their energy consumption, coupled with the provision of AMI data) will support customers in their attempts to save energy, to go deeper, or to persist in terms of their engagement with energy-saving practices.

The benefits anticipated in the business cases and Smart Meter deployment plans, while not zero, cannot be well quantified. The current IOU California residential behavior feedback efforts have limited gaps and reach a large number of customers, with room to grow. The 83 identified 2013–2014 IOU-administered behavior feedback efforts cover over 8 million residential customers. These represent a few efforts that cover a large number of participants (e.g., DR efforts[65] and the HER program, which are typically opt out efforts). However, most of the 83 efforts are targeted, smaller-scale efforts with low market adoption.

Initiative #1: Improve data quality of behavior feedback efforts and associated benefits

Our team was unable to draw comprehensive conclusions regarding the achievements made and anticipated benefits given the current data availability. Given current data tracking (as described in Chapter 5), our study team and CPUC staff are unable to:

- Match budgets to impacts (and determine the cost-effectiveness of potential programs)
- Align impacts with offering type or intervention strategies
- Assess potential market penetration for efforts
- Assess whether efforts are on track to realize anticipated benefits of AMI investment
- Draw conclusions about future potential

This study was unable to answer several research questions posed by CPUC staff due to this paucity of data. We acknowledge that tracking behavioral feedback efforts is challenging given that they comprise a variety of efforts (pilots, programs, sub-activities, and projects) as well as are oftentimes considered strategies within a program that if tracked could lead to double-counting savings. These challenges underlie a need to better define a behavioral program (see section 8.2) Limited and poor data tracking hampers the ability to prioritize future efforts, as well as limits the ability to determine whether existing programs will realize anticipated benefits of AMI investments. Without high-quality data, CPUC staff are limited to anecdotal information when creating policy options or performing regulatory oversight. Tracking should start with standalone pilot, program, and projects, not necessarily strategies within existing programs that are already captured through other tracking efforts or those that do not purport to achieve impacts.

- **Recommendation: The IOUs should make improvements to data tracking, including units, reporting requirements, and timing, to support management and oversight over time**. There is limited information regarding participation, expenditures, impacts, or other benefits, both within and across funding streams. IOUs should coordinate to propose harmonized tracking metrics across behavior efforts and funding streams and propose these to the CPUC. This would be the most expedient way to improvements in this area. At a later date the CPUC could confirm these IOU proposals and/or provide additional guidance requiring the IOUs to track program costs and impacts and other indicators in specific ways We recommend tracking the following:
  - **Define the universe of AMI and behavior efforts and flag accordingly:** To better understand benefits that have accrued and oversee future efforts, the IOUs could propose to the CPUC definitions of the universe of interest (e.g., programs that leverage AMI data, programs that offer behavior feedback). Once defined, we recommend creating a flag for an effort that would indicate the efforts

[65] All time-of-use rates in our scope include feedback efforts (such as alerts) on top of the rates themselves.

that leverage AMI data or provide behavior feedback to allow for tracking of potential benefits enabled through smart grid deployment.

- **Program budgets and expenditures:** Includes effort-specific budgets and expenditures, rather than behavior feedback efforts incorporated within a program.
- **Program objectives:** Includes a brief program design description (1-2 sentences) as well as describe the objectives for the effort via selecting specific categories provided in a tracking document (i.e., energy savings, promotion of other DSM programs, increased knowledge of energy management strategies, etc.).
- **Program engagement**: Provides program participation levels, as well as describe whether the program design was opt in or opt out.
- **Energy impacts**: Includes specific information regarding energy savings, demand impacts, or GHG emissions reductions that resulted from the intervention on an annual basis.
- **Other indicators**: These interim indicators may suggest future energy-saving benefits (e.g., web analytics, actions recommended or taken, programs promoted).
- **Tracking over time:** The IOUs should consider developing a dashboard that shows success over time, to assess the value of each program, and how they perform relative to each other since any prioritization or decision about potential efforts would need to be reviewed over time, as a longitudinal study. Again, this could be submitted to the CPUC, and confirmed or further guidance provided at a later time. Additionally, the CPUC could consider setting up an annual meeting where IOU staff present to the CPUC oversight group (see recommendation below) the variables suggested above to document the value of these efforts.

Notably, many of these metrics would need standardization to compare across efforts (e.g., providing annual expenditures coupled with annual savings impacts that use the same units). For example, we have found that when metrics are tracked, savings have been shown as a percent per household, as a percent per square foot, as an absolute savings value, etc.

Initiative #2: Improve the ability of CPUC staff to assess and prioritize behavior feedback efforts across funding streams

As shown through our review of the 2013–2014 California residential behavior feedback efforts, funding spreads across multiple sources with differing reporting requirements and cost-effectiveness calculations. While this is not a problem per se, the dispersion causes difficulty when attempting to oversee California residential behavior feedback efforts and hampers the CPUC and a program administrator's ability to determine if the same interventions are receiving overlapping funding.

One of the objectives of this review is to identify potential funding overlaps between AMI-funded Smart Grid projects across multiple years and across funding streams (e.g., AMI-, EE-, DR-funded projects), as well as differences in cost-effectiveness calculations. Since this study focuses on providing information to help in future CPUC decisions, it is important to determine whether the Smart Grid efforts are double-counting benefits and/or undercounting costs.

Based on the business cases, the IOUs have estimated over $1 billion in benefits from customer engagement efforts. Based on the SGDPs, the IOUs estimated up to $1.4 billion in benefits.[66] Given the information available, we cannot determine which funding sources were approved as additional (incremental) benefits, beyond the investments made in grid infrastructure. For example, AMI-funded Smart Grid projects reflect costs projected in the AMI business case decisions, while other funding sources reflect incremental costs to support realizing the benefits of providing customer access to AMI data (via customer engagement efforts). If this is the case, any projects funded outside of AMI are in addition to the approved cost-benefit ratios determined in these business cases. However, the available reporting does not make this distinction clear. AMI reporting (SGDPs) has the least granularity and spottiest data across various funding stream reports. The Smart Grid Annual Reports seek to capture any AMI-related effort, but do not consistently track needed metrics to provide policy guidance.

Given limited transparency from available reports, we also cannot state if the IOUs have accounted for benefits across more than one funding source. In other words, for IOU-funded projects through non-AMI funding streams, such as DR or EE, it is not clear whether their benefits accrue to the non-AMI funding source or both AMI and non-AMI streams, or if the benefits from the projects were counted under the original AMI benefits. If they accrue to both DR and EE funding streams, there is potential for double-counting of benefits across funding streams, as would any project with benefits associated with the original AMI funding that are now funded elsewhere.

There is also substantial variation across the IOUs and funding streams in terms of the cost-benefit inputs and assumptions employed. This variation prevents the CPUC from making apples-to-apples comparisons of the IOUs' respective cost-effectiveness of behavior feedback efforts. We note that under the integrated demand-side management (IDSM) effort, there is work under way to better understand differences in cost-effectiveness calculations across the different groups.

Our review did not identify evidence of double-counting of benefits across funding streams. However, we are unable to verify that no double-counting occurs given the limited data and reporting requirements. Given the current reporting, we note that it would be difficult to manage and oversee projects to ensure that double-counting and potential program redundancies do not occur.

- **Recommendation: Integrate oversight of residential behavior feedback programs.** The CPUC and the IOUs should consider centralizing oversight, across the various funding streams. The CPUC should establish centralized regulatory guidance to better understand value, track achievements, and identify potential redundancies. We assume that if guidance is given from a single regulatory "voice," it will allow the CPUC to set tracking requirements to effectively follow all efforts with fewer required resources. IDSM may be a natural space for establishing program oversight as it cuts across various funding sources and organizations within the IOU, as well as focuses on customer engagement. Conversely, a behavior oversight group tasked with setting reporting requirements, and reviewing initiatives at a holistic level, could also serve this function. The oversight group should incorporate relevant stakeholders as needed. The Integrated Demand Side Resource Programs Proceeding may be one possible area, subject to review.

- **Recommendation: Make improvements to data tracking across funding streams.** Despite limited evidence of program overlap or redundancy across funding streams, the current reporting requirements limit the ability to oversee and manage efforts strategically. Because there are many efforts offered across organizational teams, it might be difficult for program regulators or

[66] Based on the data we reviewed, it is unclear if these two amounts are cumulative or if they should be summed for a total of up to $2.4 billion in benefits.

administrators to effectively prioritize program efforts and minimize double-counting of benefits, especially if ongoing communication is limited across funding streams and rulemakings. As such, future reporting would benefit from enhanced tracking requirements to support accounting for, and allocating, costs and benefits appropriately, to better inform cost-effective choices for future efforts. We recommend that, barring systematic tracking across all funding streams, that the IOUs incorporate a flag to indicate that the program is behavioral and leverages AMI data (see Initiative #3 below). This system, once in place, could then be applied across funding streams.

- **Recommendation: Coordinate cost-effectiveness across different funding streams.** In addition to establishing a regulatory guidance oversight group, we recommend that the CPUC consider developing some framework for understanding differences in inputs and assumptions for cost-effectiveness across efforts in EE, DR, and AMI funding streams. Greater requirements for tracking costs and benefits from residential behavior feedback efforts would support greater understanding of the benefits realized to date, and serve to inform future prioritization of projects. This will support rationalizing and prioritizing efforts moving forward, and allow the CPUC to make comparisons across efforts.[67]

Initiative #3: Reduce vendor barriers

A competitive market is in place for residential behavior feedback products, and vendors report a clear value proposition to bringing energy information to customers. However, it is a nascent and fast-moving market with vendor entry and exit occurring quickly, especially for software-based options.

We found that vendors reported difficulties accessing AMI data, engaging with the IOUs, and trying to comply with timelines associated with entering the IOU portfolio of programs. Without providing an environment whereby vendors are able to access and leverage AMI data or operate within the IOU space, the benefits of AMI investments may not be realized or captured.

The CPUC continues to make efforts to reduce existing barriers to open data access, specifically related to Decision D.11-07-056 and subsequent Electric Rules[68] to create procedures for the secure release of customer usage data to third parties. However, vendors indicated that access to and privacy concerns related to AMI data are driving vendors to identify workarounds to using utility-provided data. Many vendors expressed that they or other companies have developed alternative approaches to collecting home energy consumption data (e.g., deploying sensors within homes, widgets that can be installed on Smart Meters) to get around some of these concerns.

Vendors also noted that there are challenges inherent with engaging with IOUs and entering IOU portfolios. These barriers include a limited awareness of how to work with IOUs to develop a partnership, a lack of transparency in terms of how IOUs select vendors for programs, and a disconnect between vendor and utility

[67] The cost-effectiveness methodology for behavior feedback efforts may be informed by the outcome of several other Commission proceedings where cost effectiveness is being considered. These include: (1) the Integrated Demand-Side Resource Programs (IDSR) OIR (R.14-10-003); (2) the Demand Response OIR (R.13-09-001) (draft methodology issued); (3) the Energy Efficiency OIR (R.13-11-005) (cost-effectiveness identified as a phase 3 issue); (4) and potentially other proceedings.

[68] These Rules and CPUC D.14-05-016 "Decision Adopting Rules to Provide Access to Energy Usage and Usage-related Data while Protecting Privacy of Personal Data," discuss approaches to how AMI data should be transferred in accordance with current data privacy regulatory frameworks, rules and regulations, to ensure protection of customer privacy.

timelines. We acknowledge that the IOUs have limited funding and must be careful to not choose winners when working with vendors to offer products and services to customers.

The ability of the CPUC and IOUs to foster a robust marketplace for residential feedback efforts relies on three levers: 1) ensuring that access to AMI data (via GBC) is readily available in the market, 2) enhancing processes for building partnerships with IOUs, and 3) determining an approach to shortening the timeline for introduction into the EE portfolio that aligns with the vendors offering these products and services. Absent intervention, it is highly possible that the state could not reach the full potential of behavioral feedback efforts or that the full potential would take much longer.

- **Recommendation: Ensure that AMI data (via GBC) is readily available in the market.** We recommend that the IOUs, with CPUC involvement when feasible, continue to work to support access to AMI data through GBC or other avenues. In particular, we suggest that the IOUs ensure that entry to GBC is available and easy to access for vendors, and that the CPUC monitor the number of GBC vendors across the IOUs as a proxy for engagement and open access.

- **Recommendation: Expand and consolidate marketing of current IOU/vendor partnership opportunities.** We recommend that the IOUs continue to consider opportunities to build partnerships with vendors, including broadening their marketing of the Emerging Technologies Open Forum, Emerging Technologies Summit, and other solicitation efforts (such as IDEA 365) that allow vendors to participate in describing their technology/product, and gain access to ETP and third-party program staff. In terms of exploring a wider range of technologies, various technology agnostic models that allow customers to choose from a wide range of technologies and assess use and savings in the field can help facilitate incorporating market-based solutions.

- **Recommendation: Determine an approach to shortening the timeline for introducing behavior feedback products and services into the demand-side management (DSM) portfolio**. We recommend that the IOUs, with CPUC involvement when feasible, work with interested stakeholders to identify opportunities and develop an approach to shorten the timeline for DSM program entry, particularly for software vendors, given their shortened time horizons. Our prior recommendations can help shorten timelines for DSM integration, such as ensuring entry to GBC as well as broadening exposure to solicitations to enter third-party and ETP programs and projects. Additionally, the IOUs should consider if it is feasible to create a fast-track review process for vendors with shorter time horizons to get to market. Further, we acknowledge that moving to a rolling portfolio cycle could potentially alleviate some of the aforementioned barriers, particularly lengthy timelines to DSM portfolio integration. IOUs should report on their progress on this activity to the CPUC within a year.

In addition to behavior feedback efforts offered through IOU programs, vendors will likely continue to offer products and services directly to consumers in California. As additional vendors leverage AMI data outside of IOU programs (through GBC), it will be important to understand the benefits that accrue outside of IOU programs but that are facilitated by access to AMI data. We recommend that the CPUC conduct a future study to understand, and potentially capture, these potential benefits. We recommend conducting this study when sufficient vendors who operate outside IOU programs leverage Smart Meter data supported through infrastructure investments captured within the Smart Grid proceeding.

8.2. Guiding Future Behavior Efforts

Currently, California does not fully realize the value of efforts given the current EE PGS framework. As noted earlier, this study seeks to understand how residential behavior feedback programs can support California's

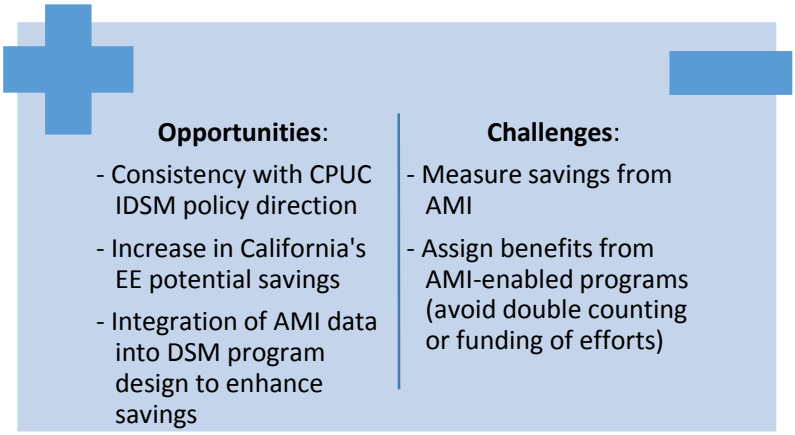
strategic EE impacts and emission goals. An important first step is to forecast the potential for feedback efforts.

Our review indicates that it is difficult to realize the value of these offerings because currently there is no framework for feedback efforts to be incorporated within the PGS. Currently, the PGS incorporates benefits only from the HER program. The HER program represents substantial savings potential, but other program types could theoretically contribute additional benefits that are not captured in the 2013 PGS study.[69] Since the CPUC uses the PGS to set future goals and targets, if the potential from additional behavior feedback efforts are not incorporated within the PGS, these types of offerings may not be considered for the portfolio moving forward.

While including more behavior feedback efforts sounds relatively straightforward, it is not. Our team convened a meeting with four CPUC staff involved with EE, DR, AMI, and the PGS to discuss opportunities and challenges of incorporating savings from AMI-enabled devices and behavior feedback efforts within future PGS efforts (see Figure 19).

This figure summarizes detailed results documented in Volume II: Appendix E.

Figure 19: Opportunities and Challenges to Incorporating Behavior Efforts in the PGS



Initiative #4: Expand definition and create framework for PGS

As per CPUC Decision D.12-05-015, the minimum definition and description of implementing and measuring behavior programs includes: 1) comparative energy usage and disclosure, 2) ex post measurement, 3) experimental design, and 4) 5% target for residential households by 2014. The CPUC and IOUs are in the process of considering how future behavior programs can support California's EE and DR goals in developing a straw proposal for defining and setting parameters for EE behavior programs for 2015–2017. Currently, the 2013 PGS[70] incorporates one behavior-based program: the feedback-based HER program. The study excluded savings from other efforts, such as AMI-enabled behavior programs and DR initiatives.

[69] The study authors and CPUC staff are aware of these limitations to the PGS and plan to incorporate additional behavior-based savings in the next PGS, where possible. Opinion Dynamics is member of the newly scoped PGS and will bring our knowledge to support improving the behavior component.

[70] Navigant Consulting and Heschong Mahone Group. March 2012. Analysis to Update Energy Efficiency Potential, Goals, and Targets for 2013 and Beyond.

As we mentioned above, given the current definition of behavior, there is no framework in place to capture and determine the potential energy impacts from other behavior efforts.

- **Recommendation: Continue to redefine and broaden behavior definition**. For the CPUC to count residential feedback efforts as California attempts to meet ambitious GHG and EE goals, they must broaden their definition of behavior programs. The IOU straw proposal represents a first step toward broadening behavior program scope. The IOUs should formally propose this definition in the EE Rulemaking for CPUC consideration. Additionally, we recommend that the behavior oversight group (recommended in Section 8.1) support efforts to redefine the behavior definition.

- **Recommendation: Develop a framework to capture residential behavior feedback programs in the EE PGS based on the new definition.** The CPUC currently incorporates only one behavioral program, the HER program, within the PGS model for determining savings potential. However, the PGS has a large role to fill as it provides assessments of savings potential to help the CPUC frame and choose EE goals to meet CPUC policy objectives. Incorporating residential behavior feedback savings could potentially support realizing many of the customer empowerment and engagement benefits explicated in the AMI business case decisions and SGDPs. Additionally, integrating these projects into future planning and goals could also support enhancing quantification of anticipated benefits and results from these efforts, as they would require greater measurement and evaluation. Performing these activities, though, is not straightforward and requires collaboration. We recommend that the behavior oversight group (recommended in Section 8.1) work with PGS evaluators to determine approaches to using consistent assumptions across funding streams, rationalize cost-effectiveness assumptions, and ensure that comparisons across activities are equivalent.

- **Recommendation: Continue to conduct efforts to understand the benefits of residential behavior feedback to inform PGS specifics.** Currently, there is insufficient information tracked to comprehensively understand and verify the benefits or savings potential of residential behavior feedback efforts. Consistent with the IOUs' current approach, pilots and initiatives under behavior programs are an effective approach to rolling out alternative or innovative strategies to garner savings, given that they do not need to achieve cost-effective savings or that they can be folded into program-level cost-effectiveness. Insights from vendors, CPUC and IOUs suggest that technology agnostic efforts with a strategic focus that build on prior results are a good framework for capturing additional information regarding these efforts. As behavior initiatives continue to be offered and evaluated, greater evidence will be available to support prioritizing and scaling programs that leverage behavior intervention strategies. We recommend that the IOUs consistently track efforts moving forward, in line with the data categories recommended earlier to garner greater insights from existing and future efforts.

- **Recommendation: Coordinate with the DR PGS**. The California Energy Efficiency Strategic Plan recognizes the integration of DSM options, including EE, DR, and distributed generation (DG), as fundamental to achieving California's strategic energy goals.[71] Additionally, the DR team is working to develop a PGS with Lawrence Berkeley National Laboratory. As such, we recommend that these groups work together and collaborate across disciplines to better integrate planning efforts to realize the potential benefits from these efforts across these groups. While it may take time to implement, if the CPUC were to create a single potential study that incorporates all aspects of EE, DR, and DG, such a

[71] Integrated Demand Side Management Program (2013-2014) Fact Sheet: http://www.cpuc.ca.gov/NR/rdonlyres/1A990EF9-1D4F-4BE4-9B3E-0B8DE4700726/0/201314IDSMProgramFactSheet.pdf.

tool could facilitate tradeoffs between the three areas as well as synergies. We recommend the CPUC work with stakeholders to identify the benefits and challenges of integrating these studies.

This concludes our study of the PY2013-2014 California Energy Efficiency and Demand Response Residential Behavior Market Characterization. Volume II of the report includes the following appendices:

- Appendix A: Detailed Evaluation Methods
- Appendix B: Study Research Questions
- Appendix C: Definitions of Product Offerings
- Appendix D: Data Cleaning and Assumptions
- Appendix E: Smart Grid Memo
- Appendix F: Data Sources
- Appendix G: IOU Comments on Study Report

For more information, please contact:

Olivia Patterson
Behavioral Research Manager

510 444 5050 tel
510 444 5222 fax
opatterson@opiniondynamics.com

1999 Harrison St.
Suite 1420
Oakland, CA 94612