



Together, Building
a Better California

DRAFT

Energy Efficiency Business Plan

Residential Sector Chapter

Draft – October 18, 2016

PG&E Residential Sector Business Plan - *Draft*

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Residential

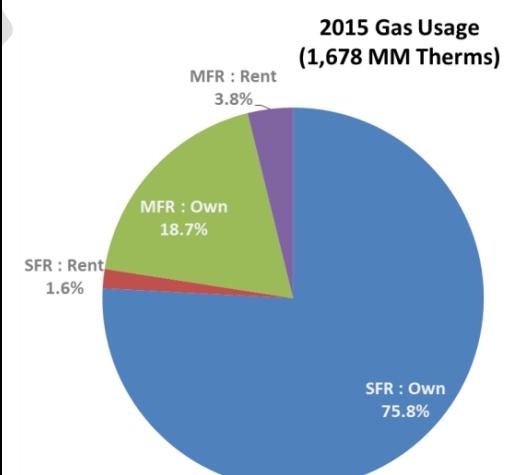
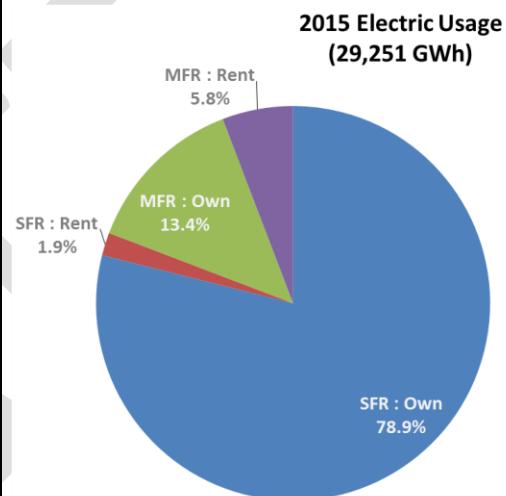
Customers by the Numbers¹

	2011-2015 Average	2015 Trend ^a	2015 Total
Customer Counts (Number of customers)^b			
Electric	5,620,511		5,613,246
Gas	5,037,188		5,012,720
Total	6,643,703		6,634,733
Annual Sales (GWh, MM Therms)			
Electric	30,409.6		29,251.3
Gas	1,891.6		1,678.0
Energy Savings (GWh, MW, MM Therms)			
Electric	50.5		57.5
Demand	21.6		24.2
Gas	2.1		1.3
Program Participation (% of total)			
Electric	2.1%		1.7%
Demand	2.1%		1.7%
Gas	0.2%		0.1%
Segment Program Participation (% of segment)			
Electric (GWh) Savings participants			
SFR : Own	2.9%		2.3%
SFR : Rent	0.8%		0.7%
MFR : Own	1.0%		0.8%
MFR : Rent	0.3%		0.3%
Gas (Therms) Savings participants			
SFR : Own	0.3%		0.2%
SFR : Rent	0.1%		0.1%
MFR : Own	0.1%		0.1%
MFR : Rent	0.1%		0.1%

Notes: ^a Sparklines represent 2011 to 2015. Blue and red dots are the low and high points respectively

^b Customer count by unique combination of Account ID and Premise ID

Single family and multifamily customers accounted for more than 90% of residential energy usage in 2015



¹ PG&E program and customer data

A. PG&E's Residential Sector Vision

Pacific Gas and Electric's (PG&E) vision for the residential sector is to achieve deep energy savings, and robust grid benefits through more focused customer engagement, improved energy efficiency programs and strong partnerships. These opportunities are driven by the combination of rapidly advancing technologies and policies that enable PG&E to bring new technologies and approaches to a broader residential market.

Near real-time advanced metering infrastructure (AMI) data enables PG&E to empower customers with unprecedented awareness of their energy usage. When combined with two-way communications from home energy management systems (HEMS), a detailed usage profile emerges that can enable tailored solutions that maximize savings and cost-effectiveness.

Over the next ten years, California has an opportunity to integrate energy efficiency with other distributed energy resources (DER) technologies to provide customers with coordinated solutions. These trends include growing electric vehicle (EV) infrastructure, increasing adoption of rooftop solar, and greater use of appliances and plug load electronics.

In addition, California's energy efficiency building standards (Title 24) are moving towards increasing levels of performance by aiming to achieve zero net energy (ZNE) for all new residential buildings by 2020. ZNE Building goals have also been supported in the California Energy Action Plan, the AB 32 Scoping Plan, the Governor's Clean Energy Jobs Plan, the Clean Energy Futures Vision, and the Existing Building Energy Efficiency Action Plan. PG&E's residential portfolio will coordinate closely with codes and standards (C&S) initiatives to pave the way towards ZNE goals for both existing and new buildings through code readiness activities that prime the market for successful design and operation of ZNE buildings.

Complementing the technology landscape are policies that accelerate energy efficiency. PG&E's residential portfolio will play a leading role in achieving the goals of Senate Bill (SB) 350, Assembly Bill (AB) 758, AB 793, AB 802, and CPUC's 2020 ZNE Residential Building goals. AB 793 is particularly impactful for the residential sector because it directs IOUs to develop more robust solutions to spur greater adoption of HEMS and energy management technologies (EMTs), such as smart thermostats and other "connected" devices. AB 802 also empowers PG&E to target stranded potential and measure savings at the meter. Finally, SB 350 requires doubling energy efficiency in California by 2030. In light of the fact that the residential sector accounts for 31% of PG&E's electricity and more than 44% of gas consumption, residential intervention strategies and supporting tactics will play a central role in achieving these goals.

PG&E's Residential Sector Goals

Within the next 10 years, PG&E seeks to:

- Save XX GWh, XX MW, and XX MM therms focusing on high savings opportunities within both single family and multi-family properties

PG&E's Residential Customers in Brief

PG&E serves over 6.5 million residential customers throughout its service territory. The residential sector accounts for 31% of electricity consumption and 44% of natural gas consumption in PG&E's service territory. California's economy continues to outpace the overall US economy leading to a continued influx of new residents and housing starts across the state. CA is leading the way in energy efficient homes with its goal of Zero Net Energy (ZNE) in all new homes by 2020.

Although average site energy consumption in California homes is already among the lowest in the nation, overall residential electricity and gas consumption within the PG&E service territory are forecast to increase by approximately 10% and 5% respectively in the next decade. These increases are driven mainly by continued population growth, rising plug load energy consumption, and the advent of electric vehicle ownership. This growth provides opportunities for energy efficiency in both single family and multifamily homes.

Energy efficiency opportunities are also targeting disadvantaged communities through efforts like the Energy Savings Assistance (ESA) program.

Secondary goals that we intend to track include:

- Reach an increasing percentage residential customers (increasing from X% to XX% over the 10-year period) by targeting customers with high savings opportunities within both SF and MF
 - Within multifamily, reach an increasing number from about X% in 2017 to XX% over the 10-year period.
- Increase customers' ability to manage energy by increasing the proportion of customers utilizing EMTs from X% to Y%
- Integrate energy efficiency with other DER options within x% of residential buildings
- Increase operational efficiencies by reducing costs of the residential energy-efficiency programs through a metric such as reducing the ratio of \$/kWh and \$/therm saved by x% through the use of cost-effective scalable program models such as P4P

In addition to these goals that are directly attributable to our programs, we also seek to influence the market through larger market transformation efforts. Through these efforts, we seek to:

- Assist California in reaching the CEESP goal of ZNE for 100% of all new residential construction by 2020 by engaging builders and other market actors, and supporting new C&S
- Transform specific markets, in particular:
 - Increasing the market share of efficient lighting such as high quality LED lighting
 - Increase plug load efficiency

Greater detail on the intervention strategies supporting these goals can be found in *Section G: PG&E's Approach to Achieving Goals*.

B. PG&E's Residential Sector Proposal Compared to Prior Cycles

To meet the goals laid out in its vision, PG&E has identified nine major intervention strategies (further detailed in *Section G: PG&E's Approach to Achieving Goals*) for the residential sector, with particular emphasis on where they diverge from past practice:²

- **Data Analytics:** In prior cycles, PG&E evaluated methodologies for targeted outreach to residential customers based on usage patterns, geography, and climate, among other factors. PG&E will continue refining these methodologies in the short-term and will deploy customer targeting strategies in the mid-term. Potential tactics include identifying inefficient equipment and promoting retrofits, as well as discovering opportunities for targeted demand side management (TDSM). This tactic reinforces AB 802 and AB 758 by capturing stranded potential in existing buildings, and will be critical as PG&E works towards doubling energy efficiency by 2030.
- **Data Access:** PG&E developed data platforms such as My Account, My Energy, and Share My Data to encourage increased access to energy data for residential customers and authorized third parties. In the short-term, PG&E will use its marketing, education, and outreach (ME&O) resources to drive greater customer engagement with data platforms and improve access to aggregated multifamily data in accordance with AB 802. In the mid-term, PG&E will promote data platforms to third parties, who play a critical role in delivering energy savings through implementation of deep retrofits and the design of new tools.

² For more information on PG&E's residential program in the 2013-2015 program cycle, see the 2013-2014 program implementation plans (PIPs) at <http://eestats.cpuc.ca.gov/>

- **Technical Assistance and Tools:** In prior cycles, PG&E offered a diverse suite of technical assistance and tools to help customers use energy more efficiently. Offerings include strategic energy planning support, energy audits, and retrofits through Energy Upgrade California (EUC).
In addition to these offerings, PG&E will optimize Home Energy Reports (HERs) for greater effectiveness and expanded reach. PG&E will also continue working with the statewide emerging technologies (ET) team to inform the design of offerings that promote EMTs in accordance with AB 793.
- **Financial Solutions:** Loans, rebates, and incentives have always played a major role in PG&E's residential energy efficiency offerings. In the future, data analytics and the advent of meter-based savings present an opportunity for PG&E to target bundled financial solutions for customers with high savings potential as well as low-income communities. PG&E will also develop financial solutions to promote greater adoption of EMTs.
- **New Program Models:** In prior cycles, energy efficiency offerings have been designed based on modeling techniques that estimate the savings delivered by a particular measure. Moving forward, the opportunity to develop new offerings based on normalized metered energy consumption facilitates market-based solutions that capture stranded savings potential. PG&E will continue to test the effectiveness of the pay for performance model and use the lessons learned from the initial rollout of its residential P4P high opportunity project and program (HOPP) to evaluate applying this model to multifamily communities.
- **Assistance for the Design and Building Communities:** In the past, PG&E worked with the design and building communities to develop code readiness projects and ZNE demonstrations to move the market towards greater adoption of ZNE. Since all new residential construction must be ZNE by 2020, PG&E will continue to complement C&S activities by incorporating primary data on equipment and building performance into demonstrations and future offerings. In addition, PG&E will develop financial solutions to mitigate the cost barriers that impede ZNE construction.
- **Upstream and Midstream Partnerships:** PG&E values the partnerships it maintains with retailers, distributors, manufacturers and other market actors in the supply chain to increase the awareness and availability of energy efficient products and equipment. These partnerships will remain a critical component of PG&E's approach to promoting EMTs, light emitting diodes (LEDs), and products that reduce plug loads.
- **Outreach and Education:** Market outreach and education played a key role in prior cycles to increase awareness of the value of energy efficiency. Since individuals tend to be biased towards maintaining the status quo, outreach and education uses normative approaches such as community-based social marketing to encourage customers to take action. In the future, PG&E will continue to implement campaigns such as Step Up and Power Down³ to broaden residential communities' engagement outside of traditional programs.
- **Midstream Training:** Education and training opportunities have historically been provided to midstream actors such as contractors and technicians. In light of recent policies that set ambitious targets for energy efficiency and ZNE, it will be critical that these market actors receive sales training that incorporates the availability of financing opportunities to promote the adoption of optimal energy management solutions.

The individual tactics for each of these strategies are discussed in greater detail in *Section G, PG&E's Approach to Achieving Goals*. Below is a brief summary:

³ <https://stepupandpowerdown.com/>

- **In the short-term (1-3 years):** PG&E will optimize portfolio offerings around new energy savings paradigms such as net savings goals and meter-based savings, while exploring new models to scale promising approaches. Data analytics will play a key role in targeting customers and designing and evaluating new program models, such as P4P.⁴ PG&E will further develop code readiness projects, ZNE demonstrations, and ZNE financial solutions to facilitate the shift to ZNE for all new residential construction by 2020.
- **In the mid-term (4-7 years):** All new residential construction will be ZNE and PG&E will continue to optimize building performance while promoting integration with other demand side management tools. These efforts will be complemented by PG&E's support for EMTs, which will be promoted through upstream and midstream partnerships, bundled with other tools, and made accessible through comprehensive financial solutions. Further, PG&E will transition from comprehensive whole building energy savings initiatives to more meter-based, and pay for performance models.
- **In the long-term (8-10 years):** Tactics deployed in support of AB 793 and AB 802 will realize savings potential in existing buildings (AB 758) and meeting SB 350's energy efficiency goals. Customers will view energy use as a key part of cost-management due to the growth of energy management technologies, accessibility of accurate benchmarking data, and programs that use meter based savings. The building and design communities will continue to be engaged through accessible education and training opportunities that promote deep retrofits and ZNE design and construction.

Key Learnings from Recent EM&V Reports of California's Residential EE Programs

EM&V evaluations from prior cycles will also inform the design of PG&E's intervention strategies moving forward. In particular, the following six key learnings from recent EM&V reports influenced the strategies and tactics proposed in this plan:

- Some residential sectors, such as plug load, would benefit from a transition from traditional downstream rebate programs to market transformation-centered programs that more effectively address plug load barriers. One such program that embodies this approach is the Retail Products Platform (RPP) midstream incentive market transformation program.⁵
- Increased customization of energy efficiency measure to participants, such as an energy efficiency project's estimated payback period, would improve uptake of energy efficiency upgrades.⁶
- To help address gaps in effective program performance, training for retailers and contractors should be aligned and improved across various residential programs.⁷

⁴ Berkeley Law, Center for Law, Energy & the Environment and the Emmett Institute on Climate Change and the Environment, UCLA, 2016. "Powering the Savings: How California Can Tap the Energy Efficiency Potential in Existing Commercial Buildings." p.2

⁵ See Program and Technology Review of Two Residential Programs: Home Energy Efficiency Rebate (HEER)/Business and Consumer Electronics (BCE), September 2012, at <http://calmac.org/publications/HEER%5FBCE%5F083012%5FFINAL%2Epdf>

⁶ See 2010-2012 CPUC HEES Impact Evaluation, July 2013, at <http://calmac.org/publications/HEES%5FFinal%5FReport%5F20130708%2Epdf>

⁷ See Program/Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER)/Business & Consumer Electronics (BCE), September 2012, at <http://calmac.org/publications/HEER%5FBCE%5F083012%5FFINAL%2Epdf>; See also SCE and PG&E Whole House Process Evaluation, Opinion Dynamics and SBW, May 2012, at <http://www.energydataweb.com/crucial/search.aspx>

- Lighting accounts for a significant percentage of residential energy consumption, 17% according to recent estimates.⁸ With more than half of residential sockets in California still containing inefficient incandescent or halogen lamps, residential lighting still represents a major savings opportunity.⁹
- Targeted demand response is an emerging energy efficiency tool that uses smart meter data to realize previously inaccessible savings. Using smart meter data allows for increased identification of savings opportunities and more tailored energy savings approaches that can result in greater program cost effectiveness.¹⁰
- ZNE homes, while technically feasible, face significant challenges to widespread adoption such as builder and consumer education, consistent tracking and labeling methods, inclusion of real estate agents and lenders in the ZNE marketing process, and community-scale solutions for homes that cannot reach ZNE on an individual basis. Technologies and strategies that can be applied across a significant subset of the building volume will likely show the greatest overall gains in moving the state toward its ZNE goals.¹¹

Implementation plans will be strategically deployed in the timeframes listed above to achieve the State of California's energy efficiency goals for the residential sector. PG&E also anticipates meeting the following energy savings goals for the following investment, as shown in Sections C-D.

C. Sector-Level Budget

Over the 10 year period, PG&E is proposing to spend X dollars to achieve savings of x GWh, x MW, and x MM Therms. Potential savings by year are shown in Table 2 and budgets by year are shown in Table 1.

Table 1. Sector Budget

Year	Budget	% of Portfolio
2018-2027	TBD	TBD

D. Annual Net Savings from Potential Study

PG&E aims to achieve net savings goals reported in the 2015 Potential Study (see Figure 6 below).

Table 2. Annual Net Savings from Potential Study¹²

Year	Annual Net Goals					
	GWh	% of Portfolio	MW	% of Portfolio	Million	% of Portfolio

⁸Goebes, M. TRC Energy Services. 2016. ACEEE. *Clearing the Path to Market Transformation in the Rapidly Evolving World of Residential Lighting*.

⁹Ibid.

¹⁰ See 2013 "PG&E Home Energy Reports Program Review and Validation of Impact Evaluation," CalMAC ID CPU0096.00, "Behavioral Demand Response Study - Load Impact Evaluation Report," CalMAC ID PGE0367.01, and "Focused Impact Evaluation of the 2013-2014 Home Upgrade Program," CALMAC Study ID CPU0118.01

¹¹ Refer to the report "Residential ZNE Market Characterization" available at

http://www.calmac.org/publications/TRC_Res_ZNE_MC_Final_Report_CALMAC_PGE0351.01.pdf and the report "The Technical Feasibility of Zero Net Energy Buildings in California" available at

http://www.energydataweb.com/cpucfiles/pdadocs/904/california_zne_technical_feasibility_report_final.pdf

¹² PG&E derived the net goals from the 2015 Navigant Potential and Goals study

					(MM) Therms	
2018	159.6	40	11.8	24	5.7	46
2019	161.3	40	10.9	21	5.7	45
2020	164.9	40	10.4	20	6.0	45
2021	163.1	39	8.7	16	6.2	46
2022	169.0	39	8.7	14	6.7	48
2023	175.0	39	9.9	15	7.2	49
2024	180.7	38	10.2	15	7.9	50
2025	TBD		TBD		TBD	
2026	TBD		TBD		TBD	
2027	TBD		TBD		TBD	
Total						

Source: Navigant Consulting 2015. Net Market Potential values specific to PG&E

E. Sector Overview

Target Audience

The PG&E service territory contains a wide variety of climates, terrains, and community types. As a result, PG&E uses data analytics to characterize its residential customers in terms of single family and multifamily, renters and owners, and geography.

Segment Overview and Energy Usage: PG&E divides the residential market into segments based on community type and ownership status (rent or own). This includes single family residence owners (SFR: Own), single family residence renters (SFR: Rent), multifamily residence owners (MFR: Own), and multifamily residence renters (MFR: Rent).

More than 90% of energy usage in the residential sector is driven by customers who own their homes. Specifically, SFR: Own accounted for more than three-quarters of energy usage in PG&E's service territory in 2015 (see Figure 1 below). MFR: Own accounted for less than 20% of usage, while both SFR: Rent and MFR: Rent comprised less than 10% of usage.

Figure 1: 2015 Residential Usage by Community Type and Ownership Status

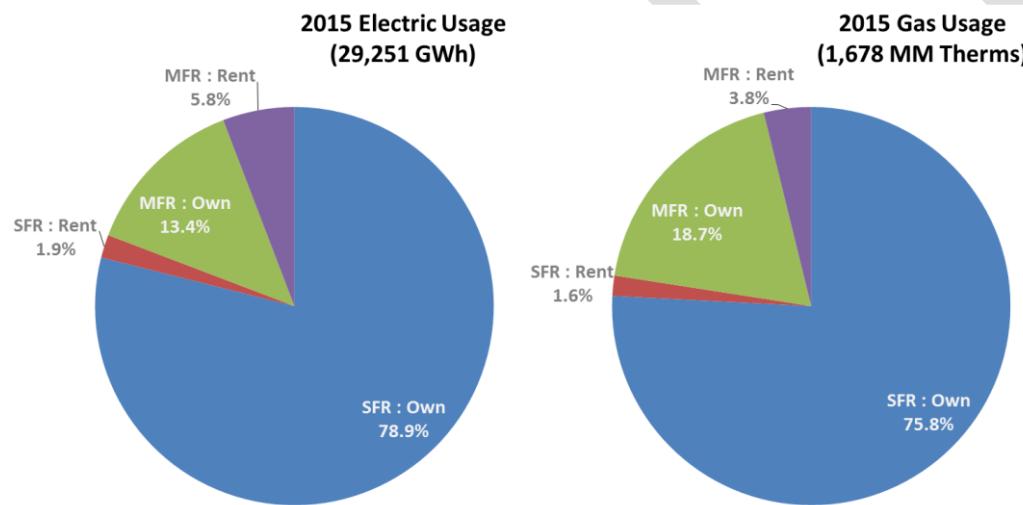
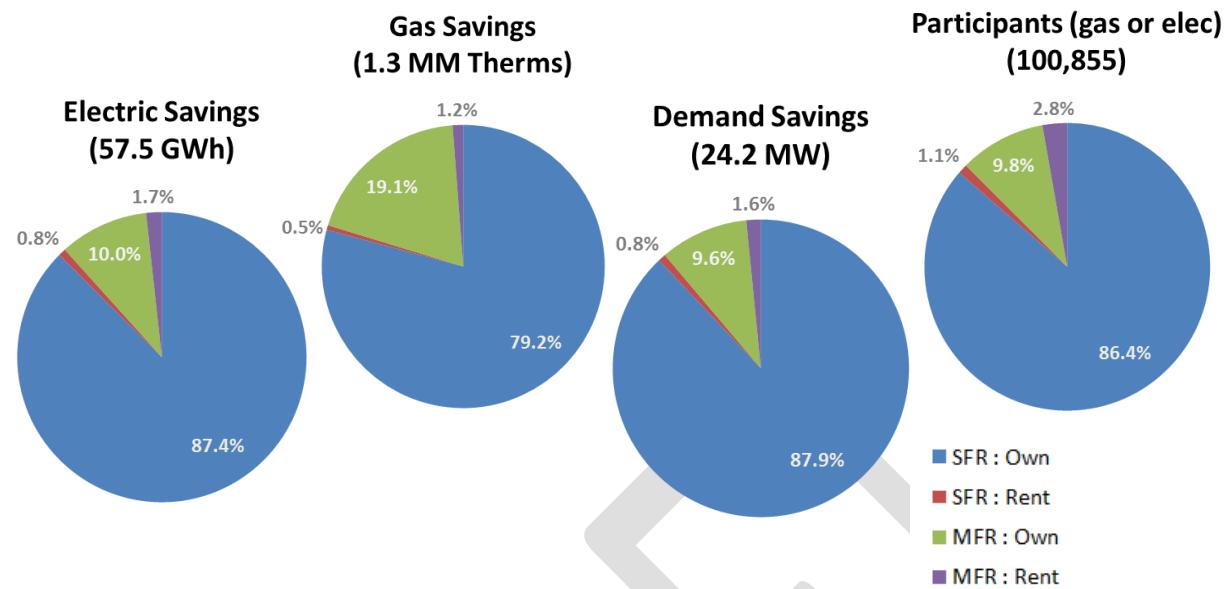


Figure 2 below identifies residential customer program participation and savings by segment in 2015, which largely follows the distribution of energy usage presented above. For example, more than 85% of participants in residential energy efficiency programs were SFR: Own, 10% were MFR: Own, and less than 5% were renters. SFR: Own and MFR: Own also accounted for nearly all of PG&E's 2015 savings in the residential sector. Program participation, energy usage, and savings for each residential segment are identified in greater detail in Appendix C: Customer Data.

Figure 2: 2015 Residential Energy Efficiency Program Participation and Savings



In addition, Figure 3 below displays residential energy consumption in 2015 through the lenses of usage, number of customers, and average usage. This data highlights the opportunity for greater participation in energy efficiency offerings among multifamily communities. For example, while 20% of residential customers are owners of multifamily units, owners of multifamily units comprise only 10% of participants in PG&E's energy efficiency offerings. PG&E will continue to refine its offerings to ensure all multifamily customers are aware of the benefits and available opportunities to make their residences more energy efficient (for more, see *Section G: PG&E's Approach to Achieving Goals*).

Figure 3: 2015 Snapshot of Usage, Customers, and Average Usage in the Residential Sector

Electric Customers ^a		% of Sector	Gas Customers		% of Sector
Electricity Usage: GWh			MM Therms		
SFR : Own	23,087.2	78.9%	1,272.1	75.8%	
SFR : Rent	546.7	1.9%	27.4	1.6%	
MFR : Own	3,916.5	13.4%	313.8	18.7%	
MFR : Rent	1,700.9	5.8%	64.4	3.8%	
Total	29,251.3	100%	Total	1,677.8	100%
Customers: Number of Electric Customers			Number of Gas Customers		
SFR : Own	3,553,398	63.3%	3,376,066	67.4%	
SFR : Rent	154,614	2.8%	131,685	2.6%	
MFR : Own	1,145,259	20.4%	978,812	19.5%	
MFR : Rent	759,975	13.5%	525,524	10.5%	
Total	5,613,246	100%	Total	5,012,087	100%
Average Usage: kWh per Customer			Therms per Customer		
SFR : Own	6,497		376.8		
SFR : Rent	3,536		208.1		
MFR : Own	3,420		320.6		
MFR : Rent	2,238		122.6		
Average	5,211		Average	334.7	

Notes: ^a SFR = Single Family Residence; MFR = Multi-family Residence

Source: PG&E customer data

Geography

PG&E's service territory includes 15 of the 16 climate zones in California.¹³ As a result, PG&E analyzes its residential customers based on their location in the Central Valley, Coastal, and Mountain regions to discern trends, barriers, and opportunities that are unique to these regions. Figure X below provides greater detail on usage, customers, savings, and participants by region. Although more residential customers are located in the Coastal region than in the Central Valley, Central Valley residents were responsible for nearly two-thirds of PG&E's residential electric savings in 2015.

Figure 4: 2015 Residential Customers and Participants by Climate Region

	Customer by Type ^a and Region ^b			Percent of Region		
	Own	Rent	Total	Own	Rent	Total ^d
Usage (GWh)						
Central Valley	14,012	924.6	14,936	94%	6%	100%
Coastal	12,666	1,313.3	13,980	91%	9%	100%
Mountain	325.5	9.7	335	97%	3%	100%
Total	27,004	2,248	29,251	92%	8%	100%
Customers						
Central Valley	2,085,261	309,697	2,394,958	87%	13%	100%
Coastal	2,548,233	602,213	3,150,446	81%	19%	100%
Mountain	65,163	2,679	67,842	96%	4%	100%
Total	4,698,657	914,589	5,613,246	84%	16%	100%
Savings (GWh)						
Central Valley	35.3	0.9	36.1	98%	2.4%	100%
Coastal	20.5	0.6	21.1	97%	2.8%	100%
Mountain	0.2	0.002	0.2	99%	1%	100%
Total	56	1.5	57	97%	2.6%	100%
Participants						
Central Valley	51,976	2,180	54,156	96%	4%	100%
Coastal	39,662	1,327	40,989	97%	3%	100%
Mountain	307	4	311	99%	1%	100%
Total	91,945	3,511	95,456	96%	4%	100%

Notes ^a Type refers to "Own" or "Rent"

^b Regions are aggregates of Climate Zones (Z01-Z16). There are 16 zones but not all are in PG&E's territory.

Central Valley includes: Z11 -Z13

Coastal includes: Z01 - Z09

^c "Unknown" size category included for completeness. Represents insufficient or partial-year data

^d Column may not sum to 100% due to a small percentage of Unknowns not included

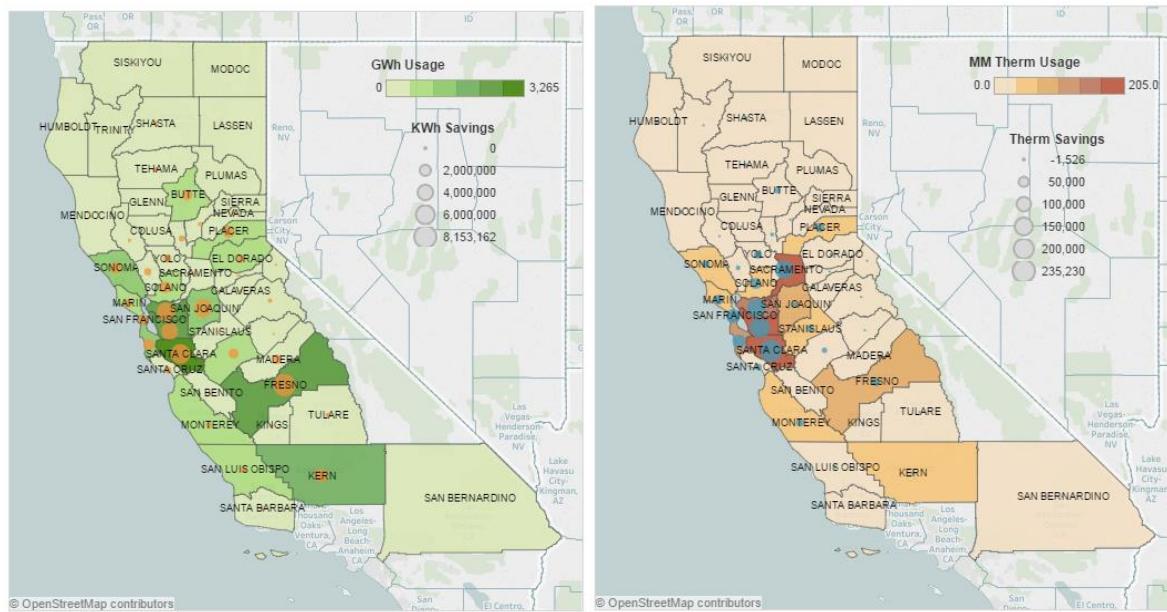
Source: PG&E customer data

In addition to analyzing residential customers' energy usage at the climate zone level, PG&E also uses data analytics to identify which counties consume and save the most energy. Figure 5 provides an overview of electric

¹³ The only climate zone not included is Climate Zone 9, which includes the Los Angeles metropolitan area. For more on Climate Zone 9, see http://www.pge.com/includes/docs/pdfs/about/edusafety/training/pec/toolbox/arch/climate/california_climate_zone_09.pdf

and gas usage and savings at the county level. Please see *Appendix C: Customer Data* for more detailed maps that display usage and savings based on community type and ownership status (i.e. SFR: Own, SFR: Rent, MFR: Own, MFR: Rent).

Figure 5: 2015 Residential Customer Usage and Savings by County



The counties that used the most electricity in 2015 are Santa Clara (3,300 GWh), Alameda (2,700 GWh), Contra Costa (2,600 GWh), and Fresno (2,600 GWh). Electric savings in 2015 were highest among Fresno (8.2 MM kWh), Santa Clara (6.4 MM kWh), Contra Costa (5.6 MM kWh), and San Joaquin (4.9 MM kWh) counties.

In addition, the counties that used and saved the most gas in 2015 are Santa Clara (205 MM therms used, 235,000 therms saved), Alameda (192 MM therms used, 186,000 therms saved), Sacramento (176 MM therms used, 151,000 therms saved), and Contra Costa (152 MM therms used, 164,000 therms saved).

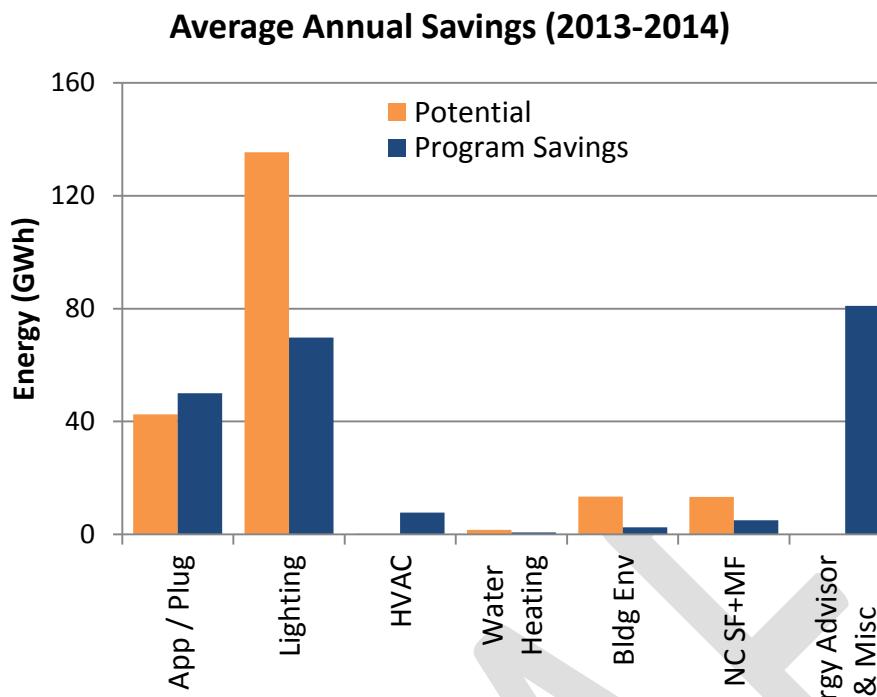
Additional insights into the residential sector are enabled by AMI data analysis. See Appendix D for examples that can help guide targeting of energy efficiency resources.

Energy Efficiency Potential

The 2015 Potential Study provides measure-level forecasts of savings and is used to define utility savings goals. Figure X highlights how PG&E program savings compare to the Potential Study. For the most part, PG&E residential programs have delivered fewer savings compared to energy efficiency potential, particularly in lighting. The remaining savings potential in lighting is further supported by a recent analysis which finds that residential lighting use must decline by 19% from 2015-2018 to meet AB 1109's goal of reducing residential lighting energy usage by 50% from 2007-2018.¹⁴

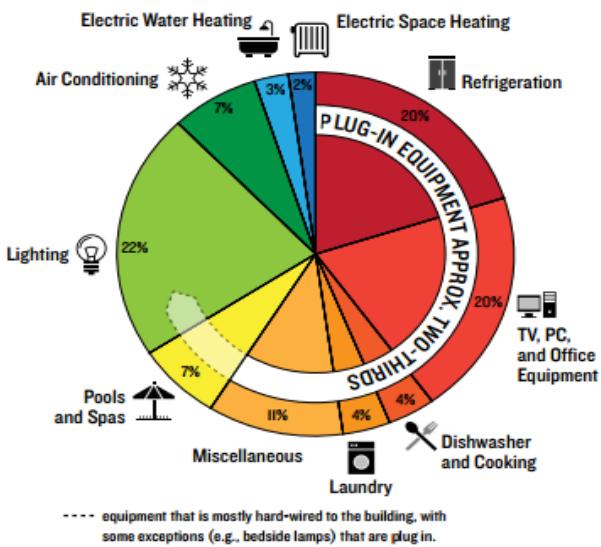
¹⁴ Goebes, Mutmansky, Caruth, et al. "Clearing the path to Market Transformation in the Rapidly Evolving World of Residential Lighting," TRC Energy Services and Pacific Gas & Electric Company—2016 ACEEE Summer Study on Energy Efficiency in Buildings, p. 6, http://aceee.org/files/proceedings/2016/data/papers/2_677.pdf

Figure 6. Average Annual Savings from Potential Study and Program Savings



In addition to lighting, a 2015 report by the National Resources Defense Council (NRDC) identifies the need to develop a comprehensive strategy to capture savings in plug-in equipment, which accounts for approximately two-thirds of electricity usage in California homes (see Figure 7 to the side).¹⁵ According to the report, curtailing electricity usage from plug-in equipment requires a comprehensive approach that includes working with manufacturers to deploy more efficient technologies, expanding customer rebate programs to accelerate adoption of efficient appliances with high upfront costs, and using data analytics to target deployment of plug-load management solutions.¹⁶ PG&E will continue to develop its partnerships with upstream and midstream actors to encourage efficient plug-in equipment, offer financial solutions that enable the greater adoption of these technologies, and use outreach and education campaigns to promote more energy efficient behaviors.

Figure 7- Figure X. Residential Plug-in Equipment Usage



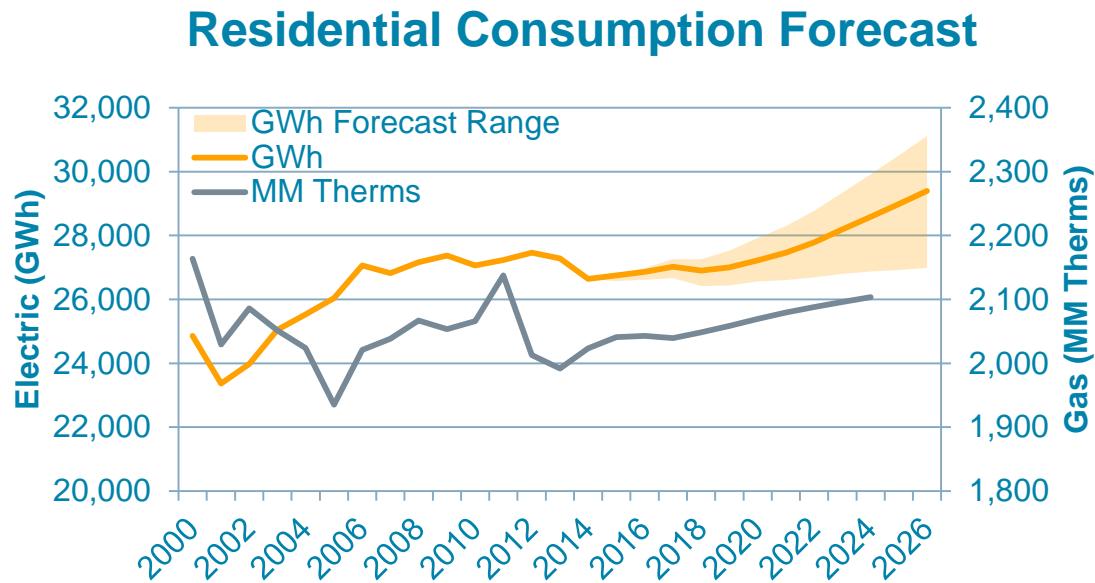
¹⁵ "California's Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals," National Resources Defense Council, August 2015, p. 45, <https://www.nrdc.org/sites/default/files/ca-energy-efficiency-opportunity-report.pdf>

¹⁶ "California's Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals," National Resources Defense Council, August 2015, p. 46, <https://www.nrdc.org/sites/default/files/ca-energy-efficiency-opportunity-report.pdf>

Energy Usage Forecasts

Overall, residential electricity and gas consumption within the PG&E service territory are projected to increase by approximately 10% and 5% respectively in the next decade. According to the 2015 Integrated Energy Policy Report, these increases are driven primarily by continued population growth, rising plug load energy consumption, and the advent of electric vehicle ownership.¹⁷ The projected increase in residential energy consumption is displayed in greater below in Figure 8.

Figure 8. Residential Consumption Forecast



In contrast to the forecasted growth in total residential electricity and gas consumption, forecasts of per household energy usage are expected to decline in the next five years as shown in Figure 9 where the solid lines indicate PG&E and dashed lines represent statewide data.

¹⁷ "2015 Integrated Energy Policy Report," California Energy Commission, p. 130-145, http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-01/TN212017_20160629T154354_2015_Integrated_Energy_Policy_Report_Small_File_Size.pdf

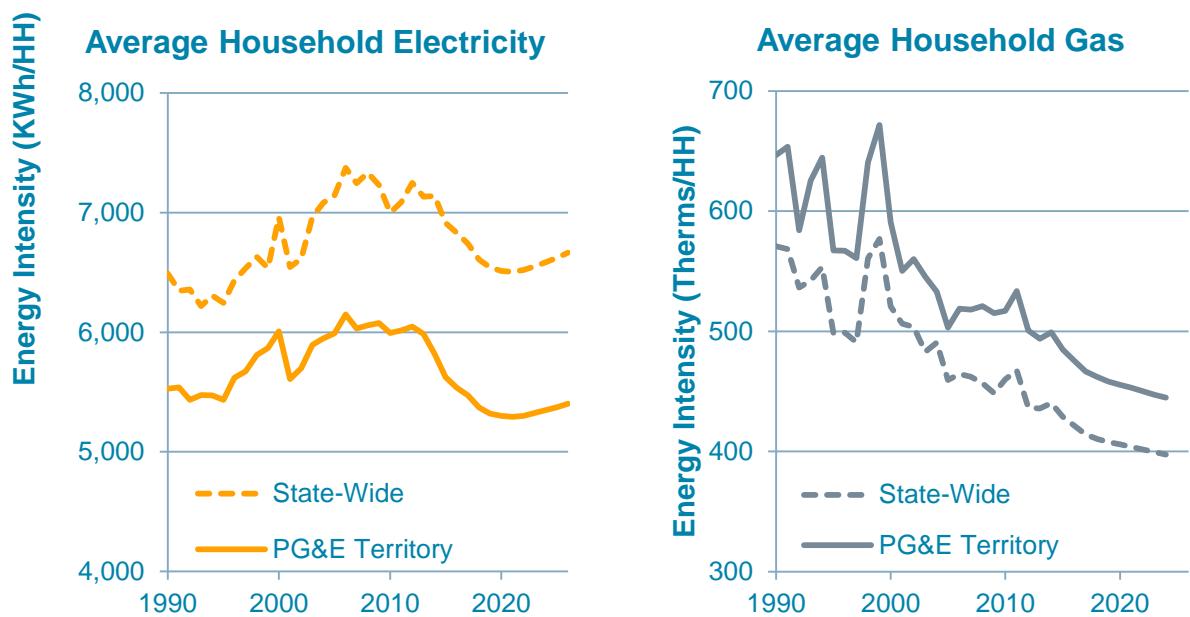


Figure 9. Average Household Energy Usage Forecast

Figure 9 also shows that average electricity usage per household in California as a whole (dashed line) is higher than in the PG&E service territory by nearly 25% while gas usage is higher in PG&E territory by about 10%. The lower average household electricity usage creates a challenge in achieving cost-effective savings as individual customers offer less average savings potential. Falling natural gas prices as fuel supply has increased also inhibits cost effective savings due to the lowered avoided procurement costs.

F. Residential Sector Trends and Challenges

PG&E's service territory contains a wide variety of climates, terrains, and customer segments. Within the residential sector, PG&E services high density multifamily rental housing in the temperate Bay Area, inland suburbs where summer temperatures routinely reach triple digits, and sparse rural populations, among others. Through experience, account representative feedback and market research analysis, PG&E has identified the following major market trends impacting its residential customers.

- **While per household energy use is decreasing, overall energy usage is projected to increase due to population growth, increasing plug load usage and growth in the electric vehicle market.¹⁸**

- Plug load energy usage continues to grow rapidly. Twenty years ago, the average household contained only four or five plug load devices. Today, the same home is now likely to have as many as 65.¹⁹ A typical household's electricity usage shows 15-30% of the load attributable to plug load products^{20,21} and these loads are the fastest growing energy end use category nationwide.²²
- Computers are a major driver of this increase in plug load, with 8.3 million sold in California each year in both the commercial and residential sectors²³. As a result, the CEC is exploring new energy efficiency standards for computers, monitors and displays from the Energy Commission through its Title 20 authority in a series of workshops scheduled through 2016.²⁴
- California leads the nation in market growth of EVs.²⁵ Registration for zero emission vehicles in California has grown steadily since 2008 – for example, electric vehicle registrations rose 115% from 2012-2014 and plug-in hybrid vehicle registrations grew 550% in that same period.²⁶
- Plug-in equipment runs the gamut of technologies from lighting to HVAC, as well as appliances and electric vehicles. For this reason, it will be increasingly important to rely on AMI data analysis to get behind the meter and target customers with high-value propositions relevant to their energy usage profile based on end use.

- **Codes and Standards activities spur tremendous energy savings for California²⁷, but leave stranded potential in some existing residential structures.**

- While codes and standards have contributed significantly to greenhouse gas emission reductions, higher baselines have presented a challenge to energy efficiency program administrators, until the passage of AB 802. AB 802 presents an opportunity to target customers with stranded potential through targeted value propositions for installing efficient equipment.

¹⁸ IEPR, http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-03/TN207439_20160115T152221_California_Energy_Demand_20162026_Revised_Electricity_Forecast.pdf

¹⁹ Natural Defense Council, "Plug Load Efficiency Strategies," presented at IEPR commissioner workshop on Plug Load Efficiency, June 18, 2015.

²⁰ *Estimated U.S. Residential Electricity Consumption by End-use, 2011*, Energy Information Administration (2011, Updated 2013).

²¹ *The 2013 California Energy Efficiency Potential and Goals Study: Final Draft Report*, Navigant Consulting prepared for the CPUC (2013).

²² *Miscellaneous Energy Loads in Buildings*, S. Kwatra, J. Amann and H. Sachs (2013).

²³ Singh, Harinder, Ken Rider. 2015. Staff Analysis of Computer, Computer Monitors, and Signage Displays. California Energy Commision. CEC-400-2015-009-SD, http://docketpublic.energy.ca.gov/PublicDocuments/14-AAER-02/TN203854_20150312T094326_Staff_Report__FINAL.pdf.

²⁴ California Energy Commission. 2015 Appliance Efficiency PreRulemaking – Computers, Computer Monitors, and Signage Displays. <http://www.energy.ca.gov/appliances/2014-AAER-2/prerulemaking/>.

²⁵ <http://next10.org/sites/next10.org/files/2016-california-green-innovation-index-1.pdf>, p 3

²⁶ California Energy Commission

²⁷ NRDC, "California's Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals" <https://www.nrdc.org/sites/default/files/ca-energy-efficiency-opportunity-report.pdf>

- A 2011 CEC report found that “more than half of California’s 13 million residential units and over 40% of the commercial buildings were built before 1978, when the first energy efficiency standards were implemented.”²⁸ Berkeley Law et al. found that 75% of existing housing stock was built before title 24 standards. “This older stock of buildings represents a critical and largely untapped market for energy efficiency improvements to meet state goals.”²⁹
- **Customers are interested in financing options beyond traditional rebates, such as on-bill loan repayments.**
 - High up-front project costs present a significant barrier to the uptake of residential energy efficiency. Over half of homeowners (54%) agreed that high upfront cost is why they might not make an energy-related upgrade, and a third of homeowners stated that a loan could help overcome the costs.³⁰
 - A recent survey by Parago reports that though 14% of U.S. consumers are currently taking advantage of home energy management programs, 87% indicate they would participate given the right incentives, including financing options.³¹
 - The addition of no or low-cost financing has been demonstrated to yield impressive results such as an 80% conversion rate in Arkansas.³²
 - A 2014 report by Accenture finds 76% of consumers are motivated by incentives to recruit those they know to enroll in energy-related products and services.³³
- **Customers want visibility and control of their energy use, and they are using mobile devices and social media to stay connected.**
 - The world is increasingly connected, as are individual homes. New electronic devices and appliances can now be linked to the Internet to provide real-time data that makes it easier to understand and lower energy use. The trend is increasingly tilted in favor of connectivity, with nearly one-third of consumers (especially the younger generation) expecting functionality on Web and mobile channels from their energy providers.³⁴
 - Social media is an interface no longer limited to new friend requests and hashtags – a 2014 Accenture report³⁵ shows that three-quarters of consumers can be motivated to recruit their friends and family to sign up for energy-related products and services.

²⁸ “Achieving Energy Savings in California Buildings: Saving Energy in Existing Buildings and Achieving a Zero-Net-Energy Future.” California Energy Commission Staff Report, July 2011.

²⁹ Berkeley Law, Center for Law, Energy & the Environment and the Emmett Institute on Climate Change and the Environment, UCLA, 2016. “Powering the Savings: How California Can Tap the Energy Efficiency Potential in Existing Commercial Buildings.” p.6

³⁰ “Existing Buildings Energy Efficiency Action Plan Draft 2016 Plan Update,” *California Energy Commission*, p. 62.

³¹ “Turn Up Demand Response: Educate and Incent Consumers,” June 17, 2014 <http://www.parago.com/energy-demand-response-survey-press-release/>

³² Agard, T. 2016. Financing Building Energy Upgrades with Tariffed On-Bill Investments. Washington, DC: DOE. betterbuildingssolutioncenter.energy.gov/sites/default/files/Energy_Efficiency_Financing_for_Low_Income_Communities_Finance_WED.pdf.

³³ “The New Energy Consumer: Architecting for the Future,” *Accenture*, 2014, p. 22, https://www.accenture.com/_acnmedia/Accenture/next-gen/insight-unlocking-value-of-digital-consumer/PDF/Accenture-2014-The-New-Energy-Consumer-Architecting-for-the-Future.pdf

³⁴ “The New Energy Consumer: Architecting for the Future,” *Accenture*, p. 22, May 23, 2015 <https://www.accenture.com/us-en/insight-new-energy-consumer-architecting-future>

³⁵ “The New Energy Consumer: Architecting for the Future,” *Accenture*, p. 22, May 23, 2015 <https://www.accenture.com/us-en/insight-new-energy-consumer-architecting-future>

- PG&E has installed more than 9 million smart meters, accounting for more than 84% of all meters in the service territory. These devices have paved the way for improved customer-facing programs, advanced technologies, and improved system understanding. AMI data enables powerful analytics and management tools, facilitating exploration enhanced understanding of energy usage patterns.
- **Single family new construction is on the rise, while multifamily housing is experiencing a dip in the number of new buildings.**
 - The number of new single family residential buildings rose 14% from 2014-2015 while multifamily construction decreased by 21% for the same period.³⁶ Due to rising mortgage rates in 2016, single family residential construction is anticipated to slow and end the year at 10% over 2015 numbers and multifamily construction will likely end the year 10% below 2015 performance.
 - Per a recent report on residential housing trends, the next peak year for both single family and multifamily new construction is likely to be in 2020, which happens to coincide with the state's progressive ZNE goals.³⁷
 - The state is continuing its leadership by setting a goal to achieve ZNE by 2020 for all new residential buildings. California's building energy efficiency standards are among the most progressive in the nation and are moving the market towards increasing levels of high energy performance in new buildings. To date, California has more buildings that are closer to ZNE, than any other state in the nation.³⁸

Driven largely by these five trends, residential customers face five key barriers to participation in energy efficiency programs. PG&E's nine major intervention strategies seek to overcome these key barriers for the residential sector, as shown in Table 3 and explained in greater detail in *Section G, PG&E's Approach to Achieving Goals*.

Table 3: Residential Market Trends and Barriers to Energy Efficiency Program Participation

Key Barriers for Residential Sector	Residential Interventions
Customers have different values, perceptions, and barriers to action ³⁹	Data Analytics
Customers lack access to their energy usage ⁴⁰	Data Access
Customers do not know how to act on energy usage information ⁴¹	Technical Assistance and Tools
Projects that generate deep savings often have high up-front costs, long payback periods, and	Financial Solutions

³⁶"The Rising Trend In California Construction Starts," *First Tuesday Journal*, September 30, 2016 <http://journal.firsttuesday.us/the-rising-trend-in-california-construction-starts/17939/>

³⁷ "The Rising Trend In California Construction Starts," First Tuesday Journal, September 30, 2016 <http://journal.firsttuesday.us/the-rising-trend-in-california-construction-starts/17939/>

³⁸ <http://www.californiaznehomes.com/faq>

³⁹ Fuller, Kunkel, Zimring, et al. "Driving Demand for Home Energy Improvements," *Lawrence Berkeley National Laboratory*, September 2010, p. 37, <http://drivingdemand.lbl.gov/reports/lbnl-3960e-print.pdf>

⁴⁰ "California's Existing Buildings Energy Efficiency Action Plan," p. 13, 15.

⁴¹ "Driving Demand for Home Energy Improvements," p. 29.

are not recognized as valuable by the real estate market ⁴²	
New program models based on performance-driven value are needed to increase the efficiency of existing buildings ⁴³	New Program Models
The incremental cost for ZNE construction is estimated to be 5-15% greater than to-code homes ⁴⁴	Assistance for the Design and Building Communities
Downstream incentives may not always be sufficient to increase customer adoption of energy efficient products or equipment ⁴⁵	Upstream and Midstream Partnerships
Customers are biased towards maintaining the status quo and discount the future benefits of taking action ⁴⁶	Outreach and Education
Workforce training must align with overcoming barriers to achieve state policy goals ⁴⁷	Midstream Training

⁴² Cluett, Rachel and Jennifer Amann "Scaling Up Participation and Savings in Residential Retrofit Programs," *American Council for an Energy-Efficient Economy*, October 2016, p. v.

⁴³ "California's Existing Buildings Energy Efficiency Action Plan," p. 74-75.

⁴⁴ "Residential ZNE Market Characterization," *TRC Energy Services*, February 27, 2015, p. 13,
http://www.calmac.org/publications/TRC_Res_ZNE_MC_Final_Report_CALMAC_PGE0351.01.pdf

⁴⁵ "Customer Incentives for Energy Efficiency Through Program Offerings," *U.S. Environmental Protection Agency*, p. 6,
https://www.epa.gov/sites/production/files/2015-08/documents/program_incentives.pdf

⁴⁶ "Driving Demand for Home Energy Improvements," p. 29.

⁴⁷ "California Existing Buildings Energy Efficiency Action Plan: October 2016," *California Public Utilities Commission and California Energy Commission*, October 2016, p. 1.

G. PG&E's Approach to Achieving Goals

Strategic Interventions: Overview

PG&E has a long and successful history of providing a diverse range of energy efficiency offerings to its residential customers. As California's residential energy efficiency technological and policy landscape evolves, PG&E has identified nine major strategic interventions building on past strategies.

- **Data Analytics** enable PG&E to strategically target high-opportunity projects and provide targeted value propositions for residential customers based on their energy usage profiles.
- **Data Access** empowers customers with enhanced awareness of their energy usage and informs the design of technical assistance and tools through data sharing with authorized third parties.
- **Technical Assistance and Tools** address the fact that customers may not know how to act upon reviewing their energy usage and therefore require tailored energy solutions. Engaging customers with the appropriate suite of measures establishes PG&E as a trusted energy advisor.
- **Financial Solutions** provide requisite financial impetus to spur energy efficiency investments. These offerings address the unique challenges faced by single family and multifamily communities through bundled loans, rebates, and incentives to encourage customers to take action.
- **New Program Models** support PG&E's efforts to capture stranded potential by facilitating the design of new offerings based on meter-based savings.
- **Assistance for the Design and Building Communities** is required to overcome the cost barriers of ZNE construction and pave the way for all new residential construction as ZNE by 2020.
- **Upstream and Midstream Partnerships** with retailers, distributors, manufacturers, and other supply chain actors enable PG&E to promote greater access to efficient products and equipment, while driving down the cost of new technologies over time (e.g., EMTs).
- **Outreach and Education** use positive normative social influence strategies such as community-based social marketing to broaden residential communities' engagement with energy efficiency outside of traditional programs.
- **Midstream Training** contributes to the development of a well-equipped workforce that is prepared to succeed and deliver savings as the market shifts from widget-based incentives to deeper retrofits and pay-for-performance models to achieve state policy goals.

The next section provides further detail on the selected intervention strategies and exploratory tactics. Before proceeding with implementation, PG&E will expose each tactic described to a rigorous internal development process to assess its relative viability and cost effectiveness.

Intervention Strategy 1 –Data Analytics

Achieving California’s ZNE goals, improving the efficiency of existing buildings, and capturing stranded potential is facilitated by identifying inefficient dwellings and providing these customers with personalized energy solutions. These efforts are made possible by the more than 9 million smart meters deployed in PG&E’s service territory.⁴⁸ Since “people have different values, different perceptions, and different barriers to action,”⁴⁹ using data analytics to target specific customers will enable PG&E to increase both the number of projects among residential customers and therefore drive deeper savings.

In the mid-term, PG&E’s targeting strategies will select customers who stand to benefit the most from specific programs and offer the most savings per program dollar. For example, targeting should increase the effectiveness of programs such as the Middle Income Direct Install program (MIDI), which currently sends contractors into the field to assess the eligibility of residential homes for direct install measures, such as showerheads, aerators, heating system, and indoor lighting.

In recognition of the fact that energy efficiency is a valuable grid resource and complements demand response, PG&E will use analytics to identify opportunities for targeted demand side management (TDSM). The combined approach will defer investments in transmission and distribution capacity, which in turn frees capital to fund other investments yielding enhanced system-wide safety and reliability.⁵⁰ In particular, TDSM strategies may contribute to addressing resource needs from the retirement of the Diablo Canyon Power Plant.⁵¹

Ultimately, data analytics lays the foundation for PG&E to contribute to the doubling of energy efficiency by 2030 as it enables PG&E to concentrate its resources on specific residential customers that stand to contribute the greatest amount of energy savings.

Table 4. Intervention Strategy 1 - Data Analytics

Intervention Strategy	Barriers	Example Tactics	Existing, New or Modified	Short, Mid, or Long-term
Individual customer targeting via interval data analysis	Customers lack an understanding of energy efficiency opportunities at key trigger points	Identify customers most in need of building shell and HVAC maintenance/system upgrades using load shape analysis, seasonal usage comparisons, and HVAC disaggregation modeling	N	M
		Identify usage patterns indicative of old or inefficient equipment using innovative tools or third party offerings to reach stranded potential	N	M

⁴⁸ “Putting Energy Efficiency First,” Pacific Gas & Electric Company, <http://www.pge.com/myhome/environment/pge/energyefficiency/>

⁴⁹ Merrian C. Fuller, et.al, “Driving Demand for Home Energy Improvements,” p. 28.

⁵⁰ “California’s Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals,” *National Resources Defense Council*, August 2015, p. 39, <https://www.nrdc.org/sites/default/files/ca-energy-efficiency-opportunity-report.pdf>

⁵¹ PG&E announced in June of 2016 plans to take Diablo Canyon Power Plant off line in 2025. Diablo currently operates with 2.3 GW capacity and supplies 22% of PG&E power, which accounts for nearly 10% of California’s statewide electricity consumption. *Economic Benefits of Diablo Canyon Power Plant; An economic Impact Study*, P. Mayeda and K. Riener (2013).

Intervention Strategy	Barriers	Example Tactics	Existing, New or Modified	Short, Mid, or Long-term
		<p>and promote deep retrofits</p> <p>Identify and engage customers who drive evening system load peaks about integrated energy efficiency and demand response offerings to help avoid high procurement costs (TDSM)⁵²</p>	N	M
Partners: Data analysis experts; evaluators; energy procurement planners				

A 2016 impact evaluation of the 2013-2014 - Home Upgrade Program identifies a need to better target outreach efforts based on particular climate zones. Specifically, it finds concentrating on inland climate zones could result in higher electric savings and demand reductions, while focusing on climate zones with higher heating loads could maximize gas savings.⁵³ This finding demonstrates the value of using data analytics to better concentrate program outreach efforts to specific customers. Moreover, it highlights the value of incorporating additional factors beyond energy usage into targeting efforts. Energy usage will be combined with other key inputs to best identify customers with the largest savings potential. For specific examples of how AMI data analytics can be used to target customers, refer to Appendix D.

While consideration of a customer's location facilitates enhanced customer targeting, the 2014-2015 Home Upgrade Process Evaluation finds significant savings opportunities still exist in residential buildings constructed prior to the adoption of California's Building Energy Efficiency Standards in 1978.⁵⁴ In particular, the evaluation recommends "program administrators should harass data-mining techniques to target pre-1978 homes in any IOU-led marketing campaigns."⁵⁵ Given the energy savings potential from pre-1978 homes, PG&E will explore incorporating this finding into its methodologies to maximize the effectiveness of customer targeting campaigns.

⁵² "California's Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals," p. 39.

⁵³ "Focused Impact Evaluation of the 2013-2014 Home Upgrade Program," *DNV GL*, March 22, 2016, <http://www.energydataweb.com/cpucFiles/pdaDocs/1497/Focused%20Impact%20Evaluation%20of%20the%202013-2014%20Home%20Upgrade%20Program%20draft%20for%20comment%204-1-16.pdf>

⁵⁴ "Energy Upgrade California-Home Upgrade Program Process Evaluation 2014-2015," *EMI Consulting*, September 12, 2016, p. 12.

⁵⁵ "Energy Upgrade California-Home Upgrade Program Process Evaluation 2014-2015," *EMI Consulting*, September 12, 2016, p. 12.

Intervention Strategy 2 – Data Access

Residential customers report a key barrier to adopting energy efficiency is a lack of awareness of their energy usage and opportunities to manage their usage more effectively.⁵⁶ Due to the extensive deployment of AMI in its service territory, PG&E is well positioned to provide customers with access to their energy data. This intervention strategy will strive to ensure all customers have access to their energy usage and can easily share this information with an authorized third party.

Tactics to support improved data access will focus on those that deliver relevant messaging to residential customers at key decision points to maximize adoption of energy efficiency. A 2014 briefing by the American Council for Energy Efficient Economy (ACEEE) points out that data access is a necessary first step towards enabling customers to analyze their usage patterns and identify the need for energy efficiency.⁵⁷ In this way, engaging customers with resources that empower them with a greater understanding of their usage provides a key entry point to begin the conversation about energy efficiency. This approach is further supported by the 2015 Integrated Energy Policy Report (IEPR), which states, “Data access is the first step to behavioral and operational efficiency improvements that have great potential to optimize energy use.”⁵⁸

In the short-term, PG&E will use its marketing, education, and outreach (ME&O) resources to promote awareness of data platforms among residential customers, such as My Account, My Energy, and Share My Data. Implementation of AB 802, which requires PG&E to maintain usage records for all multifamily residential buildings to which it provides service, aggregate usage across meters for multifamily dwellings, and deliver this data to building owners, their agents, or operators upon request, will complement these efforts.⁵⁹ The National Resources Defense Council (NRDC) finds “increasing the transparency of buildings’ energy usage...can drive more retrofits and help owners better manage how their buildings use energy.”⁶⁰

In the mid-term, PG&E will begin promoting greater access to data sharing platforms among third parties. A 2016 report by ACEEE finds providing contractors and energy assessors with more consistent access to interval data enables them to “understand what devices and equipment are responsible for energy waste, which can help them determine appropriate solutions for the home.”⁶¹ Moreover, this tactic provides third parties with the insights needed to create innovative, inspiring tools for customers to relate to, manage, and ultimately reduce their energy usage.

Ultimately, deploying this tactic in the short-term (within three years) aligns with the AB 758 Existing Buildings Energy Efficiency Action Plan’s goal of “data-driven decision making.” In particular, the Action Plan highlights,

⁵⁶ Merrian C. Fuller, et.al, “Driving Demand for Home Energy Improvements,” Berkeley: LBNL, 2010,p. 28; Lowell Ungar, Rodney Sabin, Neal Humphrey, et al, “Guiding the Invisible Hand: Policies to Address Market Barriers to Energy Efficiency,” paper presented at ACEEE Summer Study on Energy Efficiency in Buildings, p. 6-324.

⁵⁷ “Best Practices for Working with Utilities to Improve Access to Energy Usage Data,” *American Council for an Energy-Efficient Economy*, June 2014, p. 1-2, <http://aceee.org/files/pdf/toolkit/utility-data-access.pdf>

⁵⁸ “2015 Integrated Energy Policy Report (IEPR),” California Energy Commission, p. 22, http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-01/TN212017_20160629T154354_2015_Integrated_Energy_Policy_Report_Small_File_Size.pdf

⁵⁹ “Assembly Bill No. 802,” https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB802

⁶⁰ Stamas, Maria “How California’s Unprecedented Public Benchmarking law Can Yield Even More Benefits for Customers,” *Natural Resources Defense Council*, February 3, 2016, <https://www.nrdc.org/experts/maria-stamas/how-californias-unprecedented-public-benchmarking-law-can-yield-even-more>

⁶¹ Cluett, Rachel and Jennifer Amann “Scaling Up Participation and Savings in Residential Retrofit Programs,” *American Council for an Energy-Efficient Economy*, October 2016, p. 11.

“building owners and residents demand energy efficiency services informed by the full range of information relevant to them.”⁶²

Table 5. Intervention Strategy 2: Data Access

Intervention Strategy	Barriers	Example Tactics	Existing, New or Modified	Short, Mid, Long-term
Data access to facilitate customer understanding of energy efficiency	Customers lack access to their energy usage	Promote third-party access to Share My Data/Green Button Connect	M	M
		Streamline access to aggregated whole-building data and consent-based tenant data ⁶³	M	S
		Increase customer adoption of data platforms (e.g. My Account, My Energy, and Share My Data) where customers can engage with personalized energy usage data and tools	N	S
Partners: Third-party vendors				

The “Program Year 2015 Evaluation of Customer Web Presentment and Energy Alerts” by Applied Energy Group, Inc. analyzed the effectiveness of the My Energy platform, which allows customers with smart meters to view their electricity usage at daily or hourly intervals. One of the key findings from this study is that customers who are highly engaged with My Energy tend to save energy while those that are less engaged typically do not.⁶⁴ This finding illustrates the dual importance of designing an appealing, user-friendly platform and conducting effective outreach that encourages customers to consistently engage with their data. In other words, creating a data platform is not enough to drive savings; customers must use the platform consistently to drive results.

⁶² Zawadzki, Lin, Dahlquist, Bao, et al. “Personalized energy efficiency program targeting with association rule mining,” *Pacific Gas and Electric Company—2016 ACEEE Summer Study on Energy Efficiency in Buildings*, p. 8-7.

⁶³ “California’s Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals,” p. 46.

⁶⁴ “Pacific Gas and Electric Company’s SmartMeter Enabled Programs: Program Year 2015 Evaluation of Customer Web Presentment and Energy Alerts,” *Applied Energy Group, Inc.*, April 29, 2016, p. iii-iv.

Intervention Strategy 3 – Technical Assistance and Tools

California’s Existing Buildings Energy Efficiency Action Plan notes even when residential customers have complete access to their energy usage, they “do not always make rational decisions to prioritize energy efficiency.”⁶⁵ As a result, PG&E plays a key role in connecting customers with the appropriate suite of energy efficiency offerings that are best suited to their resources and needs. While PG&E will continue to promote existing resources such as integrated audits, home energy reports, and the “Marketplace” platform (see right),⁶⁶ AB 793 presents an opportunity to develop and deploy innovative energy-saving offerings in the short-term.⁶⁷ Successful implementation of this intervention strategy will lead to customers knowing EMTs are available to them and using them more frequently, as needed.

In the short-term, PG&E will prioritize developing and delivering EMTs to residential customers. This includes promoting existing EMTs such as advanced power strips and the Home Energy Checkup, as well as offering new EMTs such as a smart phone application that engages customers about time-of-use rates. The use of smart phone applications aligns with the Existing Building Energy Efficiency Action Plan’s observation that these applications can “...break down consumption by end use, understand usage patterns, pinpoint opportunities for savings, and provide ongoing regular seasonal advice to customers.”⁶⁸

The continued development of data analytics will also play a key role in the adoption of EMTs because they enable PG&E to target residential customers that stand to save the most energy from these technologies. In addition, streamlined third party data access processes will ensure that technology companies are able to effectively design technical assistance and tools that best meet customer needs. In this way, both data analytics and data access provide detailed usage and savings data that will be used to inform the design and delivery of technical assistance and tools.⁶⁹

PG&E’s Marketplace

Marketplace is an online platform that helps customers identify and purchase efficient products through a user-friendly interface that includes a product’s energy score, satisfaction rating, price, rebate information, and cost savings.

This platform enables PG&E to serve as a trusted energy adviser by connecting customers with the information they need to increase plug-load efficiency, as described in Strategy 1.6 in the Existing Buildings Energy Efficiency Action Plan.

⁶⁵ “California Existing Buildings Energy Efficiency Action Plan,” p. 13.

⁶⁶ For more information, see Binley, Niederberger, Champniss et al. “Insights from PG&E’s Marketplace Initiative on Influencing Purchasing Decisions,” *Pacific Gas & Electric Company and Enervee—2016 ACEEE Summer Study on Energy Efficiency in Buildings*, http://aceee.org/files/proceedings/2016/data/papers/6_361.pdf

⁶⁷ For more information, see Appendix F: PG&E Planned AB 793 Offerings

⁶⁸ “California’s Existing Buildings Energy Efficiency Action Plan,” p. 67.

⁶⁹ California’s Golden Energy Efficiency Opportunity: Ramping Up Success to Save Billions and Meet Climate Goals,” p. 46.

Table 6 Intervention Strategy 3: Technical Assistance and Tools

Intervention Strategy	Barriers	Example Tactics	Existing, New, or Modified	Short, Mid, or Long-term
Technical assistance and tools to facilitate customer awareness of their energy use	Customers do not know how to act on energy information	Continue promoting existing EMTs (e.g. advanced power strips, bill forecasts, energy alerts) ⁷⁰	E	S
		Continue promoting Marketplace to provide customers with information that motivates the purchase of an energy efficient product	E	S
		Optimize HERs and expand the population of recipients	M	S
		Promote behavioral peak load reduction in capacity constrained areas (TDSM) using HERs	M	S
		Improve tools to support benchmarking, audits and other assessments for multifamily communities	N	M
		Provide customers with bundled EMT solutions tailored to meet their needs and maximize energy savings	N	S
Partners: Third party implementers, contractors, evaluators, retail partners				

The impact evaluation of PG&E's 2013 Home Energy Reports Program confirms HERs can be used to estimate energy savings coincident with periods of high electricity demand.⁷¹ Furthermore, a 2016 study by Nexant concludes HERs may be effective as behavioral demand response tools to reduce peak usage during periods of particularly high load (i.e. summer days). Both of these findings support PG&E's continued development of HERs to reduce peak load, particularly as part of TDSM opportunities to delay costly investments in energy infrastructure.

Intervention Strategy 4 – Financial Solutions

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⁷¹ "2013 PG&E Home Energy Reports Program: Review and Validation of Impact Evaluation," *DNV GL*, January 16, 2015, p. 9.

According to a 2016 report by ACEEE, residential customers face financial barriers to energy efficiency such as high up-front costs, long payback periods, and the lack of added property value as a result of energy efficiency.⁷² The Existing Buildings Action Plan also notes multifamily buildings must overcome the “split incentive” barrier, which describes the diverging incentives between tenants and landlords. On one hand, 80% of multifamily households are renters who pay the utility bill but do not control decisions over the structural or appliance improvements that could lower their bills.⁷³ On the other hand, building owners pay the utility bill for common areas but cannot control tenant behavior to reduce costs.⁷⁴ These financial barriers are particularly acute for low-income customers, 43% of whom live in multifamily housing.⁷⁵ In light of the significant financial barriers residential customers face, PG&E will provide a suite of financial solutions that will result in more residential customers taking energy efficiency actions and a higher percentage of customers using loans or other scalable models.

In the short-term, PG&E will continue to provide residential customers with existing loans, rebates, and incentives to overcome the up-front cost barriers that impede greater adoption of energy efficiency. This includes continuing to mitigate the split-incentive barrier through its coordinated approach of offering rebates for multifamily energy efficiency measures (see above). Moving forward, PG&E will complement these offerings with incentives for EMTs. These incentives provide added financial impetus for residential customers to actively manage their energy usage and realize control, operational, and behavioral savings. The California Energy Commission’s SB 350 Barriers Study Draft Report points out that the minority of low-income Californians who own homes have limited disposable income, which makes them “more risk-averse and less capable of participating in programs with high up-front payments or copayments for energy efficiency.”⁷⁶ PG&E is exploring tactics to improve accessibility to EMTs for low-income residential customers through the help of ESA and the California Alternate Rates for Energy (CARE) program.⁷⁷

PG&E will also modify its current approach by engaging residential customers with bundled financial solutions to drive deep savings. For example, bundled solutions may be coupled with data analytics to target customers with

Multifamily Energy Efficiency Collaboration

PG&E currently offers multifamily rebates to heighten awareness of energy efficiency among property owners, property managers, and tenants. These offerings are provided in collaboration with BayREN and MCE for multifamily event coordination and via a common customer interest form to help determine the best solutions to offer. In an effort to maximize savings potential and customer benefits, these rebate measures are coordinated with Energy Savings Assistance (ESA) and other energy efficiency programs, such as the Multifamily Upgrade Program. This integrated approach combines market-rate and income-qualified measures to ensure energy efficiency is accessible to all customers.

⁷² Cluett, Rachel and Jennifer Amann “Scaling Up Participation and Savings in Residential Retrofit Programs,” *American Council for an Energy-Efficient Economy*, p. v.

⁷³ Cluett, Rachel and Jennifer Amann “Scaling Up Participation and Savings in Residential Retrofit Programs,” *American Council for an Energy-Efficient Economy*, p. v.

⁷⁴ Cluett, Rachel and Jennifer Amann “Scaling Up Participation and Savings in Residential Retrofit Programs,” *American Council for an Energy-Efficient Economy*, p. v.

⁷⁵ “DRAFT STUDY REPORT: A Study of Barriers and Solutions to Energy Efficiency, Renewables, and Contracting Opportunities Among Low-Income Customers and Disadvantaged Communities,” *California Energy Commission*, September 9, 2016, p. 17,
http://docketpublic.energy.ca.gov/PublicDocuments/16-OIR-02/TN213599_20160909T160021_SB_350_BARRIERS_STUDY_DRAFT_REPORT.PDF

⁷⁶ “DRAFT STUDY REPORT: A Study of Barriers and Solutions to Energy Efficiency, Renewables, and Contracting Opportunities Among Low-Income Customers and Disadvantaged Communities,” *California Energy Commission*, September 9, 2016, p. 17,
http://docketpublic.energy.ca.gov/PublicDocuments/16-OIR-02/TN213599_20160909T160021_SB_350_BARRIERS_STUDY_DRAFT_REPORT.PDF

⁷⁷ For more information, see Advice Letter 3744-G-B/4886-E-B, “Second Supplemental: Request for Approval of PG&E’s Assembly Bill 793 Implementation Plan,” September 20, 2016.

high HVAC usage because these customers often require multiple interventions, including replacement of old HVAC equipment along with duct repair/replacement and building shell enhancements.

In addition, PG&E will collect proof of permit closure before paying rebates or incentives for all downstream central air conditioning or heat pumps and their related fans, in accordance with SB 1414.⁷⁸

Ultimately, this intervention strategy plays a critical role in spurring customers to take action. To recap, data analytics yields targeted customers, data access and awareness help customers identify energy saving opportunities, technical assistance and tools provide the means to realize savings, and financial solutions serve as added motivation to get energy efficiency measures off the ground. In this way, PG&E's customer intervention strategies can be thought of sequentially and are mutually reinforcing. Moving forward, all four strategies must be implemented in sync to reach stranded potential, maximize savings in existing buildings, and double energy efficiency by 2030.

Table 7. Intervention Strategy 4: Financial Solutions

Intervention Strategy	Barriers	Example Tactics	Existing, New, or Modified	Short, Mid, or Long-term
Financial solutions	Projects that generate deep savings often have high up-front costs, long payback periods, and are not recognized as valuable by the real estate market	Continue to offer loans, rebates, and incentives to overcome up-front cost barriers	E	S
		Continue to offer prescriptive incentives that motivate multifamily property owners and property managers to take action	E	S
		Bundle financing options with downstream rebates and incentives to provide targeted value propositions for customers with high savings potential	M	S
		Transition from standard measure-by-measure incentive models to a comprehensive, targeted approach supported by financing and metered savings to provide “performance-driven value” ⁷⁹	N	M

⁷⁸ For more information, see “Senate Bill No. 1414,” *California Legislative Information*, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB1414

⁷⁹ CEC, 2016. “California’s Existing Buildings Energy Efficiency Action Plan – 2016 Update.” p. 46

Intervention Strategy	Barriers	Example Tactics	Existing, New, or Modified	Short, Mid, or Long-term
		Incentivize EMTs to encourage customers to actively manage their energy usage ⁸⁰	N	S

Partners: Government agencies; financial lending institutions

A process evaluation of 2014-2015 Energy Upgrade California offerings identifies “53% of near-participants with incomes under \$50,000 reported that the cost of equipment was a barrier to their participation...while only 28% of near-participants with incomes above \$250,000 reported the cost of equipment as a barrier.”⁸¹ These findings support the fact that high upfront costs remain a significant barrier to managing energy efficiency offerings that both realize high savings potential and are accessible to all of PG&E’s customers. As a result, PG&E will manage incentive programs that promote greater accessibility to EMTs, HVAC, and other technologies that drive deep, persistent energy savings. Additionally, PG&E will look to bundled financial solutions such as loans and incentives to make energy efficiency a more attractive investment.

Intervention Strategy 5 – New Program Models

According to the California Energy Commission’s (CEC) Existing Buildings Energy Efficiency Action Plan, new program models based on performance-driven value are needed to increase the efficiency of existing buildings.⁸² Current models that pursue whole home retrofits have encountered cost-effectiveness challenges that constrain program reach, resulting in only 0.3% of eligible single family homes participating in the Home Upgrade Program.⁸³ The ability to measure energy savings at the meter presents a prime opportunity to re-think program design and implementation to achieve cost-effective energy savings. PG&E will continue to design, test, and refine new program models that aim to increase both the number of customers that take energy efficiency actions and the percentage using these scalable new models.

In the short-term, PG&E will continue to test its P4P model,⁸⁴ which enables third party aggregators to develop, design, and implement innovative energy solutions in exchange for payments based on gross portfolio savings achieved at a set rate per kWh and therm.⁸⁵ PG&E envisions a dynamic approach to program planning in which tactics can be modified in future years to prioritize locational savings, develop new measures or products (e.g., HEMS, HVAC), and aid workforce education and training market transformation objectives.

New program models using meter-based savings⁸⁶ will be facilitated by the development of the CalTRACK platform, which aims to develop “a standardized process for measuring residential energy efficiency savings.”⁸⁷

⁸⁰ “California Existing Buildings Energy Efficiency Action Plan,” p. 67.

⁸¹ “Energy Upgrade California Home Upgrade Program Process Evaluation 2014-2015,” *EMI Consulting*, September 12, 2016, p. 8.

⁸² “California’s Existing Buildings Energy Efficiency Action Plan,” p. 74-75.

⁸³ “Advice Letter 3698-G-A/4813-E-A,” p. 9.

⁸⁴ Berkeley Law, Center for Law, Energy & the Environment and the Emmett Institute on Climate Change and the Environment, UCLA, 2016. “Powering the Savings: How California Can Tap the Energy Efficiency Potential in Existing Commercial Buildings.” p.2

⁸⁵ “Advice Letter 3698-G-A/4813-E-A,” p. 1.

⁸⁶ Berkeley Law, Center for Law, Energy & the Environment and the Emmett Institute on Climate Change and the Environment, UCLA, 2016. “Powering the Savings: How California Can Tap the Energy Efficiency Potential in Existing Commercial Buildings.” p.14

⁸⁷ “Advice Letter 3698-G-A/4813-E-A,” p. 4.

CalTRACK will be an open source platform that enables third parties to conduct analysis using a standardized calculation method for consistent EM&V.⁸⁸ The successful implementation of CalTRACK highlights the importance of data access because its operation is based on energy data obtained through the Share My Data platform.⁸⁹ PG&E will continue to collaborate with the CEC, California Public Utility Commission (CPUC), other IOUs, and data analysis experts to drive development, launch, and refinement of the CalTRACK platform.

In the mid-term, PG&E will explore transitioning multifamily offerings to the P4P model based on key learnings from its initial deployment as a HOPP. PG&E is optimistic that successful P4P models can help transition a greater share of its portfolio to third parties while keeping administrative costs as low as possible. While the P4P model emerged in response to AB 802 and SB 350, its development also aligns with the CEEPS's goal to "develop partnerships for innovative financing programs, such as performance contracts"⁹⁰ and the California Existing Buildings Energy Efficiency Action Plan calls for "performance-based incentives."⁹¹ Ultimately, continued development of P4P and other innovative, scalable program models will play a key role in doubling energy efficiency by 2030.

Table 8. Intervention Strategy 5: New Program Models

Intervention Strategy	Barriers	Example Tactics	Existing, New or Modified	Short, Mid, Long-term
New program models to cost-effectively deliver comprehensive energy savings	New program models based on performance-driven value are needed to increase the efficiency of existing buildings	Test P4P program models that are proposed, developed, and implemented by third parties. Scale effective designs and seek innovative new approaches	E	S
		Develop the CalTRACK platform and use immediate feedback for real time program adjustments	N	S
		Transition multifamily offerings to the P4P model based on learnings from the initial P4P enrollment.	N	M
Partners: Third party implementers, Contractors, Evaluators, Retail Partners				

A process evaluation of PG&E's 2010-2012 Whole House Retrofit offerings finds participants struggled to realize energy savings from investments in energy efficiency due to factors such as negative behavior changes and a lack of financial resources to implement all recommendations.⁹² This finding reveals the need for new program

⁸⁸"Advice Letter 3698-G-A/4813-E-A," p. 4.

⁸⁹"Advice Letter 3698-G-A/4813-E-A," p. 4.

⁹⁰ "California Energy Efficiency Strategic Plan," *California Energy Commission*, January 2011, p. 21.

⁹¹ "California's Existing Buildings Energy Efficiency Action Plan," p. 74-75.

⁹² "2010-2012 PG&E Whole House Retrofit Program Phase II Process Evaluation Study—Methods and Findings," *SBW Consulting, Inc.*, December 31, 2013, p. 27, 163,

designs that encourage continued engagement between customers and their contractors so that customers are aware of all opportunities to increase savings.⁹³

To this end, the P4P model aims to create an on-going relationship between customers and their contractors by incentivizing third party aggregators to bundle behavioral, retro-commissioning, and operational activities for persistent savings. Since third party aggregators are paid based on metered savings, this type of new program design promotes innovative and flexible solutions that produce measurable results. New program models to reach stranded HVAC and building shell potential tie together several of the intervention strategies laid out here. Please see Appendix D for more detail.

Intervention Strategy 6 – Assistance for the Design and Building Communities

The 2015 Residential ZNE Market Characterization study finds the incremental cost of paying for a ZNE home compared to a code-built home ranges between 5-15%, or \$15,000 to \$50,000.⁹⁴ To achieve the CEESP's goal of constructing all new residential buildings as ZNE by 2020,⁹⁵ PG&E will provide assistance and incentives for the design community. Successful implementation of this intervention strategy will lead to a larger percentage of the design community and builders consistently building to ZNE specifications.

In the short-term, PG&E will continue to support its “Master Builder” initiative and California Advanced Homes Program (CAHP), which works with builders to adopt progressive energy efficiency measures that are part of future code updates. Current Master Builder and CAHP efforts include incentivizing high performance attics and walls, which are key components of the 2016 approved code. These efforts will be expanded in the short-term to incentivize measures to be included in the 2019 code update. PG&E’s continued use of the Master Builder initiative and CAHP aligns with the California New Residential ZNE Action Plan’s (“ZNE Action Plan”) goals of “creating a robust and well-trained industry that is able to implement and adapt to the technological innovations and integrated business strategies...to effectively meet the ZNE goals.”⁹⁶

Along these lines, PG&E will also continue to provide technical assistance and energy monitoring for ZNE demonstration pilots to educate and empower builders with the ability to implement ZNE designs. A particular emphasis will be made to include low-rise multifamily dwellings, which are included along with single family homes in the 2020 ZNE goal. In addition, PG&E will integrate innovative financial solutions into future ZNE demonstrations to identify pathways for increasing the affordability of ZNE. This approach also supports the ZNE Action Plan’s goal of “financing, affordability & value,” which includes informing “the creation of various financing and incentive products that will support the market.”⁹⁷

Ultimately, continued support of code readiness and ZNE demonstration projects will provide key building performance data while improving the workforce’s capacity to design and build residential ZNE buildings.

⁹³ For more information, see PG&E Advice Letter 3698-G-A/4813-E-A, p. 10.

⁹⁴ “Residential ZNE Market Characterization,” p. 13,

⁹⁵ “California Energy Efficiency Strategic Plan: January 2011 Update,” *California Public Utilities Commission and California Energy Commission*, January 2011, p. 9.

⁹⁶ “New Residential Zero Net Energy Action Plan 2015-2020: Executive Summary,” *California Public Utilities Commission and California Energy Commission*, p. 3.

⁹⁷ “New Residential Zero Net Energy Action Plan 2015-2020: Executive Summary,” *California Public Utilities Commission and California Energy Commission*, p. 3.

Beyond the CEEPS's ZNE goals, these progressive efforts serve as a testing ground for innovative energy efficiency practices that will contribute to doubling energy efficiency by 2030.

Table 9. Intervention Strategy 6: Assistance for the Design and Building Communities

Intervention Strategy	Barriers	Example Tactics	Existing, New or Modified	Short, Mid, or Long-term
Assistance for the Design and Building Communities	<p>The incremental cost for ZNE construction is estimated to be 5-15% greater than to-code homes</p> <ul style="list-style-type: none"> Implementation of new code occurs early and often in the technology adoption curve, which makes pushing builders beyond code a challenge while leaving some builders behind Cost effectiveness metrics used to assess code readiness activities do not take into account market effects and the state's ability to pursue more stringent code iterations 	<p>Continue the "Master Builder" initiative and CAHP, which helps builders with early adoption of measures that are a part of the next code cycle⁹⁸</p> <p>Continue ZNE demonstrations to equip builders with the assistance and tools to meet 2020 ZNE goals</p> <p>Investigate new financial solutions for builders and buyers as part of future demonstrations</p>	E E N	S S S
Partners: Builders, Statewide PMs, CEC				

The 2015 Residential ZNE Market Characterization finds that despite promising activity among innovative ZNE adopters, there are indications that "...the market is not currently poised to achieve a ZNE homes 2020 aspirational goal, including a lack of consumer demand, a lack of qualified building professionals, early adopters' misperceptions about the ZNE concept, [and] questions regarding the cost effectiveness of ZNE-type homes..."

⁹⁸ For more information, see "PG&E's California Advice Homes Program," TRC Energy Services, <http://www.trcsolutions.com/projects/utilities/pg-e-california-advanced-homes-program>

As a result of these barriers, PG&E is adopting a comprehensive approach that includes continuing to demonstrate new designs and approaches, pursuing code readiness projects, developing new financial solutions, and promoting workforce education and training opportunities for the design and building communities.

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Intervention Strategy 7 – Upstream and Midstream Partnerships

The CEESP identifies the need to improve Title 20 compliance by “working directly with manufacturers and distributors to improve appliance and equipment.”⁹⁹ Through partnerships with manufacturers, distributors, retailers, and other market actors in the supply chain, this intervention strategy will enable PG&E to increase the availability and stocking of LED lighting, EMTs, and plug load-related equipment. The Environmental Protection Agency (EPA) finds upstream and midstream incentives “can affect larger markets than direct incentives targeted to individual customers, because upstream and midstream players are able to offer the desire products or service to all the customers they serve, not just those who learn about direct customers rebates.”¹⁰⁰

In the short-term, PG&E will continue to partner with supply chain actors to increase awareness of offerings that reduce energy usage across technologies with high savings potential. For instance, recent research attributes 15-30% of a typical household’s electricity usage to home appliances and consumer electronics (“plug load” products).^{101,102} Combined, these plug loads are the fastest growing energy use category nationwide, a trend largely driven by the increasing number of plug load products per residence.¹⁰³

However, due to the relatively small savings offered by each plug load device, PG&E finds it can be difficult to keep administrative costs low and achieve market transformation through a downstream rebate program. In these cases, upstream and midstream approaches may be more effective at increasing customer adoption. This approach of targeting plug loads aligns with Strategy 1.6 (Plug-Load Efficiency) of the Existing Buildings Energy Efficiency Action Plan¹⁰⁴ and the CEESP’s goal to “develop comprehensive, innovative initiatives to reverse the growth of plug load energy consumption through technological and behavioral solutions.”¹⁰⁵

As part of AB 793 implementation, upstream and midstream partnerships will also be tapped to increase the availability and ultimately the cost of EMTs. In addition, these partnerships provide an opportunity for PG&E to improve customers’ experience with EMTs by working with product manufacturers and national standard setting organizations to increase demand for nationwide connectivity standards and protocols. PG&E will also conduct a “bottoms-up” review of its current partnerships to promote their continued success and cost-effectiveness.¹⁰⁶

Ultimately, upstream and midstream partnerships will enable PG&E to ensure supply chain actors are creating, distributing, and stocking the most effective energy solutions for customers.

Table 10. Intervention Strategy 7: Upstream and Midstream Partnerships

Intervention Strategy	Barriers	Example Tactics	Existing, New, or Modified	Short, Mid, or Long-term
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⁹⁹ “California Energy Efficiency Strategic Plan: January 2011 Update,” p. 66.

¹⁰⁰ “Customer Incentives for Energy Efficiency Through Program Offerings,” p. 6,

¹⁰¹ *Estimated U.S. Residential Electricity Consumption by End-use, 2011*, Energy Information Administration (2011, Updated 2013).

¹⁰² *The 2013 California Energy Efficiency Potential and Goals Study: Final Draft Report*, Navigant Consulting prepared for the CPUC (2013).

¹⁰³ Kwatra, Sameer, Jennifer Amann, and Harvey Sachs “Miscellaneous Energy Loads in Buildings,” *American Council for an Energy-Efficiency Economy*, June 2013, p. 1. http://www.ceesingersollrand.com/CEES_documents/2013.ACEEEMiscEnergyLoadsinBuildings.pdf

¹⁰⁴ “California’s Existing Buildings Energy Efficiency Action Plan,” p. 54.

¹⁰⁵ “California Energy Efficiency Strategic Plan: January 2011 Update,” p. 21.

¹⁰⁶ For more information, see Fogel, Cathy “Overarching Comments Program Administrator Business Plans Focus on Market Transformation Strategies,” September 27, 2016, or D.16-08-019, p. 60.

Intervention Strategy	Barriers	Example Tactics	Existing, New, or Modified	Short, Mid, or Long-term
Promote upstream and midstream activities to curtail the growth of miscellaneous plug load and increase availability of high quality LED products.	Downstream incentives may not always be sufficient to increase customer adoption of energy efficient products or equipment	Encourage manufacturers, distributors, and retailers to create, offer, and promote efficient products to reduce energy use	E	S
		Continue successful upstream and midstream program models such as Retail Product Platform (RPP)	E	S
		Perform a bottom-up review of upstream and midstream activities to rationalize and optimize them into the most cost-effective configurations ¹⁰⁷	N	S
		Drive demand for nationwide connectivity standard and protocols	N	S

Partners: manufacturers, distributors, retailers, regional and national utilities, government agencies such as EPA and local governments, Western Regional Utility Network (WRUN), third party vendors

The 2012 Program & Technology Review of PG&E's Home Energy Efficiency Rebate and Business & Consumer Electronics offerings highlights the need for a holistic and flexible approach whose ultimate goal is market transformation.¹⁰⁸ This finding underscores the importance of evaluating the market barriers for specific products and designing incentive approaches that are targeted to overcome those barriers.¹⁰⁹

To these points, this intervention strategy includes evaluating PG&E's existing upstream and midstream activities to determine which approaches are best suited to achieve energy savings cost-effectively. As a result of these efforts, future upstream and midstream activities will be paired with products or equipment that stand to benefit the most from these partnerships.

¹⁰⁷ Fogel, Cathy September 27, 2016. "Overarching Comments Program Administrator Business Plans Focus on Market Transformation Strategies."

¹⁰⁸ "Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER)/Business & Consumer Electronics (BCE), *Research into Action and Energy Market Innovations*, August 30, 2012, p. v,
http://www.calmac.org/publications/HEER__BCE_083012_FINAL.pdf

¹⁰⁹ "Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER)/Business & Consumer Electronics (BCE), *Research into Action and Energy Market Innovations*, August 30, 2012, p. v,
http://www.calmac.org/publications/HEER__BCE_083012_FINAL.pdf

Residential lighting has been a longstanding upstream program focused on manufacturers and retail partnerships. The focus of that effort has shifted from driving energy savings to ensuring high product quality. For more information on challenges and plans for residential lighting, see Appendix X.

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Intervention Strategy 8 – Outreach and Education

A 2010 report by the Lawrence Berkeley National Laboratory (LBNL) finds people tend to be biased towards maintaining the status quo and discount the future benefits of taking action.¹¹⁰ To overcome this barrier, PG&E will explore effective outreach and education approaches so that the engagement of residential communities in energy efficiency broadens outside of traditional programs.

In the short-term, PG&E will continue to engage customers through community-based social marketing campaigns, such as Step Up and Power Down. A 2012 study by the American Council for an Energy-Efficient Economy finds these campaigns are “an accessible way to apply a behavioral perspective in sustainability and energy efficiency programs.”¹¹¹ In addition, it concludes, “Strategies that encourage people to make public and durable commitments to behavioral change, or affect a social norm in a community, can have ongoing impacts as entire communities begin to view themselves differently, potentially leading them to complete additional energy-efficient actions.”¹¹² Ultimately, this market intervention strategy will enable PG&E to engage an entire community, inspiring those that do not participate in energy efficiency programs to realize the value of taking action.

Step Up and Power Down Residential (SUPD-R)

SUPD-R is designed to drive increased awareness of PG&E’s residential energy efficiency measures, change attitudes toward energy efficiency, and increase customer engagement and uptake in PG&E’s programs.

Campaign activities include grassroots organizing, volunteerism, and leveraging local community partnerships to share experiences, resources, and support for taking energy efficient actions at home.

The campaign was launched in Redwood City, San Carlos, and Woodland in 2015 and resulted in XX metrics.

Table 11. Intervention Strategy 8: Outreach and Education

Intervention Strategy	Barriers	Example Tactics	Existing, New, or Modified	Short, Mid, or Long-term
Outreach and education, such as community-based social marketing initiatives	People are biased towards maintaining the status quo and discount the future benefits of taking action	Engage customers through community-based social marketing such as Step Up and Power Down that operate based on the spirit of competition and normative social behavior	E	S
Partners: Regional Communities, third party vendors				

¹¹⁰ “Driving Demand for Home Energy Improvements,” p. 29.

¹¹¹ Vigen, Michelle and Susan Mazur-Stommen “Reaching the ‘High-Hanging Fruit’ through Behavior Change: How Community-Based Social Marketing Puts Energy Savings within Reach,” *American Council for an Energy-Efficient Economy*, October 2012, p. 10.

¹¹² Ibid.

Research conducted in 2006 on the California Local Energy Efficiency Program, highlights the impact that a champion or change agent can have on influencing the behavior of a larger group. In particular, the study reports "...a few people in a group will typically adopt innovative ideas and behaviors first, and spread them throughout the group."¹¹³ Encouraging customers with outreach and education campaigns that use normative social behavior to drive behavioral change aligns with PG&E's continued use of innovative campaign models such as Step Up and Power Down.

Increasing market awareness of energy efficiency will help broaden the reach of residential energy efficiency opportunities beyond those who have already participated in a PG&E offering. This heightened awareness contributes to greater adoption of behaviors that are needed to doubling energy efficiency by 2030.

Intervention Strategy 9 – Midstream Training

As the energy efficiency portfolio continues to shift from widget-based incentives to deeper retrofits and P4P models, having a knowledgeable workforce that is prepared to succeed in that demanding environment and deliver for the customers will be even more essential. Contractors and technicians must have the skillset to promote the best options for the customer and the program design must elicit that approach.

Further, studies suggest most residential sale transactions inadequately value efficiency, yet energy-efficient homes sell for 3%-20% more than comparable non-certified homes. In addition, studies find most homebuyers rate energy costs and efficiency as somewhat to very important when purchasing a home.¹¹⁴ As a result, untapped opportunity exists to "ignite the market for efficient homes and increase demand for residential energy efficiency."¹¹⁵

Table 12. Intervention Strategy 9: Midstream Training

Intervention Strategy	Barriers	Example Tactics	Existing, New or Modified	Short, Mid, Long-term
Midstream Training	Workforce training must align with overcoming barriers to achieve state policy	Collaborate with industry partners to increase awareness of and create market demand for energy efficiency during real estate transactions ¹¹⁶	E	S
		Incorporate sales training and awareness of financing opportunities into contractor and technician training programs	M	S

¹¹³ "Evaluation, Measurement, and Verification of the California Local Energy Efficiency Program," *Ridge & Associated, Vanward Consulting, and Brown, Vence & Associates, Inc.*, October 16, 2006, p. 3-10.

http://www.calmac.org/publications/CALEEP_Final_Report.pdf

¹¹⁴ US DOE, 2015. "Capturing Energy Efficiency in Residential Real Estate Transactions." p.1

¹¹⁵ US DOE, 2015. "Capturing Energy Efficiency in Residential Real Estate Transactions." p.1

¹¹⁶ CEC, 2016. "California's Existing Buildings Energy Efficiency Action Plan – 2016 Update." p. 55

Intervention Strategy	Barriers	Example Tactics	Existing, New or Modified	Short, Mid, Long-term
	goals			

Partners: Western Regional Utility Network (WRUN), EPA, WHPA, local governments, third party vendors, real estate organizations, builders, trade professionals, etc.

A recent study by Energy Market Innovations Consulting on the HVAC market finds that technicians rate utility training, apprenticeship, and in-field training are more effective than online or classroom training programs.¹¹⁷ In the last decade, PG&E has worked with industry experts to develop and enhance training programs and has required their completion as a prerequisite for participation in its HVAC and Home Upgrade offerings. This training may need to be expanded depending on the needs of contractors and technicians who deliver services through PG&E's comprehensive HVAC offerings.

In addition, when major building shell renovations or new HVAC systems are needed, contractors and technicians face the challenge of assessing the need for that work and upselling those deeper retrofits to customers who are often most concerned with up-front cost. In fact, the large majority of HVAC technicians working in the residential sector report being responsible for selling maintenance contracts and new HVAC equipment to customers.¹¹⁸ Further, only about half of technicians report having received sales training from their company. Yet three quarters of technicians responded that additional sales training would be helpful.¹¹⁹ Because these technicians and contractors ultimately have the most personal and direct contact with the customer, PG&E views sales training in conjunction with technical training as an opportunity to encourage deep retrofits going forward.

The “Market Research on Builder’s Selling Practices and Strategies for Energy Efficiency Homes” study found increasing home buyer interest in energy efficiency, and that energy efficiency will continue to be a key differential.¹²⁰ As a result, the study recommends an increased focus on training for builder and real estate communities so that they can speak confidently on the energy efficient building features.¹²¹ PG&E plans continued support for training¹²² for key stakeholders that can give them the tools to motivate the value of energy efficiency in residential real estate transactions, such as real estate brokers and agents, appraisers, home inspectors, lenders, and contractors.¹²³

¹¹⁷ “California HVAC Contractor & Technician Behavior Study, Phase II” *Energy Market Innovations Consulting*, (2015), Pg. 41; For residential technicians who received the following trainings, the fraction who rated the training as “very effective” or “effective” is given in parentheses. On the Job Training (99%), Union Apprenticeship Training (100%), Utility Training (85%) Online HVAC Course Training (69%), Community College Training (64%).

¹¹⁸ *California HVAC Contractor & Technician Behavior Study, Phase II*, Energy Market Innovations Consulting, (2015), Pg. 66 - 71; of technicians operating in the residential HVAC sector, 93% report being responsible for selling new HVAC equipment directly

¹¹⁹ *California HVAC Contractor & Technician Behavior Study, Phase II*, Energy Market Innovations Consulting, (2015), Pg. 66 - 71

¹²⁰ Navigant, 2013. “Market Research on Builder’s Selling Practices and Strategies for Energy Efficiency Homes.” p. 24

¹²¹ Navigant, 2013. “Market Research on Builder’s Selling Practices and Strategies for Energy Efficiency Homes.” p 13

¹²² CEC, 2016. “California’s Existing Buildings Energy Efficiency Action Plan – 2016 Update.” p.55

¹²³ US DOE, 2015. “Capturing Energy Efficiency in Residential Real Estate Transactions.”p.10

H. Leveraging Cross-cutting Resources

Finance: Finance offerings will play a critical role in *Intervention Strategy 4: Financial Solutions* and will enable residential energy efficiency measures to get off the ground through a suite of loans, rebates, and incentives. PG&E will continue to offer low-risk financing for multifamily such as On-Bill Financing (OBF) and OBF Alternative Pathway, and facilitate On-Bill Repayment (OBR). The availability of flexible financing options will play a key role in ensuring that all customers can access and use residential energy efficiency offerings, regardless of their income levels.

PG&E is also working with mortgage lenders to explore incorporating the value of energy efficiency as a loan parameter. This approach aims to mitigate the fact that “energy efficiency is not recognized in property listing, appraisals, or valuation processes.”¹²⁴

Emerging Technologies (ET): ET primarily supports *Intervention Strategy 3: Technical Assistance and Tools* because it plays a leading role in testing and recommending EMTs that will be provided to residential customers to meet AB 793’s goals. ET not only tests whether a given EMT promotes smarter energy management, but also identifies which technologies are best suited for integration with other demand side management offerings, such as demand response.

Workforce Education & Training (WE&T): PG&E will continue to use WE&T resources to improve the skills and knowledge-base of the design and building communities. In this way, WE&T will play a critical role in supporting *Intervention Strategy 7: Assistance for the Design and Building Communities* because it will provide education and training opportunities for these stakeholders to implement ZNE measures. WE&T currently offers more than 100 courses relevant to the residential sector, ranging from training for Title 24 compliance to ZNE retrofits.

In addition, WE&T will support *Intervention Strategy 9: Midstream Training*. WE&T will provide training and support for contractors to right-size HVAC installations and complete proper permits as required by the recent approval of SB 1414. WE&T will also use existing partnerships with organizations such as the Sheet Metal and Air-Conditioning Contractors National Association (SMACNA) and the California Building Industry Association (CBIA) to develop the appropriate training programs and promote their availability throughout their memberships. WE&T will also support training real estate professionals on the value of energy efficiency in the home buying and selling process.

Marketing, Education, and Outreach (ME&O): ME&O will play a central role in *Intervention Strategies 1-4* due to the importance of engaging residential customers at the appropriate time, through the proper communication channel, and with the most effective messaging. For instance, PG&E will use data analytics to conduct targeted outreach to residential customers with the greatest savings potential and empower them with a personalized suite of technical assistance, tools, and financial solutions.

In addition, ME&O will be used to lead the design and implementation of engaging outreach and education as part of community-based social marketing campaigns such as Step Up and Power Down (See *Intervention Strategy 8: Outreach and Education*).

PG&E will collaborate with the IOUs, the CPUC, and other state actors (e.g., California Energy Commission, State Treasurer’s Office) to ensure that we are aligned with them in pursuing our common energy efficiency goals. An important means for doing this is through our role as a stakeholder in the statewide marketing, education, and outreach (SW ME&O) program.

¹²⁴ “Existing Buildings Energy Efficiency Action Plan,” p. 13.

SW ME&O seeks to empower Californians to take actions that will lead to lower bills, higher energy efficiency, and the adoption of demand-side solutions including customer-owned renewable energy technologies. As an active participant in the creation for SW ME&O's Five-year Marketing, Education, and Outreach Strategic Roadmap and Annual Joint Consumer Action Plan in 2017, PG&E will work with other stakeholders to determine the right blend of state and local efforts to ensure that customers are aware of, and encouraged to participate in, California's energy management and efficiency programs and opportunities.

Codes and Standards (C&S): C&S will coordinate closely with PG&E's residential program as part of *Intervention Strategy 7: Assistance for the Design and Building Communities* to support the transition to ZNE for all new residential construction by 2020. Specifically, C&S will continue to collect primary data on equipment performance both *in situ* and in laboratory conditions to determine how equipment impacts overall building performance uniquely in single family and multifamily communities as well as on the grid as a whole. This detailed information will serve as a key input in the design of PG&E's broader offerings of technical assistance, tools, and financial solutions (See *Intervention Strategy 3: Technical Assistance and Tools* and *Intervention Strategy 4: Financial Solutions*) that contribute to improving the efficiency of existing buildings and doubling efficiency by 2030.

PG&E Residential Programs/Incentives Targeted by Intervention Strategies

PG&E's nine intervention strategies will translate into a set of existing, modified, and new programs, as illustrated below. This table is illustrative, and does not represent the full suite of program offerings.

Table 13. PG&E Residential Programs/Incentives Targeted by Intervention Strategies

	Plug Load and Appliances	Energy Upgrade California	Pay for Performance	Energy Advisor	Multifamily Energy Efficiency Rebates	California New Homes Multifamily	HVAC
Data Analytics		x	x	x			x
Data Access		x		x			
Financial Solutions		x	x	x	x	x	x
New Program Models		x	x			x	x
Technical Assistance and Tools		x		x			
Incentives for the Design Community							

Upstream and Midstream Activities	x						
Outreach/ Education							x
Training for Midstream Market Actors		x	x				x

Within *Section G: PG&E's Approach to Achieving Goals*, PG&E describes new and innovative strategies and tactics, some of which will lead to pilot efforts at the program level. PG&E will describe any unique and innovative aspects of each program, as well as any pilots contemplated or underway, within its program-level implementation plans.

Additionally, PG&E will consider the appropriate workforce standard requirements, such as any required certifications, minimum performance standards, or pre-qualification process for specific programs in support of its energy efficiency portfolio. As applicable, PG&E will detail workforce standard requirements in each Implementation Plan (IPs).

I. Integrated Demand Side Management (DSM)

Integrated demand side management is a company-wide effort that integrates energy efficiency, distributed generation, storage and demand response with new business applications and distribution planning to support cost effective distribution and transmission system reliability.¹²⁵ PG&E will expand this locational effort by utilizing the existing framework of offerings and explore third party opportunities to support PG&E in this important initiative. IDSM leverages the residential portfolio's segments and identifies the dominant segment within the target location (constrained substation).¹²⁶ This platform delivers a strategy and implementation plan that enhances the marketing, outreach and location energy efficiency participation that feeds energy from the identified substation.

Residential Market and TDSM

The recognition that energy efficiency is a valuable grid resource and partners effectively with demand response programs led PG&E to develop the Targeted Demand Side Management (TDSM) Program. This effort integrates both energy efficiency and demand response tools that partner to defer investments in transmission and distribution capacity, which in turn frees capital to fund other investments to ensure system-wide safety and reliability. To date, the residential energy efficiency programs have contributed to meeting load needs in more than ten regions across the service territory. The strategies developed through the TDSM Program will help PG&E hit the ground running in addressing resource needs from retirement of Diablo Canyon nuclear generation

¹²⁵ Russell, Baatz, Cluett, et al. "Recognizing the Value of Energy Efficiency's Multiple Benefits," *American Council for an Energy-Efficient Economy*, December 2015, pp. 28-29.

¹²⁶ Zawadzki, Lin, Dahlquist, Bao, et al. "Personalized energy efficiency program targeting with association rule mining," *Pacific Gas and Electric Company—2016 ACEEE Summer Study on Energy Efficiency in Buildings*, p. 8-9.

facility is taken offline.¹²⁷ The program met its original target load reductions on three of its four targeted substations. With a total goal of 7.8 MW in savings, PG&E achieved 8.9 MW total paid savings. The final substation, Lammers/Banta, met goal in early 2016. In 2016, six additional substations are targeted for approximately 8.2MW reduction by the end of 2017.¹²⁸

Residential and Distributed Energy Resources (DER)

The IDSM effort is conduit to better integrate controls and the power of data analytics into the operations of PG&E's customers. PG&E leverages the following programs:

- Demand Response (DR) programs can take advantage of new controls to better integrate residential customers into DR programs building a more robust response to potential grid events and leveraging control over localized residential activities. Understanding the residential customer mix is important in offering the right DR program for their needs.
- Distributed Generation (DG) participation has been on the rise in the residential segment, specifically as it relates to solar. PG&E will continue to support the interconnection of solar systems in the residential market and as solar continues to rise; Storage will be an important element to maintain transmission reliability.
- Storage is one area where PG&E is preparing for future growth. As peak demand hours are shifting past the sunny times of the day, Storage will help keep the transmission lines less constrained so the customer can pull from the on-site energy storage directly. PG&E anticipates that the residential segment will be active in this emerging technology.

Time-of-Use (TOU) Rate Changes

The existing residential rate structure in California has not changed in over 15 years. PG&E's goal is to meet customer expectations by offering more choices and control. Today the existing rate plan has multiple pricing levels (tiers). The price of energy increases as more energy is used. Moving forward, the number of pricing levels will be reduced making energy usage easier to understand and manage. PG&E is introducing two new Time-of-Use (TOU) rate plans with pricing based on time of day. Starting in 2019, all residential customers will default to TOU rates, but customers can choose to stay on two-tiered rates if they prefer.

TOU customers will pay lower prices for electricity used during periods of low demand, such as late night, early morning, mid-day and weekends. With more rate options, customers will have greater control over when and how they use energy. Additionally, the changes are intended to encourage customers to shift their usage to support energy conservation. If a customer experiences an increase in energy costs due to the change, energy efficiency can be pitched as an opportunity to mitigate the negative cost impact.

How BPs will help reduce load during TOU periods

Customers can take a free, five-minute online Home Energy Checkup to see personalized information on programs available to help manage energy use and lower their bills.¹²⁹ Data analytics and the advent of meter-based savings present an opportunity for PG&E to target bundled financial solutions for customers with high savings potential as well as low-income communities. PG&E will also develop financial solutions to promote greater adoption of EMTs. All of these strategies and tactics will help reduce load and diminish barriers to load reduction during TOU periods.

¹²⁷PG&E announced in June of 2016 plans to take Diablo Canyon Power Plant off line in 2025. Diablo currently operates with 2.3 GW capacity and supplies 22% of PG&E power, which accounts for nearly 10% of California's statewide electricity consumption. *Economic Benefits of Diablo Canyon Power Plant; An economic Impact Study*, P. Mayeda and K. Riener (2013).

¹²⁸ PG&E energy efficiency Annual Report, p. 7

¹²⁹ www.pge.com/homecheckup

How BP will diminish barriers to load reduction during TOU periods

In the short-term, PG&E will use its marketing, education, and outreach (ME&O) resources to drive greater customer engagement with data platforms. In the mid-term, PG&E will promote data platforms to third parties, who play a critical role in delivering energy savings through implementation of deep retrofits and the design of new tools. PG&E will optimize Home Energy Reports (HERs) for greater effectiveness and expanded reach. PG&E will also continue working with the statewide Emerging Technologies (ET) team to inform the design of offerings that promote EMTs in accordance with AB 793. PG&E's Marketplace as well upstream and midstream program models such as Retail Product Platform (RPP) help customers choose energy efficient products.

How strategies will provide info to customers and/or provide a tool to show how program may impact customer energy usage during different TOU periods?

Customers can make smarter energy choices and manage their energy costs through PG&E developed data platforms such as My Account, My Energy, and Share My Data. These products reduce the barriers to load reduction during TOU periods by increasing access to energy data for residential customers and authorized third parties. Customers can choose to be notified when their bill is forecasted to reach a certain dollar amount. And, they can set their own amount and choose their own channel for notification, such as text, email or phone.

How strategies will analyze whether a customer may experience greater savings by switching to a different, opt-in TOU rate

PG&E is helping customers understand whether they may experience greater savings by switching to a different, opt-in TOU rate plan. Customers can do a rate comparison where the PG&E website will analyze their usage and recommend the best rate based on the estimated annual cost.^{130 131} Customers can also find out about other rate opportunities including SmartRate and SolarChoice.

ME&O and Rate Reform

PG&E is communicating these changes to customers through town hall meetings, events and workshops, email/social media, and rate comparison mailers.

¹³⁰ Not all customers are eligible (example, non-SmartMeter™, CCA, Customer Generated Solar, etc.)

¹³¹ www.pge.com/myrate

J. PG&E and State Policy Goals

Policy Drivers	Guidance Given	PG&E's Support for Policy
SB350	<ul style="list-style-type: none"> • Doubling of energy efficiency savings by 2030 • Address barriers for low-income customers to energy efficiency and weatherization investments, including those in disadvantaged communities, as well as recommendations on how to increase access to energy efficiency and weatherization investments to low-income customers. 	<ul style="list-style-type: none"> • Leverage data analytics and customer segmentation to target customers based on high savings potential and market transformation needs • Continue to partner with manufacturers and distributors to make purchasing energy efficiency equipment easy and affordable • Drive qualifying customers to Energy Savings Assistance and CARE programs, continue to serve customers with no-cost Moderate Income Direct Install services, and coordinate with public agencies on targeting opportunities for public housing • Develop community-level initiatives such as Step Up and Power Down to increase awareness of energy efficiency and reduce energy waste
AB 802	<ul style="list-style-type: none"> • Benchmarking • Provide financial incentives and assistance for high opp. projects 	<ul style="list-style-type: none"> • Test pay for performance (P4P) program models that are proposed, developed and implemented by third parties. Scale up the most effective designs and continually seek innovative new approaches.
AB 793	<ul style="list-style-type: none"> • Provide education on energy management technologies • Help customers understand and manage energy • Provide incentives for energy management technology 	<ul style="list-style-type: none"> • PG&E will continue to promote and enhance online energy management tools to provide customers with insights on their energy usage, rate education and comparison and ways to save. PG&E will continue to promote third party vendors access to Stream my Data/Green Button Connect as a way to encourage innovation in customer tools and offerings. Additionally, PG&E will launch a smart thermostat incentive to help customers better manage their energy use.

Policy Drivers	Guidance Given	PG&E's Support for Policy
AB 758	<ul style="list-style-type: none"> • Access to data, partnering to increase awareness • Increase plug load efficiency • energy efficiency procurement model • Recognized value of energy efficiency upgrades 	<ul style="list-style-type: none"> • PG&E helped create and continues to refine an innovative Retail Product Platform (RPP) strategic market transformation effort designed to create long-lasting, sustainable changes in the functioning of product-specific markets by reducing market barriers to the adoption of energy efficient plug-load appliances • Training real estate professionals on the value of energy efficiency
SB 1414	<ul style="list-style-type: none"> • Requires that, beginning Jan 1, 2017, IOUs collect proof of permit closure before paying rebates or incentives to customers or contractors for central air-conditioning or heat pumps and their related fans. 	<ul style="list-style-type: none"> • Collect proof of permit closure before paying rebates or incentives for all downstream central air conditioning or heat pumps and their related fans.
CEESP	<ul style="list-style-type: none"> • New construction will reach “zero net energy” (ZNE) performance (including clean, onsite distributed generation) for all new single and multi-family homes by 2020. • Home buyers, owners and renovators will implement a whole house approach to energy consumption that will guide their purchase and use of existing and new homes, home equipment (e.g., HVAC systems), household appliances, lighting, and “plug load” amenities. • Plug loads will be managed by developing consumer electronics and appliances that use less energy and provide tools to enable customers to understand and manage their energy demand. • The residential lighting industry will undergo substantial transformation through the deployment of high-efficiency and high-performance 	<ul style="list-style-type: none"> • Continue to build on the Residential New Construction Core Program (CAHP) to drive builders to the ZNE goal for single family new construction through the next Code cycle. • PG&E helped create and continues to refine an innovative Residential Product Platform (RPP) strategic market transformation effort designed to create long-lasting, sustainable changes in the functioning of product-specific markets by reducing market barriers to the adoption of energy efficient plug-load appliances

Policy Drivers	Guidance Given	PG&E's Support for Policy
	lighting technologies, supported by state and national codes and standards.	

K. PG&E's Partners and Commitment to Coordination

PG&E's success in the residential sector will rely on a broad range of program administrators, regulators, government agencies, universities and other educational entities, market actors, and stakeholders.

As discussed in *Section G: PG&E's Approach to Achieving Goals*, PG&E's emphasis on strategic partnerships is a key component to its vision for the residential sector.

Program Administrators

PG&E will collaborate with program administrators and publicly-owned utilities (POUs) to share best practices and lessons learned, ensure consistent messaging and program delivery, minimize gaps and program overlap, and coordinate implementation of statewide offerings, and local offerings that cut across multiple service territories. For example, customers in overlapping counties should have access to the same program offerings.

BayREN and MCE

Both BayREN and MCE work closely with PG&E to deliver energy efficiency programs. While PG&E provides funding to both BayREN and MCE, PG&E does not have oversight over BayREN or MCE's activities, and it will be important to ensure cooperation between the two PAs to create a positive experience for the customer and maximize energy savings for both parties. PG&E will continue to support collaboration as both BayREN and MCE continue to grow and develop their services.

California Public Utilities Commission (CPUC)

PG&E will work with the CPUC and staff to assess business plan performance, and identify opportunities for continuous improvement. Additionally, PG&E will coordinate with Commission staff to identify and perform market research studies and other studies to ensure the business plans metrics are effectively evaluated. As PG&E modifies existing residential programs, and/or develops new programs, PG&E will work in close concert with Commission staff to ensure that these programs are "EM&V-ready," and meet CEEESP, and other state policy directives.

Freddie Mac

Collaborating with Mortgage industry leaders to explore new approaches to financing by conducting research to assess impact and trend analysis of financing elements with respect to energy efficiency home improvements affecting loan performance, property value and loan prepay speed.

Government Agencies

PG&E will maintain and/or develop new partnerships with government agencies to advance collective interests in the agricultural sector. PG&E will work closely with these agencies to develop, refine, and implement, where applicable, key intervention strategies and programmatic activities. Agencies include:

- CEC
- Local Building Code Agencies - PG&E will work with building departments throughout our service territory to streamline permitting process and encourage enforcement of permitting laws.
- EPA – Continued work via the Retail Products Platform

Third Party Implementers and Market Actors

Third party program implementers have been, and will continue to be, an important delivery channel for PG&E. In addition, PG&E plans to continue to, and expand its work with organizations that represent key residential equipment and service providers such as HVAC companies, pump companies, specialized vendors; farm management services, pest control advisors, and agricultural banks. PG&E will use these relationships to bring new products and services to its residential customers, and provide enhanced training and technical support for key areas of focus for residential customers.

Stakeholders

PG&E will continue to engage with experts through participation in the California Energy Efficiency Coordinating Committee (CAEECC), and the residential subcommittee. PG&E will solicit stakeholder feedback input through the life of its Business Plan, and in the development, refinement, and modification of intervention strategies and programmatic activities for Implementation Plans.

Disadvantaged Communities

PG&E has offered free energy efficiency programs to income-qualified customers in its 48 counties since 1983. The Energy Savings Assistance Program's (ESA) objective is to help income-qualified customers reduce their energy consumption and costs while increasing their comfort, health and safety. The ESA Program is ratepayer-funded and is available to PG&E customers living in all housing types (single family, multifamily, and mobile homes), regardless of whether they are homeowners or renters. ESA uses a prescriptive, direct install approach to provide free home weatherization, energy efficient appliances and energy education services to income-qualified PG&E customers throughout the PG&E's service area. To qualify for the ESA Program, the total customer household income must be equal to or less than 200 percent of the Federal Poverty Guidelines, with income adjustments for family size. The 2015 ESA Program treated 100,573 homes with a mix of measures and services, including energy education, energy efficient appliances, and home weatherization.¹³²

¹³² Pacific Gas and Electric Company ESA Program and CARE 2015 Annual Report

L. Statewide Administration and Transition Timeline

TBD

M. Solicitation Strategies

TBD

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N. Metrics and EM&V Considerations

PG&E and the other PAs understand the importance of ensuring that all metrics provide value to the CPUC, program administrators, or other stakeholders. We also recognize that listed metrics can have powerful and unintended effects¹³³.

Below we propose draft metrics as of October 2016. We expect that these metrics will change before the final draft as we attempt to compute and thoroughly document the baseline values. Where the metrics may not make sense, we intend to revise to better capture what will be valuable to the CPUC, program administrators, or other stakeholders.

Ultimately, all of the metrics that we propose for the final BP draft will be consistent with the agreed-upon statewide guiding principles for the metrics that was shared with the Energy Division on Aug 16, 2016 (see Table 1 below).

Metrics should...
Be used and useful by PAs to manage portfolio
Inform on the progress to achieving desired market effect(s) and strategy effectiveness
Rely on data collected during program implementation and/or data reporting to CPUC
Simple to understand and clear of any subjectivity
Outcome metrics preferred, but output metrics have high benefit to cost ratio
Not all metrics have a readily interpretable meaning, context is needed
Not a replacement for EM&V

Table 1. Guiding Principles for Metrics

The primary metrics that we are proposing are our energy savings metrics. We are also proposing additional secondary metrics, such as participation, to meet the expectations (and requests) of the CPUC; however, we note that there are times when participation may actually need to decrease in order to focus resources to reach savings goals. As such, more participation does not always track to more savings. Moreover, although we anticipate that participation will increase in the long-term as we bring in new scalable models, it will not be possible to track participation at the customer level as programs start to move to mid- or upstream program models.

The draft metrics proposed are aligned with the overall program goals. Specifically, within the next-10-year period, PG&E's primary goal for the residential sector is to:

- Save XX GWh, XX MW, and XX MM therms focusing on high savings opportunities within both single family and multi-family properties

Secondary goals that we intend to track include:

¹³³ Perrin, in an article in the American Journal of Evaluation, discussed certain known limitations of performance metrics. Among these limitations, he described varying interpretation of the “same” term and concepts, goal displacement, use of meaningless and irrelevant measures, and cost-savings vs. cost-shifting. (Perrin, Burt. 1998. *Effective Use and Misuse of Performance Measurement. American Journal of Evaluation 1998:19,367.*)

- Reach an increasing percentage residential customers (increasing from X% to XX% over the 10-year period) by targeting customers with high savings opportunities within both SF and MF
 - Within multifamily, reach an increasing number from about X% in 2017 to XX% over the 10-year period.
- Increase customers' ability to manage energy by increasing the proportion of customers utilizing EMTs from X% to Y%
- Integrate energy efficiency with other DER options within x% of residential buildings
- Increase operational efficiencies by reducing costs of the residential energy-efficiency programs through a metric such as reducing the ratio of \$/kWh and \$/therm saved by x% through the use of cost-effective scalable program models such as P4P

In addition to these goals that are directly attributable to our programs, we also seek to influence the market through larger market transformation efforts. Through these efforts, we seek to:

- Assist California in reaching the CEESP goal of ZNE for 100% of all new residential construction by 2020 by engaging builders and other market actors, and supporting new C&S
- Transform specific markets, in particular:
 - Increasing the market share of efficient lighting such as high quality LED lighting
 - Increase plug load efficiency

Direct Effects from PG&E Efforts

PG&E's proposed sector-level metrics that can be tracked and monitored with some frequency (i.e., monthly, quarterly, or annually) are shown in

Table 2.

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Table 2. Direct PG&E Residential Sector Effects and Metrics

PG&E Goals	Intervention Strategies	Metrics	Baseline (or Benchmark)	Metric Source	Short Term Target (1-3 years)	Mid Term Target (4-7 years)	Long Term Targets (8-10+ years)
Save XX GWh, XX MW, and XX MM therms	All	Electricity saved	Average of XX GWh/year across 2011-2015	Annual Ex ante Net Savings from program tracking	XX GWh	XX GWh	XX GWh
		Demand saved	Average of XX MW / year across 2011-2015		XX MW	XX MW	XX MW
		MM Therms saved	Average of 4.1 MM Therms/year across 2011-2015		XX MM Therms	XX MM Therms	XX MM Therms
Reach an increasing percentage residential customers (from about X% to XX% over the 10-year period) by X%	Technical Assistance and Tools	Annual proportion of all customers participating in energy efficiency programs	XX% per year average across 2011-2015 (electric participants only) with tracking by MF versus SF	Program tracking databases	X% / year	X%/year	X%/year
	Financial Solutions	Cumulative participating in energy efficiency programs (unique customers)	(could include a benchmark if you have one for 2013-2015)		XX% cumulative over time frame	XX% cumulative over time frame	XX% cumulative over time frame
Notes on this metric: Participation may go up or down based on the type of program design. Over time, we expect to touch a larger percentage of customers with our programs, but these will not be able to be tracked if most programs move to mid- and upstream program models. We will revisit this metric and revise based on the final program models. We expect that the denominator for the population will need to stay constant over some period of time.							
Increase customers' ability to manage energy	Data Access	Proportion of customers who access their data through EMTs	XX% in 2015	Web analytics and tracking databases for programs with EMTs	XX% per year	XX% per year	XX% per year
	Technical assistance and Tools	Notes on this metric: EMTs will need to be defined during the baseline period, but "may include a product, service, or software that allows a customer to better understand and manage electricity or gas use in the customer's home or place of business."					

PG&E Goals	Intervention Strategies	Metrics	Baseline (or Benchmark)	Metric Source	Short Term Target (1-3 years)	Mid Term Target (4-7 years)	Long Term Targets (8-10+ years)
Integrate energy efficiency with other DER options within x% of residential buildings	Technical Assistance and Tools Financial Solutions	Proportion of residential buildings with energy efficiency and at least one other DER option through PG&E (such as DR participation, DG, or storage)	(some insight from IDSM report but will need to see if PG&E can track)	Tracking databases for EE, DR, DG or other utility DER efforts	XX% buildings over time frame	XX% buildings over time frame	XX% buildings over time frame
Note on this metric: We are not currently considering savings from DER since DER enabled does not always lead directly to savings (e.g., if DR events are not called).							
Increase operational efficiency by a metric such as reducing the ratio of \$/kWh saved and \$/therm saved	All	Annual leveled cost of energy (kWh)	Need baseline value from E3 calculator used in 2017 filing	Monthly tracking spreadsheets for net reported savings and costs and EUL from program tracking database	XX \$/kWh	XX \$/kWh	XX \$/kWh
Annual leveled cost of energy (therm)							
Notes on this metric: PG&E is considering whether this metric should be leveled cost of energy saving or some other metric. If leveled costs, it will be calculated by dividing the program costs by the sector level lifetime ex ante net savings of measures installed in one year.							

PG&E Goals	Intervention Strategies	Metrics	Baseline (or Benchmark)	Metric Source	Short Term Target (1-3 years)	Mid Term Target (4-7 years)	Long Term Targets (8-10+ years)
Assist in reaching the CEEESP goal of ZNE for 100% of all new residential construction by 2020	Technical Assistance Financial Solutions	# of ZNE Residential New Construction buildings receiving financial or technical assistance	2015 RNC participation (buildings)	EE program tracking database for any activities associated with Residential New Construction	XX buildings per year	XX buildings per year	XX buildings per year

Notes on this metric: We will consider whether these should be simply designated ZNE buildings or verified ZNE (which would be a longer-term study rather than a tracking metric).
See also "market effects" table for related outcome metric

Overall Statewide Market Effects within the Sector

The tables above document outputs that can be tracked by PG&E; however, we also anticipate that broader market studies should see changes in the overall markets over time based on PG&E's program investment (as well as other factors). In the tables below, we document market level indicators. Note that these need to be tracked through longer-term EM&V studies, and thus are not considered PG&E metrics, but rather broader statewide market indicators that our efforts are leading to the changes that the state desires.

As part of a statewide effort, PG&E recommends tracking the following at the market level.

Table 3: Market Level Indicators for Residential Sector

Market Level Goals	Intervention Strategies	Market Indicators	Baseline	Source	Notes on Indicators
Assist in reaching the CEEESP goal of ZNE for 100% of all new residential construction by 2020	Technical Assistance and Tools Financial Solutions	Proportion of all residential new construction that is ZNE	<X% in 2015	Tracking or EM&V Study	XX% (Study updated by end of year DATE)

Market Level Goals	Intervention Strategies	Market Indicators	Baseline	Source	Notes on Indicators
	Incentives for Design Community				
Increase the market share of energy efficient lighting such as high quality LED lighting	Upstream and Midstream Activities to Support EE Equipment	TBD	TBD	Statewide Lighting and Appliance Saturation Study	We are considering an indicator tied to AB 1109, which sets a goal of reducing CA residential lighting electricity usage by 50% from 2007 to 2018. According to recent analysis by TRC, we have achieved 31% toward that goal to date, and have 19% more to go: http://aceee.org/files/proceedings/2016/data/papers/2_677.pdf
Increase plug load efficiency	Upstream and Midstream Activities to Support EE Equipment	Indicators TBD and may include monitoring of residential average plug load energy use	TBD	TBD	While PG&E is committed to monitoring, and will work to slow growth, plug load may grow as EVs come on the grid in major numbers. We are considering what indicators may be good to monitor through studies.

O. EM&V Preparedness and Research Needs

EM&V Needs

EM&V ‘preparedness’ refers to identifying specific data collection strategies early in a program’s history to support internal performance analysis and program evaluations. As sector-specific programs and energy efficiency measures are developed to support PG&E’s residential business plan, PG&E will collaborate with CPUC staff and their evaluation consultants to ensure that appropriate data collection and reporting capabilities are in place to facilitate accurate evaluation. Details on data collection and reporting will be provided in as much detail as possible in PG&E’s Implementation Plans (IPs). So-called ‘EM&V 2.0’ methodologies—those which leverage the increased availability of information and communications technologies including Smart Meters and communicating smart thermostats, as well as cloud-based software that can facilitate improved data access and advanced analytics—will be used wherever PG&E and CPUC evaluation teams believe these offer more accurate and cost-effective evaluations. More traditional tracking data (e.g., contact information, project development and technical descriptions, savings calculations) will also be available to support evaluation efforts.

PG&E will track and report the following residential sector data to apprise the CPUC and stakeholders of its progress, starting with monitoring efforts:

- **Monitoring:** These efforts will focus on sector-level spending, sector-level savings, participation among single family and multifamily customers, participation of three targeted segments, participation in constrained areas, average energy use among participants (not adjusted).
- **Embedded Evaluation:** Embedded evaluation involves placing internal utility evaluation specialists into program teams from the onset of program design and planning throughout implementation. By including the research perspective from an early point, embedded evaluation seeks to inform new or enhanced program designs, improve program implementation and documentation, identify and measure key performance indicators to provide program teams with ongoing feedback so that modifications can be made on an ongoing basis, and position programs for successful third-party evaluation (that is, improving their “evaluability”). The use of embedded evaluation is not a substitute for third-party evaluation. Rather, embedded evaluation complements other evaluation activities and positions pilots and programs for evaluation success. Here are some specific illustrations how PG&E’s energy efficiency programs benefit from embedding evaluation into program efforts:
 - **Retail Products Portfolio (“RPP”)**. This midstream market transformation program leverages the embedded evaluation model by having a dedicated EM&V team member share project ownership and leadership with the greater project team. Evaluability lies at the heart of any successful project or program, especially for RPP given its dedicated market transformation goal. The innovative design of RPP makes it essential that EM&V is integrated into project decision-making processes to ensure that evaluation goals are kept at the forefront of all project activities. For RPP, this entailed early M&V efforts to detail a feasible evaluation methodology and plan based on the availability of data under various operating constraints. This plan was documented and vetted with the California Technical Forum (“CalTF”) and the CPUC prior to program launch to ensure all relevant feedback had been considered and integrated into an agreed-upon evaluation framework. On an ongoing basis, EM&V co-manages the RPP program by assuming project management responsibilities for various research and strategy program

activities and guiding the program team to incorporate research findings and best practices.

- **Home Energy Reports** (“HER”). The HER program uses experimental design whereby customer residences are randomly assigned to treatment (that is, they receive detailed neighbor comparisons of energy use) or control conditions. For the past five years, evaluation staff has worked hand-in-hand with the program team to design each HER experiment to ensure that the principles of randomized control trials are applied, that adequate records are kept, and that scientific principles are respected. The result of embedding evaluation into the HER program has been continuity in program operations in the face of multiple program managers over the years and full acceptance of PG&E’s savings claims by third-party evaluation has been achieved.
- **Residential Pay-for-Performance** (“Res P4P”). PG&E is applying the principles of embedded evaluation in its Res P4P pilot, a High Opportunity Programs and Projects (“HOPP”) that will be using normalized metered energy consumption as the basis for estimating savings. Evaluation specialists are participating in the development of savings estimation protocols through a working group for the CalTRACK initiative, defining and establishing measurement plans for key program performance metrics, and in procedures to gauge and document program influence on an ongoing basis rather than after-the-fact. The development and launch of the Res P4P HOPP was a large effort that required ongoing interaction of program and evaluation specialists.

Residential Sector Research Requirements

While the following residential research needs are anticipated in 2017, they will be re-evaluated and updated as needed via the EM&V roadmap process. Current research needs are based on the following:

- Determination of lead statewide administration for certain residential programs will likely change implementation processes for certain programs
- Implementation of AB802, HOPPs, and AB793 Energy Management Technology Pilots is introducing new program designs and processes are likely to warrant evaluation
- Increased third party program involvement over the next few years
- Implementation of traditional incentive program models (e.g., deemed rebates) as well as new program models such as P4P, and behavior interventions

Expected research in the residential sector includes:

- **AB 802 Implementation Research Needs**
 - Research to support the implementation of AB 802. AB 802 provides for utilities to claim energy savings based on differences observed in normalized metered energy consumption (NMEC). Energy savings will be based on the overall reduction in usage that is observed at the meter, including savings resulting from operational, behavioral, and Retrocommissioning activities. PG&E is undertaking a number of research efforts to establish best practices for estimating NMEC including:
 - Identifying best practices for the use of quasi-experimental designs when experimental methods are not available or practical,

- Selecting appropriate comparison groups and understanding when their use results in gross savings, net savings, or somewhere between the two, and
 - In collaboration with SCE, re-examining the Energy Efficiency Evaluation Framework to meet future energy efficiency needs.
- **Lighting Research Needs**
 - EISA does not affect low lumen and high lumen output products. What are the savings opportunities for these specialty lamps and where would program resources be best targeted after the upcoming standards take effect?
 - Data collection for parabolic aluminized reflectors (PARs) workpaper updates. PARs are currently predominantly inefficient halogen bulbs and could therefore provide a significant savings opportunity in 2018.
 - LED prices have not stabilized for any high-priority LED product category and average LED lamp prices will decrease by 21% per year and luminaires by 20% per year, according to a 2015 Navigant study.¹³⁴ The IOUs should use the updated costs data from the study for the next 2 to 3 years only, and continue to track LED prices in 2017 or 2018 and beyond.
 - Current workpapers do not differentiate between the CEC-Specification compliant lamps incentivized through the Primary Lighting Program and other LEDs. However, these bulbs have different technical attributes, including efficacy, and different prices than standard lamps. Quantifying these differences would enable more accurate savings claims.
 - Better understanding of customer preferences and decision making around lighting purchases would help the programs better connect with customers to encourage efficient choices.
 - A new residential lighting metering study is needed to update the hours of use workpaper parameter and to understand customers' household lighting usage patterns
- **AB 793 Research Needs**
 - AB 793 offerings in their early stages should provide valuable insight to enable PAs to make program adjustments to maximize the effectiveness of these programs, both from a customer participation and experience perspective, and from a cost perspective.
 - Process evaluation to assess the fast-moving nature of these "smart" and connected technologies, and the varied appeal of these technologies to different customer segments. Research is needed to fully understand program participation and customer experience, motivation, and satisfaction. This PG&E study effort may be expanded in early 2018 to include the other IOUs.
- **Retail Products Platform (RPP) Research Needs**
 - Research is needed on the development of a method to appropriately characterize the national market share of RPP products and to investigate how to transition from a traditional resource-based evaluation framework to a market transformation evaluation framework.

¹³⁴California LED Workpaper Update Study, Navigant Consulting (2015).

- **Zero Net Energy (ZNE) Research Needs**
 - ZNEs face significant challenges to widespread adoption such as builder and consumer education, consistent tracking and labeling methods, inclusion of real estate agents and lenders in the ZNE marketing process, and community-scale solutions for homes that cannot reach ZNE on an individual basis. Future research will address technologies and strategies that can be applied across a significant subset of the building volume in order to achieve the greatest overall gains in moving the state toward its ZNE goals.
- **Market Studies Research Needs**
 - A new RASS study would give program administrators a much clearer picture of where savings opportunities lie and would also inform important baselines, DEER, and workpaper updates
 - New Potential and Goals Study is needed in order to characterize stranded potential and the technical, economic and market potential to achieve the associated savings.

EM&V Preparedness

What is embedded evaluation? The bulk of evaluation activities for most utility energy efficiency programs do not begin until a program cycle nears its conclusion. Typically, third-party evaluators lead the effort to estimate energy savings (impacts), assess attribution, and recommend changes to improve program design and the efficiency of program operations. By contrast, embedded evaluation involves internal, utility evaluation specialists as part of the program team, beginning in the program design and planning stages and continuing throughout implementation. By including the research perspective from an early point, embedded evaluation seeks to inform new or enhanced program designs, improve program implementation and documentation, identify and measure key performance indicators to provide program teams with ongoing feedback so that modifications can be made on an ongoing basis, and position programs for successful third-party evaluation (that is, improving their “evaluability”). The use of embedded evaluation is not a substitute for third-party evaluation. Rather, the practices of embedded evaluation complements other evaluation activities and positions pilots and programs for evaluation success.

How is embedded evaluation being undertaken at PG&E? PG&E’s team of evaluation specialists are assigned to specific customer segment-specific program teams. They serve as internal consultants to program managers to improve program design and implementation activities and position programs for evaluability and evaluation success. Specific examples of the activities and focus of these embedded evaluators are provided within each chapter of the business plan.

P. Reference List

Navigant Consulting, Inc. 2015. *Energy Efficiency Potential and Goals Study for 2015 and Beyond*. Prepared for the California Public Utility Commission. Final September 25, 2015. <http://www.cpuc.ca.gov/General.aspx?id=2013>

An Act Guaranteeing Governmental Independence, Ky. Rev. Stat. Ann. § 520.020 (LexisNexis 1985) (passed Jan. 3, 1974).

Aroonruengsawat, A., M. Auffhammer, and A. Sanstad. 2012. "The Impact of State Level Building Codes on Residential Electricity Consumption." *Energy Journal* 33 (2): 31-52.

Bamberger, L. 2010. Scaling the Nationwide Energy Retrofit of Affordable Multifamily Housing: Innovations and Policy Recommendations. Washington, DC: Brookings Institution.

This reference list is incomplete and will be updated to reflect all sources cited in future iterations.

Q. Appendices

Appendix A. Stakeholder Feedback¹³⁵

Relevant Committee or Subcommittee	Topic	Source/Issue/ Numbered Feedback	Page #
Residential	Business Plan Topic	Index #0046—Inclusion of consideration for AB 793 (energy management technology) in Business Plan	Intervention Strategy #3
Residential	Business Plan Topic	Index #0137—Re MF programs--Does public housing belongs in the public or MF sectors?	Not addressed
Residential	Business Plan Topic	Index #0161— Can we look at differential variations by climate zone in the Business Plan description of the challenges and solutions. Consistency is key across the business plans, so everyone should attempt to address this if some already are.	Section E. Sector Characterization

¹³⁵ Note that stakeholder feedback was sourced from the CAEECC website (<http://www.caeecc.org/tracking-documents>) and sorted from by sector (i.e. industrial), topic (i.e. intervention strategies & metrics; voluntary chapter drafts), issue (i.e. stakeholder concern), date entered, and status (i.e. issue closed vs. open). The above table omits all content specific to other IOUs, other business plan drafts, and/or other non-relevant items.

Appendix B. Compliance Checklist

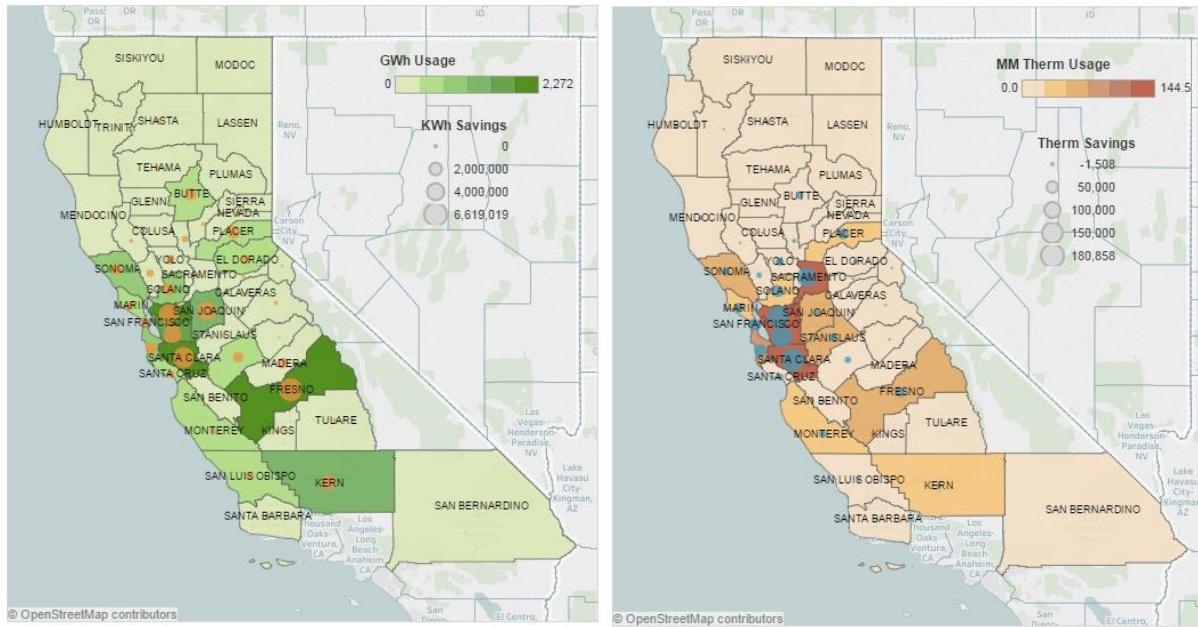
	PG&E Commercial Sector	
BP Page #	Business Plan Guidance (Market Sector)	PG&E Notes
TBD	A. Summary Table for cost effectiveness w/TRC,PAC, Emissions, Savings as well as budget and metrics/Portfolio and sector level metrics for regulatory oversight (GWh, MW, Therms, cost effectiveness, and other parameters where applicable) , including performance metrics for non-resource programs.(also p.47 D.15-10-028)/ Portfolio and sector-level budgets that meet portfolio savings and cost effectiveness requirements (p.48 D.15-10-028)	TBD - will be provided as cost-effectiveness analysis is developed
Section B, pp. 3-5.	B. Compare/contrast this proposal with past program cycles	
Section B, pp. 3-5.	C. How this proposal addresses performance issues within the sector/ Narrative description of changes from existing portfolio, including (1) budget changes; (2) program/intervention strategy changes; (3) justifications for the above. (from D.15-10-028, Appendix 3; included here to be consistent with 7/5/16 discussion with ED, but is not in the sector description of the Appendix)	Budget changes and justifications to be included in future drafts
Section E, pp. 8-14.	D. Market Characterization (Overview and market/gap & other analysis)	
Section E, pp.	1. Electricity/natural gas consumption, GHG emissions, costs, etc.	GHG emissions to be included in future drafts
Section J, pp. 42-44.	2. State goals, strategies and objectives e.g. strategic plan, SB350, AB758, etc. and other Commission policy guidance a. Descriptions of overarching goals, strategies, and approaches for each sector, as well as near-, mid-, and long-term strategic initiatives and sector-specific intervention strategies.	Goals and strategies also included in Sections A, G, and L
Section O pp. 53-56.	4. Include any EMV recommendations and how they are being addressed/Historical sector performance and evaluation takeaways/ Analysis of PA and CPUC evaluation reports for this sector within context of this proposal	EM&V recommendations included throughout document; see footnotes and reference lists
Section E pp. 8-14.	5. Customer landscape	
Section F pp. 15-18.	6. Major future trends in the above that are key for the PA and its customers	
Section F pp. 15-18.	7. Barriers to EE and other challenges to heightened EE (i.e. regulatory, market, data)	Barriers also included in Section G
Section G pp. 19-36.	E. PA's approach to achieve goals in this sector	

Section G pp. 19-36.	1. Products and services, and customer service activities/Resource Program Strategies; Non-Resource Program Strategies; Pilot Program Strategies/develop new strategies to achieve the state's energy efficiency goals in the future/	PG&E has structured its business plans around intervention strategies, and has provided examples of programs in each intervention strategy.
Section G pp. 19-36. ; Section L p. 46.	a. How does it advance goals discussed above	
Section N pp.	b. One metric or more as appropriate for each intervention strategy/PAs will still need to set more granular metrics than just sector-level metrics, but they will do so in implementation plans, not business plans. (p.53 D.15-10-028) Performance Metrics (Non-resource programs); Near-term (year one) strategic initiatives and expected outcomes; mid-term (years 2-3) strategic initiatives and expected outcomes; long-term (years 4-5+) strategic initiatives and expected outcomes/ Commission clearly states that program administrators "must establish up-front expectations for their activities" and that "business plans shall contain sector-level metrics".	PG&E has developed metrics that track to each of its goals.
Section D pp. 6-8.	c. Projected savings/(resource programs) Near-term (year one) strategic initiatives and expected outcomes; mid-term (years 2-3) strategic initiatives and expected outcomes; long-term (years 4-5+) strategic initiatives and expected outcomes	
Section G pp. 19-22.	2. Description of PA's local marketing and integration with SWMEO if applicable/ Marketing and Outreach: Strategies, approaches and outcomes	Marketing tactics can be found throughout the intervention strategies.
Section G pp. 19-22.	3. Whether items are near-, mid-, long-term strategic initiatives/Near-term (year one) strategic initiatives and expected outcomes; mid-term (years 2-3) strategic initiatives and expected outcomes; long-term (years 4-5+) strategic initiatives and expected outcomes	Timeframes can be found in each of the intervention charts.
Section J pp. 42-44.	4. Description of how each sector approach advances the goals, strategies and objectives of the strategic plan (p.46 D.15-10-028)	
Section G pp. 19-37.	5. Workforce Development, Education and Training: Strategies, approaches and outcomes 6. A description of any pilots contemplated or underway for each sector./ A description of any pilots contemplated or underway for the sector (p.46 D15-10-028)/ Describe any unique or innovative aspects of program not previously discussed, and describe any pilots contemplated or underway for the sector. (Appendix 3, D.15-10-028)	WE&T tactics can be found throughout the intervention strategies.
Section K pp. 44-45.	F. Key partners (committed and/or potential)	

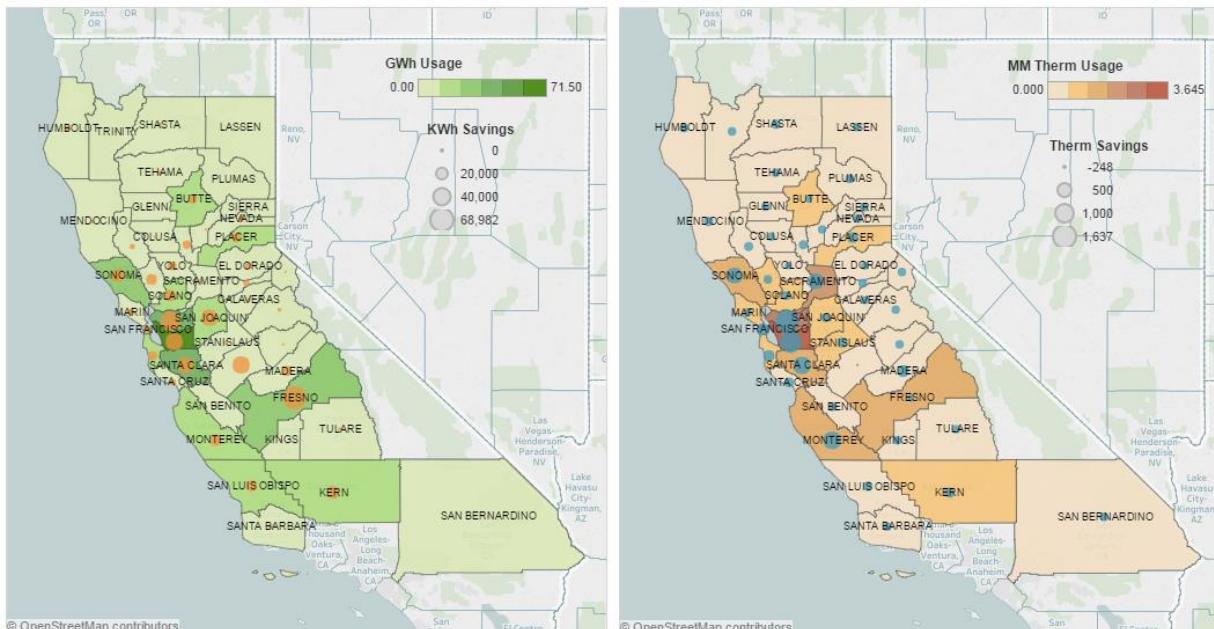
Section K pp. 44-46	G. Program/PA Coordination: Description of which and how strategies are coordinated regionally among PAs and/or other demand-side options. (IOU/REN programs; statewide programs; coordination with other state/local government activities.)/ Coordination with other state agencies and initiatives/Description of which and how strategies are coordinated statewide and regionally among PAs and/or with other demand-side options; (p.46 and Appendix 3 D.15-10-028)	
Section H pp. 37-39.	H. Cross-Cutting Coordination: Description of how cross cutting activities are addressed in customer sector strategies/ Statewide Coordination and cross-cutting efforts/Description of how cross-cutting “sectors” are addressed. (p.46 D.15-10-028)/Cross-Sector Coordination: Description of how cross cutting activities are addressed in customer sectors strategies. Include as applicable: i) Emerging Technologies program ii) Codes and Standards program iii) WE&T efforts iv) Program-specific marketing and outreach efforts (provide budget) – Appendix 3, D.15-10-028	Cross-cutting strategies and tactics can be found throughout the intervention strategies.
Section L pp. 46	I. EM&V Considerations: Statement of evaluation needs “preparedness” (i.e., data collection strategies and internal performance analysis)/Anticipated study needs/Internal performance analysis/feed-through during program deployment/(p.47-48 and Appendix 3 of D.15-10-028) J. Demand Response	
Section I pp. 39-41	K. Residential Rate Reform	N/A
Section I pp. 39-41	L. Integrated Demand Side Resources	
Section I pp. 39-41	M. Zero-Emission Vehicles (EVs)	N/A
Section K pp. 45	N. Energy Savings Assistance (Multi-family Focused)	N/A

Appendix C. Customer Data

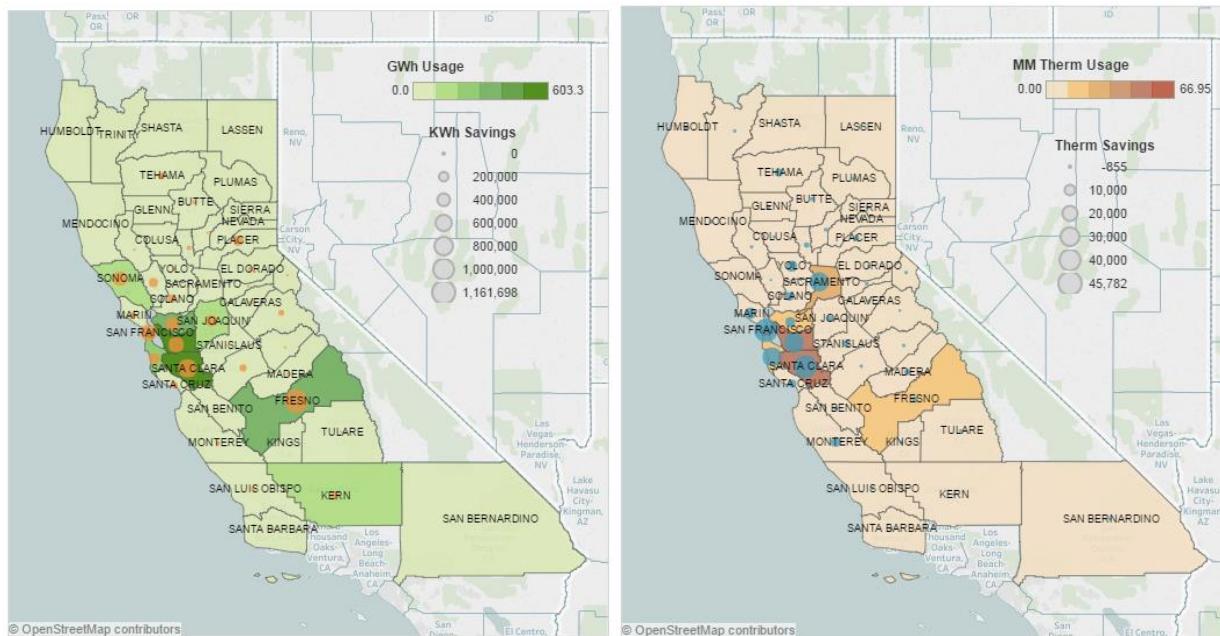
SFR: Own



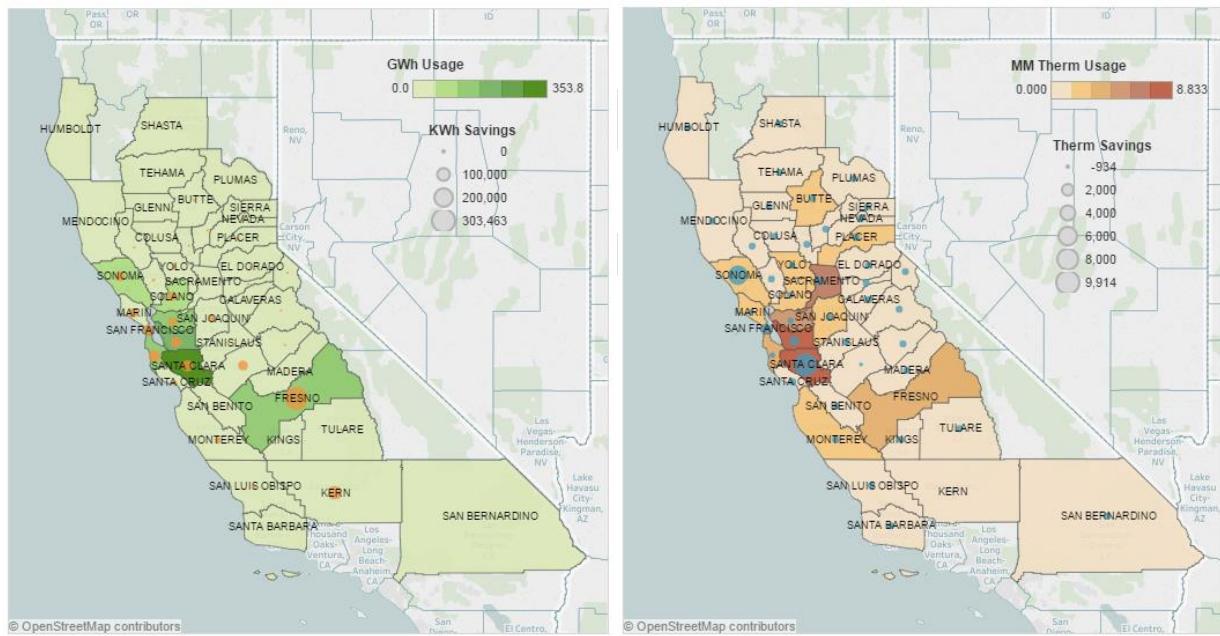
SFR: Rent



MFR: Own



MFR: Rent



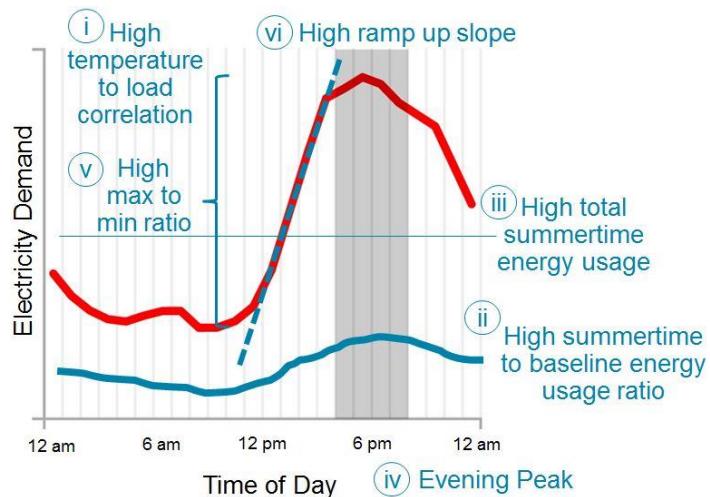
Appendix D: Targeting Customers with AMI Data

The best way to showcase the opportunity that customer targeting through AMI data analysis offers is through a few straightforward examples. In this section, we detail approaches that use AMI data analysis for innovative program design. These examples highlight how interval data can be used to reveal customers who stand to benefit most from particular programs.

Example 1: Customer Targeting for Building Shell and HVAC Maintenance/System Programs

Even without extensive modeling, AMI data can reveal characteristics of a customer's energy usage pattern that indicate air conditioning usage. Several factors that might inform potential HVAC savings are illustrated in Figure D.1, which shows a general customer's load shape over a 24-hour period.

Figure D.1: Customer Load Profile



An ideal customer for HVAC program participation would likely have the following characteristics:

- i. High temperature to load correlation
- ii. High summertime to baseline¹³⁶ electricity usage
- iii. High total summertime energy usage

Selecting customers meeting thresholds for these characteristics ensures electricity savings for building shell and AC measures are maximized. Further criteria can be used to target peak demand reduction:

- iv. Evening peaking customers
- v. High minimum demand to maximum demand in summertime load shape
- vi. Large slope in the ramp up period to evening peak

To better understand the effectiveness of targeting customers with these parameters, PG&E conducted an assessment of 855 recent program participants in the residential Air Conditioning Quality Control program, which provides HVAC maintenance services to customers. One year of AMI data before and

¹³⁶Summertime is taken as June – September and Baseline is taken as February, March and November. Cooling needs are expected to be greatest in the summer months while electricity usage for combined heating and cooling is expected to be minimal during the baseline months.

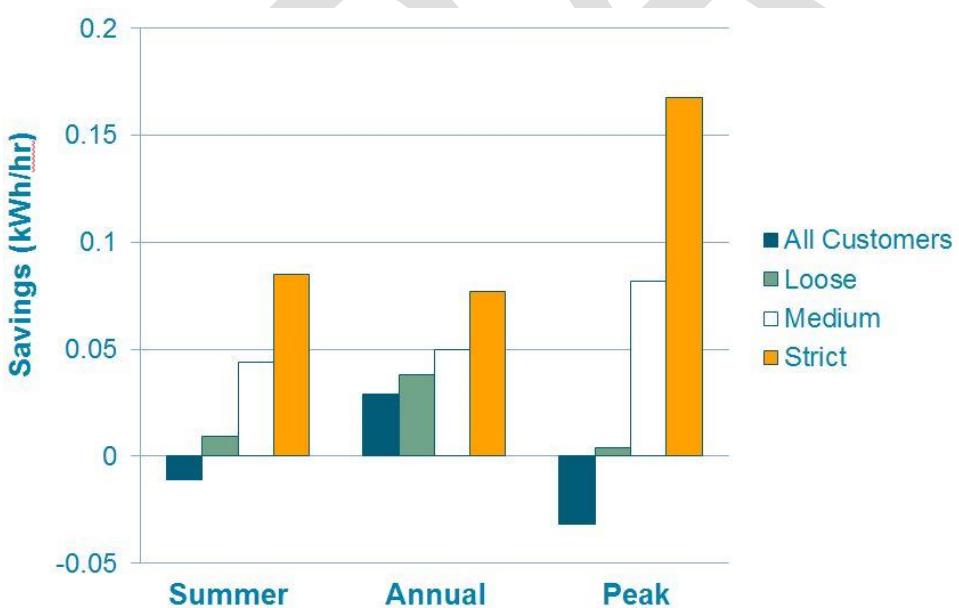
after participation was analyzed. Customers were filtered into targeted and non-targeted samples based on their pre-program energy usage and load shapes using loose, medium, and strict criteria detailed in Table D.1. Note that with loose targeting criteria, load shape requirements were not applied.

Table D.1: HVAC Customer Targeting Criteria

	Loose (top 90%) Targeted 672/855	Medium (top 75%) Targeted 310/855	Strict (top 50%) Targeted 102/855
1. Temperature to load correlation	> 0.85	> 1.25	> 1.75
2. Peak ramp up speed	-	> 0.25	> 0.40
3. Max to min ratio	-	< 0.5	< 0.2
4. Summertime energy usage	> 19 kWh/day	> 26 kWh/day	> 36 kWh/day
5. Summertime to baseline ratio	> 1.2	> 1.7	> 1.85
6. Evening Peak	Anytime, > 1.6 kW	4-9 pm, > 2.2 kW	5-8 pm, > 3.0 kW

Most (79%) customers passed the loose criteria, while only 36% and 12% of customers passed the medium and strict criteria, respectively. Figure D.2 displays a simple, pre/post billing analysis for summer, annual, and peak savings, given as kWh/hour for the four groups of customers.

Figure D.2: Pre/Post Billing Analysis



These findings highlight that savings dramatically increase as targeting criteria become more stringent. During peak summer hours (4 – 9 pm), customers who would have been targeted based on the strict

criteria saved 0.17 kWh/hour, while the entire sample of 855 customers actually used more energy in the post period than the pre period.¹³⁷ Recent evaluation results are consistent with this analysis.¹³⁸

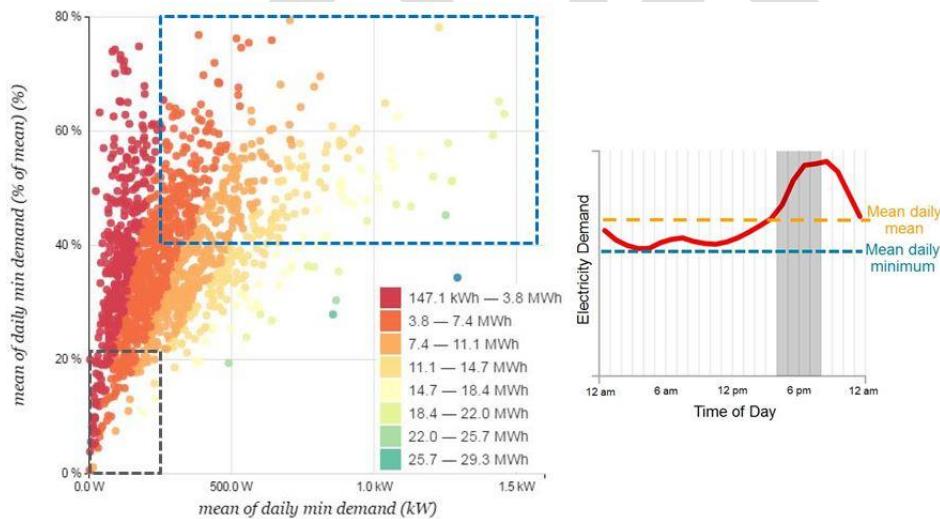
With millions of customers living in hot service territories and program budgets sufficient to reach only a small fraction of them, resources should be targeted at the customers who are expected to yield the most energy savings and the greatest reductions in their energy bills. For these customers, the value proposition of the program is real and demonstrable, even without rebates. Below we build off this analysis with a more detailed plan to address the challenges of the HVAC market through a new Comprehensive HVAC program, for which customer targeting is a central tenet.

Example 2: Customer Targeting for Appliance Recycling and Baseload Measures

Many residential customers have old equipment that runs constantly, such as refrigerators and various other motorized devices. Some of this equipment is well past its useful life but continues to be repaired indefinitely. Replacement may necessitate a substantial upfront cost, but models that use a fraction of the energy can save the customer money in the long term. Interval data can enable PG&E to target customers who could benefit from specific messaging and targeted interventions.

The lefthand plot below (Figure D.3) shows a random sampling of 1,500 PG&E residential customers. The horizontal-axis is the mean value of *minimum* daily demand, which is illustrated by the dashed blue line in the righthand plot. Customers with higher minimum daily demand have consistently high usage. In other words, these customers have high baseload usage. The vertical axis of the lefthand plot shows the percentage of a customer's total usage that can be attributed to baseload. The example load shape in the righthand plot shows a customer with a relatively high baseload usage that also comprises a high fraction of his/her total consumption.

Figure D.3: Sampling of 1,500 Residential Customers



¹³⁷The increased energy usage observed in this analysis may be the result of a takeback effect, higher cooling needs in year two, which are not captured due to unnormalized data, or both.

¹³⁸ AMI Billing Regression Study, Evergreen Economics (2016). This research shows that a significant fraction of participating customers in PG&E's AC/QC program and SCE's Residential Quality Installation program used more energy after program intervention than before.

The 1,500 customers in the lefthand plot are cataloged by colors corresponding to total annual energy usage bins. Customers within the dashed blue box have both high baseload usage (at least 250 W) and a high fraction of their total usage (at least 40%) attributable to baseload. These customers are constantly using enough energy to power at least three large refrigerators, but have relatively flat load shapes. This indicates these customers are likely consuming baseload power inefficiently. In contrast, customers in the grey box have low baseload usage but a high ratio of minimum to peak daily demand. These customers have inconsistent power usage and most have very low total usage.

Those in the blue box are likely to benefit from offerings that target systems constantly using energy, such as:

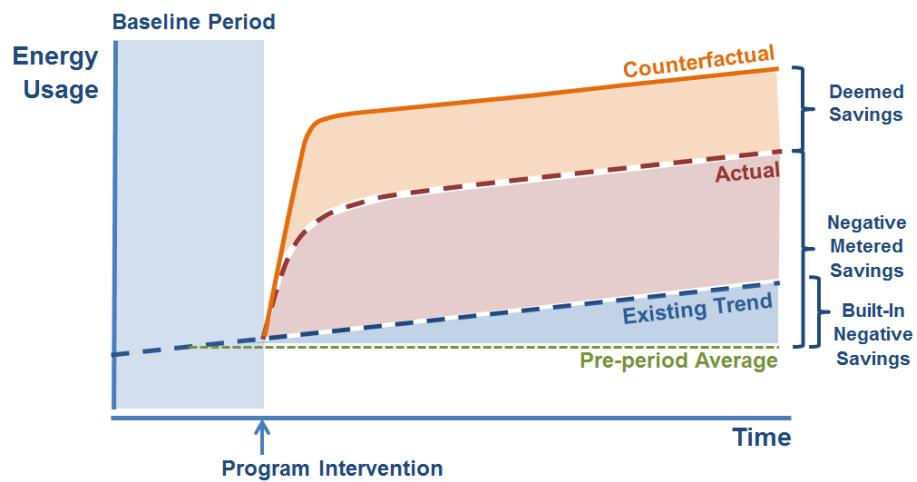
- **Appliance Recycling and Plug Load Programs** – Refrigerators, freezers, and other plug load appliances constantly use energy. When running inefficiently, customers stand to lose hundreds of dollars per year. Customers in the blue box are also more likely to have large appliances running in unconventional applications (e.g. second refrigerator outside or in a garage).
- **Smart Thermostat Installation or Thermostat Reprogramming** – Many customers are unaware they can save energy and still maintain a comfortable home by scheduling thermostats. If fans and air conditioning/heating equipment are running constantly, customers are more likely to appear in the blue box.
- **Quality Maintenance Programs** – A third cause of high baseload consumption is malfunctioning HVAC equipment. For example, if evaporator coils are dirty or air filters are clogged, an AC unit may need to work in overdrive to meet minimum cooling needs.

These types of targeting strategies should select customers who stand to be higher than average energy savers. Therefore, the traditional deemed approach is not expected to be appropriate for determining savings. Each downstream program based on customer targeting will need an alternative method to definitively demonstrate savings.

Reaching Stranded Potential

The residential sector offers higher savings potential if programs reach customers with old appliances, hollow building shells, and HVAC systems in need of major renovation. Many of these projects require large amounts of capital that customers are disinclined to invest. With the passage of AB 802, a new avenue has been established to pursue these projects. However, PG&E does not plan to convert existing programs to existing conditions baselines with only incremental changes. In fact, this approach would expose PG&E's portfolio and ratepayers to unprecedented risk. Consider the schematic energy usage trends shown in Figure D.4 for a hypothetical household that will be evaluated via billing analysis.

Figure D.4: Hypothetical Customer Targeted via Billing Analysis



This household had an upward trajectory in energy usage before intervention. The customer then participates in a program that installs new energy efficient equipment either replacing non-functioning equipment or serving as an addition. This may take the form of installing central air conditioning or purchasing a second refrigerator. This scenario is represented by the red curve labeled "Actual." Without the program, the customer may have installed inefficient equipment, which is represented by the orange 'counterfactual' curve. In this case, the program ensured the increase in energy usage was minimized and savings are real in a "deemed" sense. However, potentially large negative savings would be observed at the meter as post period energy usage could be significantly higher than the pre period. Even a small percentage of these cases when added to a larger billing analysis sample could drive meter-based savings considerably downward. The rising energy usage trend, if true for an average participant household, could have a significantly negative effect.

How might these risks be averted? Program design to find the subsets of customers who will save the most energy from the specific interventions can help alleviate risk. In the case of a program offering new energy efficient equipment, the ideal case, and the case that holds to the spirit of AB 802, is replacement of old, functioning equipment under a pattern of indefinite repair. By proactively promoting this program model to customers with inefficient usage patterns, ratepayer dollars would be invested in long-term, deep energy savings that would also be readily apparent on a customer's bill. These are the same customers who offer the highest potential for greenhouse gas reductions as well as the most avoided procurement costs and enhanced grid reliability in load constrained areas. These are benefits shared by all customers. The new paradigm offered by AB 802 constructively aligns with PG&E's desire to proactively target individual customers based on AMI data analysis.

Appendix E. The Upstream Lighting Program (Primary Lighting)

Background

Since 2006, the Upstream Lighting Program has aimed to transform residential lighting markets, first with promotion of high quantities of compact fluorescent bulbs (CFLs), and more recently by incentivizing high quality light emitting diode (LED) lamps. With more than half of residential sockets in California still using inefficient incandescent or halogen lamps,¹³⁹ residential lighting represents a major savings opportunity.

Implemented in 2014, the Energy Independence and Security Act (EISA) essentially bans the manufacturing of traditional incandescent bulbs in the 40, 60, 75 and 100 W categories. This EISA mandate was adopted one year early in California by Assembly Bill 1109. The AB 1109 legislation also set a goal to reduce residential lighting electricity use in California by 50% by 2018 from a 2007 baseline. The combination of utility-sponsored programs, technology improvements, and AB 1109 regulations has made a major difference. However, recent analysis suggests California is still short of the 50% target.¹⁴⁰

The advent of halogen lamps

One major barrier toward deeper lighting savings is the recent advent of inexpensive halogen lamps, which meet EISA lumens/watt criteria. Compared to compact fluorescents (CFLs) and LEDs, replacing an incandescent with an equivalent halogen yields only about one third of the savings.¹⁴¹ Because the California IOUs have dramatically scaled down CFL rebates¹⁴² per CPUC direction, and because LED bulbs remain expensive, halogens are most often the lowest purchase price option for the customer. The 2013 – 2014 Impact Evaluation of the Primary Lighting Program stated, “without IOU discounts, incandescent and halogens were the lowest-cost options within each replacement lamp category at the end of 2014.”¹⁴³ For customers sensitive to up-front cost, halogens have largely taken the place of the traditional incandescent market. This trend is evident in Fig. E.1, which shows California halogen sales estimates from three different sources. Each estimate shows a dramatic increase in halogen adoption after implementation of AB 1109/EISA.

¹³⁹ Goebes et al. ACEEE (2016); Analysis indicates that California is 31% of the way to the 50% target. 19% remains in the next two years.

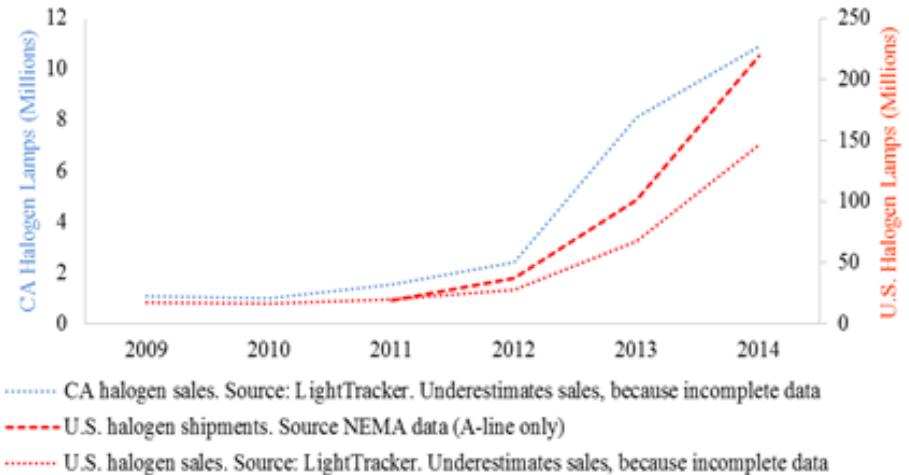
¹⁴⁰ *Clearing the Path to Market Transformation in the Rapidly Evolving World of Residential Lighting*, M. Goebes et al. ACEEE (2016).

¹⁴¹ For example, EISA requires that the maximum wattage for a 750 – 1049 lumen lamp (60 W-equivalent) is 43 W, which results in a delta watts value of 17 W. An equivalent CFL or LED would be approximately 13 W or 8 W respectively, yielding delta watts of 47 W and 52 W respectively.

¹⁴² In 2008 PG&E rebated approximately 24 million CFLs. By 2015 that number had fallen to less than 2 million.

¹⁴³ Impact Evaluation of 2013-14 Upstream and Residential Downstream Lighting Programs, p. 9

Figure E.1: Halogen Sales after AB 1109/EISA



To mitigate the trend of increasing halogen purchases, PG&E will continue to offer incentives for CFLs in hard-to-reach markets that target low income customers. PG&E will also continue to offer rebates for high lumen output CFLs for product categories not affected by EISA or AB 1109 and for which no current LED products are manufactured. PG&E also plans to encourage development of LED products in the non-EISA categories (less than 310 lumen and greater than 2600 lumen) through its relationships with manufacturers.

Support for LED market transformation and current challenges

With their long lifetime, capability for integration into interconnected homes, and substantial efficiency improvements, market transformation to LEDs poses an opportunity for substantial greenhouse gas savings and permanent load reduction across PG&E's service territory. However, despite recent growth in LED product availability and sales, market transformation is not a foregone conclusion. Due in part to poor initial experiences¹⁴⁴ with early-generation products, CFL market saturation peaked near 30%, with inefficient technologies, including standard incandescents and halogens, retaining the majority of the market.¹⁴⁵ The same risk exists today in the LED market as manufacturers and retailers race to capitalize on the profit opportunity presented by rapid LED sales. Few current quality controls exist in the LED market, and customers who switch from other technologies are largely uneducated about comparable product attributes. For instance, while incandescents, halogens, and many CFLs are dimmable, many lower cost LEDs are not. If a customer purchases a non-dimmable LED into a dimming socket, quality and burnout issues are expected that can ruin that customer's impression of LED technology. Similarly, by definition incandescent bulbs provide near perfect color rendering (CRI = 100) and naturally achieve a warmer color temperature as they are dimmed. Currently, most standard LEDs have CRI values of 85 or lower and do not change color temperature when dimmed, which creates a much different feeling for customers used to filament-based technology.

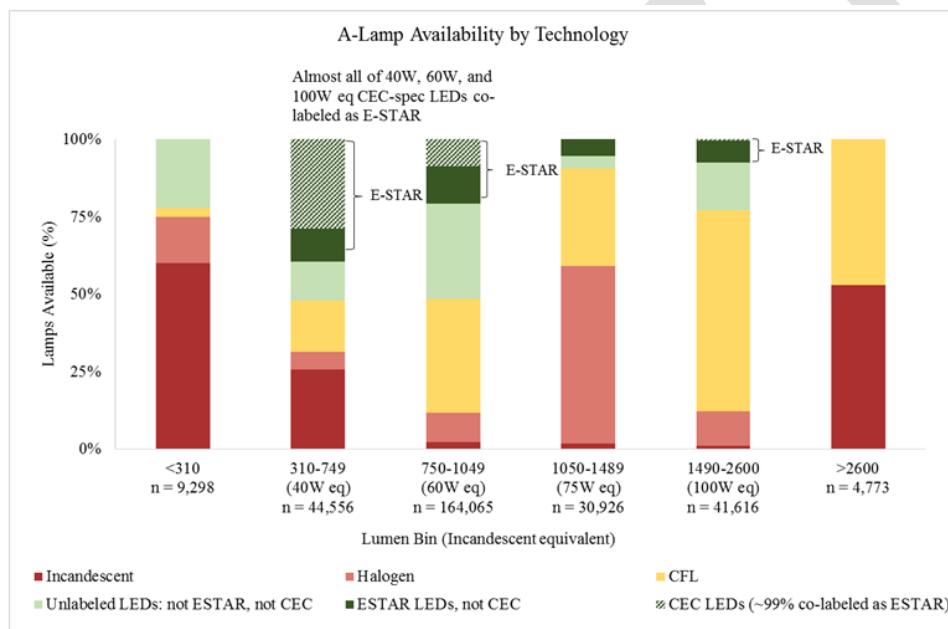
¹⁴⁴Compact Fluorescent Lighting In America: Lessons Learned on the Way to Market, June 2006 (DOE)

¹⁴⁵Saturation Comparison of Massachusetts, California, and New York: Final Report, March 2015 (Cadmus)

To promote quality products and positive customer experiences, LEDs sold through PG&E's Primary Lighting Program (ULP) must meet rigorous voluntary product specifications developed by the California Energy Commission (CEC-Spec).^{146,147,148} If the ULP effectively pushes manufacturers to adopt the CEC-Spec throughout their product portfolio, high customer satisfaction with LEDs should enable complete market transformation.

Significant work remains to reach this goal. Taking common screw-based A-lamps as an example, in-store product availability for CEC-Spec products remains low. Figure E.2 displays results from an analysis of 2015-2016 California lighting shelf surveys conducted by DNV GL. Red and pink segments designate inefficient incandescent and halogen lamps, respectively, yellow represents CFLs, and shades of green show saturation of LEDs. The light green and solid dark green are categories of LEDs that do not meet the CEC-Spec quality standard while the patterned green are CEC-Spec compliant products. From left to right, the bars represent lower light output lamps to high light output lamps.

Figure E.2: Analysis of 2015-2016 California Lighting Shelf Surveys



No CEC-Spec lamps are available for four of the six product categories. CEC-Spec LEDs are available only where the IOUs have focused incentives (40 W-equivalent and 60 W-equivalent). With the exception of the 40W-equivalent category, CEC-Spec lamps either are unavailable or are a minority of products. The utility Upstream Lighting Programs are currently an order of magnitude smaller than at their peak in 2008, in part because LED measures have struggled to meet cost effectiveness thresholds.¹⁴⁹ Without

¹⁴⁶D.12.11.015, Nov. 2012, p. 30

¹⁴⁷*Voluntary California Quality Light-Emitting Diode (LED) Lamp Specification*, December 2014 (CEC)

¹⁴⁸*Resolution Updating the Voluntary California LED Lamp Specification*, January 2015, Resolution Number 14-1210-09, Docket Number 12-BSTD-03

¹⁴⁹Low ex ante Net-to-Gross (NTG) values (0.55 – 0.6), 2017 DEER baseline updates and low ex post NTG (0.30) reported in the *Impact Evaluation of 2013-14 Upstream and Residential Downstream Lighting Programs* greatly suppress the TRC of upstream LED measures.

cost effective, high quality LED measures, it is unlikely that PG&E can devote the resources needed to safeguard future market transformation.

Despite the challenges posed for the Upstream Lighting Program to achieve market transformation under current constructs, the ULP has made strides in preparing the market for implementation of the second phase of the Energy Independence and Security Act (EISA), set to take effect Jan. 1, 2018.¹⁵⁰ When the directive was issued that all LEDs incentivized through the Upstream Lighting Program had to meet CEC-Specification criteria in 2012, no products existed that could meet these strict requirements. PG&E and the statewide IOUs have collaborated to educate manufacturers on the quality and customer satisfaction goals of the program and used incentives to spur the requisite production innovation. Since then, more manufacturers have developed capabilities needed to participate and the number of manufacturers producing CEC-Spec bulbs in the program has more than doubled each year since 2013. Currently, 15 manufacturers are participating and providing CEC-Spec quality bulbs to retailers across PG&E's service territory.

PG&E will continue to promote high quality LEDs in 2017 and develop new partnerships with manufacturers. When EISA Phase II takes effect in 2018, the ULP will also shift to statewide implementation. At this point, the number of cost effective measures are expected to decrease dramatically due to baseline changes—a reassessment of the product types and program scope will also be needed.

¹⁵⁰New EISA efficiency standards are expected to essentially eliminate the manufacture of all filament based bulbs in the 301 – 2600 lumen range.

Appendix F. Comprehensive HVAC

Background

Heating, Ventilation and Air Conditioning (HVAC) performance improvement is one of the most significant opportunities for realizing stranded potential. However, HVAC programs have historically underperformed and have not been cost effective. There are no simple solutions to the compound problems ingrained in the market. As a result, PG&E recognizes that a new approach is needed. Before detailing PG&E's strategy to renovate residential HVAC programs going forward, it is essential to understand the specific barriers that must be addressed.

Current Barriers

1. Lack of enforcement has spawned a largely unregulated market.

- A significant percentage of HVAC contractors in California operate without a license.¹⁵¹
- A very small fraction of new HVAC installations are permitted,¹⁵² as is required by law.
- A link between permitting and code compliance is tenuous and even permitted jobs often fall well short of code compliance.¹⁵³

These issues cause not just concern over wasted energy, but raise fundamental safety, health and comfort concerns for customers across California.

2. Inadequate workforce knowledge, skills, and ability leads to poor installation quality and inadequate maintenance.

- Less than half of HVAC technicians operating in California are aware of the Air Conditioning Contractors of America (ACCA) standards¹⁵⁴ for work quality.¹⁵⁵
- Despite high failure rates for job performance on routine tasks,¹⁵⁶ most technicians report needing no or very limited additional training.¹⁵³

A competent and knowledgeable workforce is essential to deliver solutions and communicate the value of improved HVAC performance to customers.

¹⁵¹Baseline Characterization Market Effects Study of Investor-Owned Utility Residential and Small Commercial HVAC Quality Installation and Quality Improvement Programs in California (Work Order 054), NMR Group, Inc. (2015) pg. 23 - 24; This study reports that the California Contractors State License Board estimates there are 12,000 – 16,000 licensed contractors (C-20), but up to 3,000 unlicensed contractors operating in California.

¹⁵²Recent research report residential permitting rates estimates between 8% (*Top-down permit rate draft report (HVAC6)*, DNV-GL (2016)) to 38% (*HVAC Permitting: A Study to Inform IOU HVAC Programs*, DNV GL (2014)).

¹⁵³*California HVAC Contractor & Technician Behavior Study, Phase II*, Energy Market Innovations Consulting, (2015).

¹⁵⁴<http://www.acca.org/standards/quality>

¹⁵⁵Reference ACCA Standards

¹⁵⁶NMR - Field observations of 13 technicians servicing units with preset faults revealed that even basic maintenance tasks were often performed incorrectly. Often the most impactful tasks for improved energy performance were not even attempted. None of the technicians were knowledgeable in ACCA 4 standards.

3. Customers do not understand HVAC systems and do not value standards-based installation and maintenance.

- More than half of residential customers do not have maintenance performed on their HVAC systems. Many others only have maintenance performed sparsely.¹⁵⁷
- The vast majority of customers do not consider energy performance when assessing the quality of HVAC maintenance or installation. The most common metric to judge HVAC service is only whether the system functions.
- Concern over cost is the leading reason customers are not willing to pay more for standards-based installation and maintenance. Technicians also report that customer cost concern is the biggest barrier to selling standards-based maintenance.

These results indicate that California customers are very unlikely to demand the quality installation and maintenance that ensure existing systems operate optimally throughout their lifecycle.

4. Uncertainty and variability in savings for specific HVAC measures and difficulty developing engineering parameters has limited program offerings and effectiveness.

- Currently, there is no reliable method to assess savings for quality installation. Data on standard installation practices are sparse, in part because it is difficult to track and sample non-permitted installations.
- The current maintenance savings are assessed on a task-by-task basis. The determination of savings for each task is highly uncertain and does not adequately account for interactive effects.¹⁵⁸ Several important maintenance tasks are not incentivized because no savings are assigned.¹⁵⁹ This can lead to a skewed approach that does not result in thorough full-system maintenance and adjustments.
- Verification of each measure and pre/post states of the system requires extensive data collection that is burdensome for implementers and time-consuming for contractors and technicians. This diverts program resources from core goals, including providing service for the most possible customers.

These issues prevent quality installation and maintenance programs from rewarding contractors and technicians who follow a common-sense approach to enhance performance and achieve maximum energy savings on a case-by-case basis.

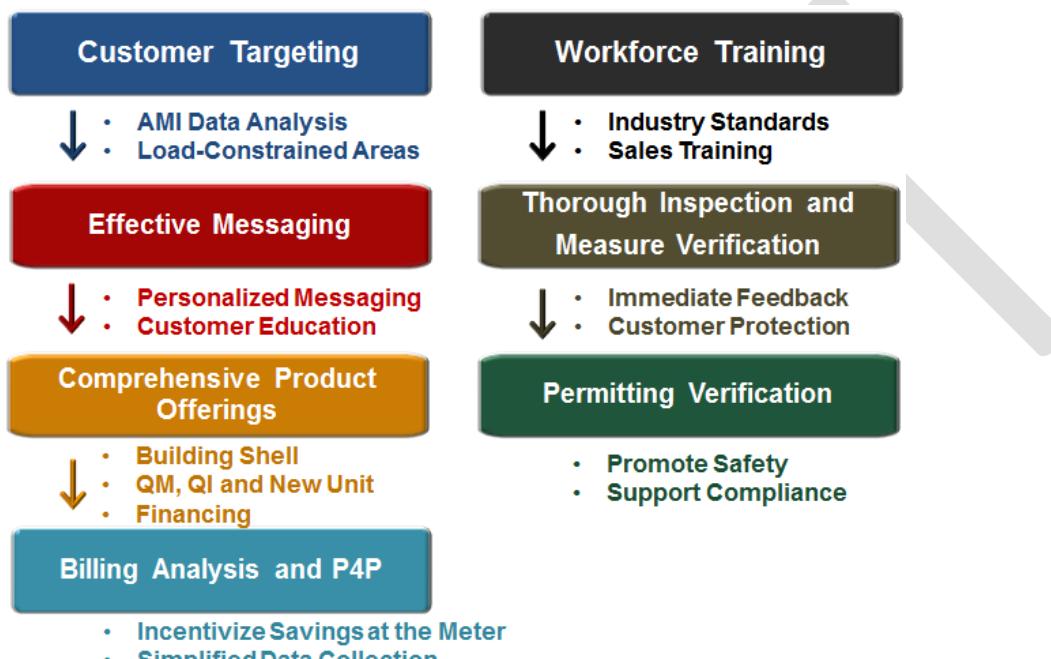
¹⁵⁷California HVAC Quality Installation/Quality Maintenance Customer Decision-Making Study, Energy Market Innovations Consulting, (2015); 58% of program non-participants surveyed report not having regular HVAC maintenance. For customers who do have maintenance performed but do not have a maintenance contract, 60% report having one or fewer maintenance visits per year.

¹⁵⁸Impact Evaluation of 2013-14 HVAC3 Commercial Quality Maintenance Programs, DNV GL (2016). Achieved precision at the 90% confidence level for the five measures in the Commercial Quality Maintenance Programs that accounted for highest statewide ex ante savings ranged from ± 24% – ±72%. Residential programs were not assessed.

¹⁵⁹For example, the utilities are allowed to claim savings for refrigerant charge adjustment and coil cleaning, but not for a number of other ACCA 4 and 5 tasks that impact energy performance such as

Future Program Design

With residential HVAC accounting for more than 25% of peak load in California and the number of households with centralized air conditioning continuing to steadily increase,¹⁶⁰ HVAC must be addressed to meet the state's energy efficiency goals. Drawing from industry expertise and the strategies described above, PG&E believes it is possible to lay the foundation for workforce development and scalable energy savings. Below, PG&E outlines a step-by-step approach to transition residential HVAC programs into a robust suite of offerings that addresses each major market and program barrier. The left track relates to the product design, marketing and evaluation while the right track shows workforce and work quality controls.



Customer Targeting – As discussed in Intervention Strategy 1, AMI data holds incredible potential to both better understand customer energy usage at an individual household level, and to tailor offerings that benefit customers most in need of specific programs. PG&E employs a team of data scientists and partners with external firms with the expertise to mine data and match customers to the best programs. Because of the strong correlation between outside temperature and household HVAC energy usage, numerous HVAC disaggregation modeling schemes have been created. However, identifying customers who are high HVAC users is only a start.

Because HVAC usage is likely to scale with home size, it is important to find the intersection of customers with high disaggregated HVAC usage *and* high HVAC usage relative to total household usage. These are the customers most likely to be using HVAC inefficiently. When also combined with evening-peaking customers, such a targeting scheme can be employed to enhance the value of energy efficiency programs for both the customer and the utility. In turn, by deploying targeted HVAC programs in load-constrained areas with temperature-driven peaks, energy procurement costs during the most expensive periods can be kept to a minimum.

¹⁶⁰HVAC6 Top Down Permitting Memo

Effective Messaging – While AMI data analysis is a powerful tool to identify energy waste among individual households, it does little to actually enroll the customer in a program and successfully encourage a deep retrofit. PG&E is a trusted energy advisor among our customer base, especially for energy usage and saving recommendations. In partnership with contractors in the field, PG&E can provide marketing material and identify the highest potential customers.

Comprehensive Product Offerings – Currently PG&E’s residential HVAC programs operate entirely independently of each other. Quality Installation contractors are not able to offer incentivized quality maintenance contracts. Quality Maintenance contractors cannot offer a customer a rebate for a new unit with quality installation and are therefore disincentivized to upsell efficient replacement equipment. PG&E believes each of these programs can have a positive influence in select arenas, but none alone will lead to a market in which customers benefit from customary high performing HVAC systems. To address the ingrained barriers enumerated above, PG&E believes the following elements could help bridge these gaps:

Participating contractors assess HVAC systems and building shell needs and discuss options with the customer. Depending on the individual situation, the contractor will recommend one or more of the following:

- i. Service packages and maintenance contracts that include the option for duct sealing, duct insulation, duct repair and building shell measures, in addition to the standard unit maintenance measures currently offered.
- ii. Quality installation of a new energy efficient unit, including options for split system variable refrigerant charge technologies. For all new unit installations, contractors should right-size the system. Oversized systems are common¹⁶¹ and result in a high degree of energy waste.
- iii. Installation of a Smart Thermostat or other energy management system as well as customer education on scheduling, connectivity and usage.
- iv. A financing package for the customer to ensure that the most extensive retrofit possible is completed with the least financial burden possible and minimized incentive spend.

While some customers may be willing to undertake a comprehensive building shell/HVAC retrofit, most will undertake only certain actions or will take an incremental approach to a longer term retrofit. Nevertheless, providing customers with a data-driven recommendation for where their limited dollars can be spent most wisely can enhance the value proposition of the HVAC programs.

Billing Analysis and Pay for Performance – HVAC systems consist of complex and interconnected individual components. Optimization of any one of these subsystems in isolation will yield an energy savings impact that is dependent on the state of the remaining system.¹⁶²

The data collection required for verification of each individual task is time-consuming for technicians who already operate under intense time pressure and detracts from their ability to serve more customers or provide thorough service to existing participants. Furthermore, because only certain tasks

¹⁶¹Mowris ACEEE (2008).

¹⁶²As a simple example, consider adding refrigerant to two undercharged HVAC systems. The first system has clean condenser coils and the second system has dirty coils. Adjusting refrigerant charge in the first system will yield different savings than in the second system because heat transfer efficiency depends on both refrigerant charge level and the state of the coils.

are approved for savings claims and incentives, a bias exists toward completion of those tasks, at the expense of others that may be the root cause of an underperforming system.

With the planned approach to target individual customers in load constrained areas, higher energy savings and more valuable peak load reduction are expected compared to the status quo.¹⁶³ Developing detailed workpapers to estimate deemed savings for each set of targeted customers adds yet another layer of complexity to achieve accurate savings.

While incremental progress is possible, the current paradigm for savings claims, evaluation, and program design is not built to facilitate more comprehensive solutions for the customer. The new strategy discussed here needs a new method to claim, reward, and evaluate savings. A pay-for-performance (P4P) approach as discussed in Intervention Strategy 5 could benefit all parties involved and lead to greater savings. The comprehensive building shell and systems design would enable contractors and technicians to pursue the true limiting factors to achieving more efficient HVAC usage on a case-by-case basis. Such a design would reward implementers for savings observed at the meter. By incorporating a P4P model, contractors and technicians would be inherently incentivized to improve performance and learn the skills to achieve standards-based service. Larger payments would be made for more savings and an up-front payment for installed measures, possibly from a third party aggregator, could be made to ensure participation and help contractors with their short-term business needs.

PG&E anticipates that multiple options may exist for determination of normalized meter-based savings. On behalf of the statewide IOUs, PG&E is leading Phase II of the AMI Billing Regression study. This research focuses on developing new billing analysis methodologies that use interval data, particularly the Random Coefficients Model that proved to be promising in Phase I research that focused on assessing savings from residential HVAC programs.¹⁶⁴ The CalTRACK billing analysis platform, which is being built and piloted for the residential P4P program described above, could also be refined and used for Comprehensive HVAC.

Workforce Training – Even with a sophisticated targeting effort, willing customers, a state-of-the art product package, and refined billing analysis evaluation, no program can be successful without a dedicated workforce to execute the program. PG&E recognizes the importance of industry partners and high-quality training that is based on industry standard protocols and rooted in adult learning principals. PG&E also understands that technicians rate utility training, apprenticeship, and in-field training as more effective than online or classroom training programs.¹⁶⁵ In the last decade, PG&E has worked with industry experts to develop and enhance training programs and has required their completion as a prerequisite for participation in the HVAC energy efficiency programs.

¹⁶³The energy usage profiles of these specific subsets of customers will be different from average customers. A targeted customer is expected to have greater total usage, more HVAC usage relative to total usage, greater summertime usage relative to other months, and have a more exacerbated evening peak than an average customer. For these reasons, targeted customers are most need of the program and will deliver greater cost savings per program dollar.

¹⁶⁴ AMI Billing Regression Study; Evergreen Economics (2016).

¹⁶⁵*California HVAC Contractor & Technician Behavior Study, Phase II*, Energy Market Innovations Consulting, (2015), Pg. 41; For residential technicians who received the following trainings, the fraction who rated the training as “very effective” or “effective” is given in parentheses. On the Job Training (99%), Union Apprenticeship Training (100%), Utility Training (85%) Online HVAC Course Training (69%), Community College Training (64%).

In addition, most technicians in the residential sector report being responsible for selling customers maintenance contracts and new HVAC equipment.¹⁶⁶ However, only about half of technicians report receiving sales training from their company and three quarters responded that additional sales training would be helpful. Therefore, PG&E views sales training in conjunction with technical training as a beneficial offering to technicians and recommends provide the combined package going forward.

2b. Thorough Inspection and Measure Verification – PG&E recognizes inspection as an effective method to reinforce training with real-time feedback as skills and methods are taken to the field. Inspection of in-field work also protects customers and ensures that any necessary modifications are completed in a timely fashion.

3b. Permitting Verification – Safety is the number one priority at PG&E. The permitting process for new HVAC installations helps ensure customer and workforce safety. Therefore, for any new HVAC installation completed through the Comprehensive HVAC Program for which the law mandates a permit, proof of permitting will be required. PG&E will also work with Building Departments throughout our service territory to streamline permitting processes and encourage enforcement of permitting laws.

PG&E also plans to learn from programs around the country, including the SCE Commercial HVAC High Opportunity Program or Pilot (HOPP), which contains some important synergies with the program described here. In developing the Comprehensive HVAC program, PG&E will lean on industry expertise, including that offered by the Western HVAC Performance Alliance, to solicit feedback, incorporate the most advanced workforce training methods, optimize program design elements, and motivate participation.

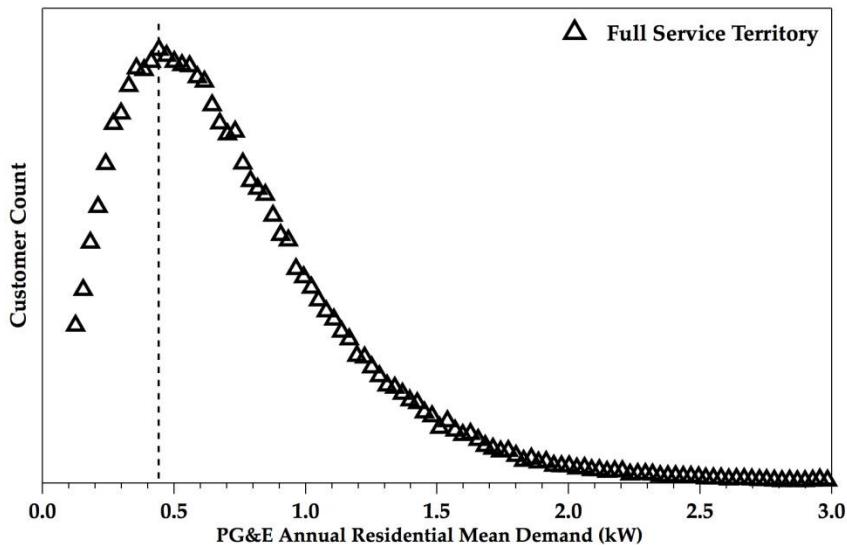
¹⁶⁶ California HVAC Contractor & Technician Behavior Study, Phase II, Energy Market Innovations Consulting, (2015), Pg. 66 - 71; of technicians operating in the residential HVAC sector, 93% report being responsible for selling new HVAC equipment directly to customers and 89% report being responsible for selling maintenance agreements directly to customers. 54% of technicians report having sales training through their current employer and 75% report that additional sales training would be helpful.

Appendix G: Residential Sector Insights from Customer AMI Data

While general overviews and trends within the residential sector are valuable, much richer insights into customer energy usage are enabled and achieved with Advanced Metering Infrastructure (AMI) data.¹⁶⁷ The data and figures presented below are the result of analysis from one year of AMI data (Aug. 2015 – July 2016) for approximately 150,000 randomly selected residential PG&E customers. The analysis was conducted with VISDOM, or Visualization and Insight System for Demand, Operations, and Management,^{168,169} an open source¹⁷⁰ energy data analytics toolkit.

Figure G.1 shows the distribution of mean electricity demand throughout the year for PG&E residential customers.

Figure G.1: Mean Electricity Demand



These data reveal the top 20% of households across the service territory account for nearly 40% of total residential electricity demand. Similarly, the bottom 20% of residences are responsible for less than 10%

¹⁶⁷For the development of our future portfolio, PG&E has undertaken a data analysis project, which is described in greater detail in Appendix A. Much of the analysis was enabled by the VISDOM software package developed at Stanford. Throughout this business plan we will present key results and insights from this effort.

¹⁶⁸VISDOM was developed in professor Ram Rajagopal's Sustainable Systems Lab at Stanford University during a multi-year ARPA-e funded collaboration with PG&E. It provides implementations of statistical, regression, state estimation, disaggregation, and load shape clustering algorithms that run against large samples of smart meter data from residential, commercial, industrial, and agricultural customers and has applications in program planning, segmentation, targeting, and evaluation.

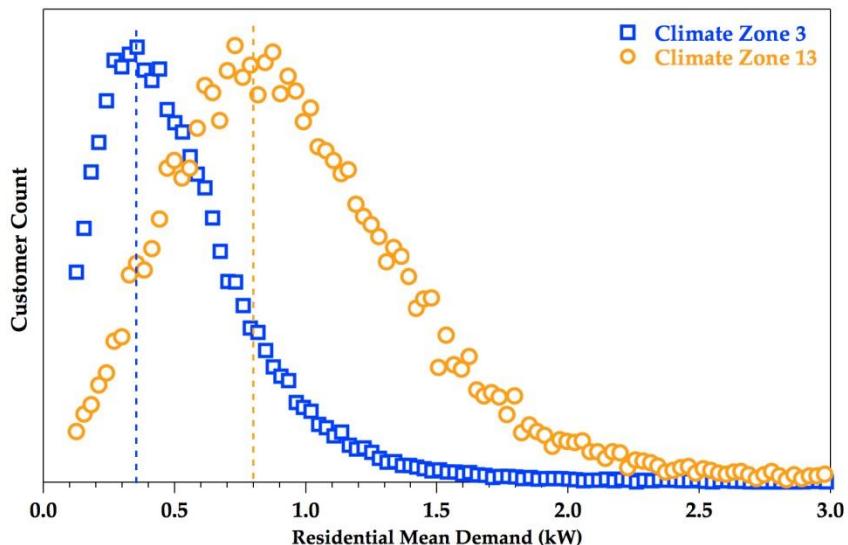
¹⁶⁹Borges, Sam, June A Flora, Jungsuk Kwac, Chin-Woo Tan, and Ram Rajagopal. "Learning from Hourly Household Energy Consumption: Extracting, Visualizing and Interpreting Household Smart Meter Data." In *Design, User Experience, and Usability: Interactive Experience Design*, 337–345. Springer, 2015.

¹⁷⁰Sam Borgeson, Jungsuk Kwac and Ram Rajagopal (2015). visdom: R package for energy data analytics. R package version 0.9. <https://github.com/convergenceda/visdom>

of demand. The peak of the distribution occurs near 450 W, and the mean at 730 W indicates that PG&E residential customers have an average demand of 730 W, which translates to 6.4 MWh of total annual consumption.

Energy usage also varies widely across climate zones. This can be seen in Figure G.2, which shows the distribution of mean demand throughout the year for residential customers in the temperate Climate Zone (CZ) 3,¹⁷¹ and in CZ 13¹⁷², which is part of the hot central valley. Average customer energy usage in CZ 13 is more than 50% greater than in CZ 3. The comparison given in Fig. X also shows there are many more low energy users (< 0.4 kW mean demand) in CZ3 and high energy users (> 1.0 kW mean demand) in CZ 13, something expected considering the smaller average occupancy, home size, and lower space conditioning needs of CZ 3.

Figure G.2: Mean Electricity Demand, Climate Zones 3 and 13

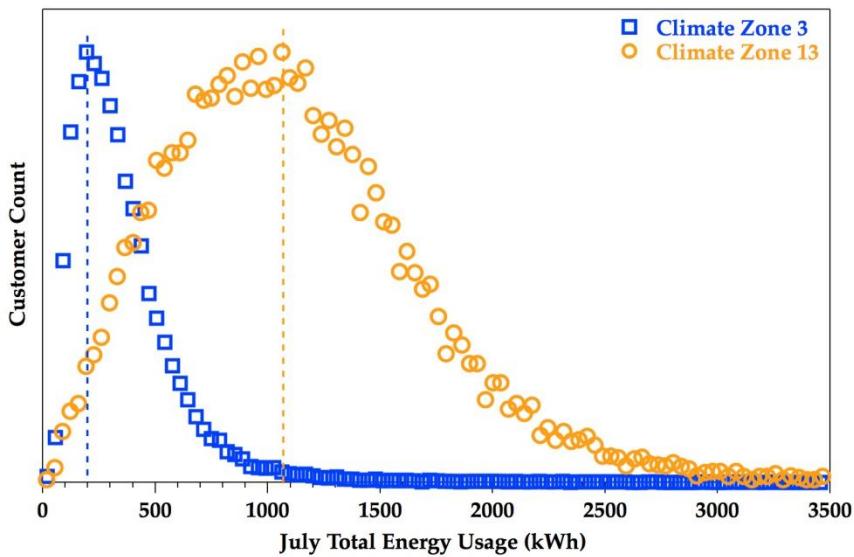


In the summer months when cooling needs dominate electricity consumption in Central Valley homes, the regional difference is much more pronounced. This can be seen in Figure G.3, which shows total consumption, again for CZ 3 and CZ 13. For central valley homes, a significant tail still exists in the distribution of monthly summertime energy consumption above 2,000 kWh. Monthly electricity bills for these customers reach \$500 or more.

¹⁷¹Climate Zone 3 includes of the Bay Area, including San Francisco and Oakland

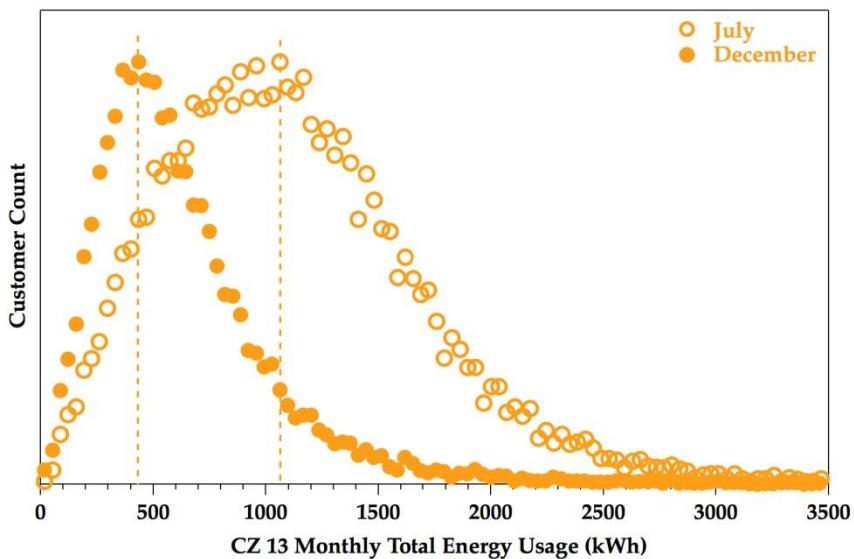
¹⁷²Climate Zone 13 includes Fresno and surrounding cities.

Figure G.3: Total Electricity Consumption, Climate Zones 3 and 13



Similarly, energy usage can vary widely in the same CZ, depending on the season. Figure G.4 compares the distributions of total usage for CZ 13 in the summer and winter.¹⁷³ In the winter, the tail above 2,000 kWh has nearly disappeared and total household consumption averages less than half that of the summer months.

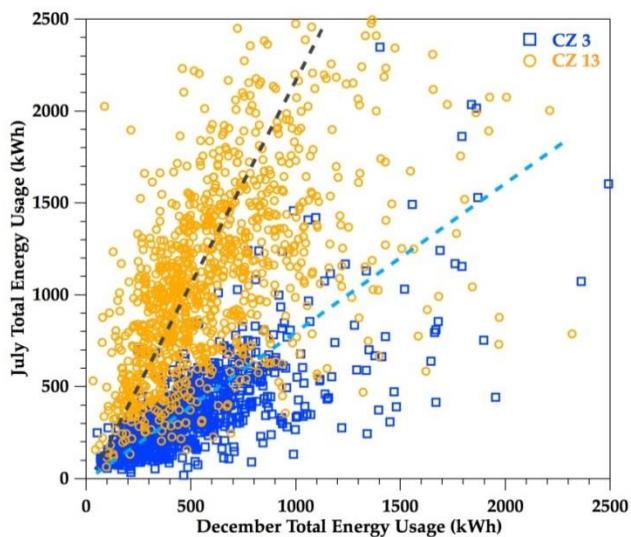
Figure G.4: Total Electricity Usage in Climate Zone 13, Summer and Winter



¹⁷³In Fresno, average July high and low temperatures are 96 and 66 °F. Average November high and low temperatures are 66 and 43 °F: <http://www.usclimatedata.com/climate/fresno/california/united-states/usca2234>

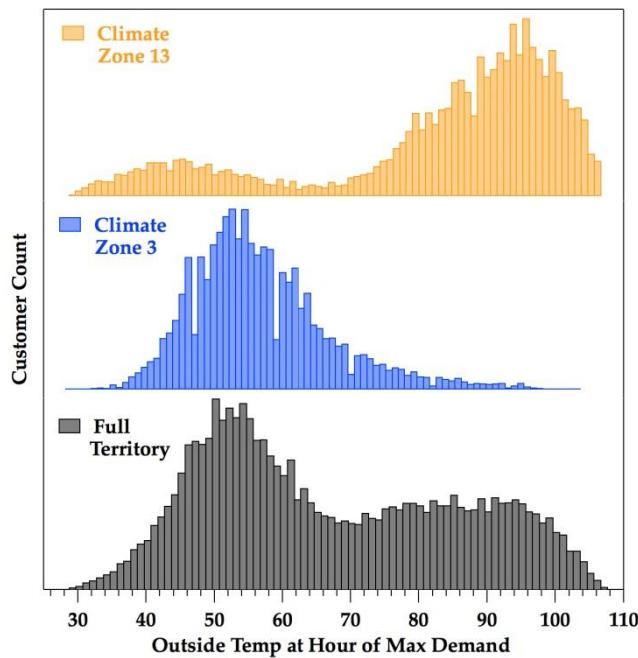
The dramatic shift in electricity needs in the Central Valley from summer to winter is in stark contrast to the experiences of customers in PG&E's more temperate areas. Higher consumption is observed in CZ 3 in December than in July, as shown in Figure G.5, along with the analogous data from CZ 13.

Figure G.5: Total December Electricity Usage, Climate Zones 3 and 13



Many households in CZ 3 do not require air conditioning and turn to electric heating in the winter months. Evidence that cooling drives demand in the Central Valley is not surprising. However, whether cooling or electric heating is generally responsible for peak usage both across the service territory and in Coastal regions is not as intuitively apparent. AMI data analysis reveals durable clues into customer energy usage patterns that shed light on PG&E customer needs and patterns. The bottom panel of Figure G.6 displays the distribution of the outside temperature coincident with the hour of maximum demand for a random sampling of residential customers across the service territory.

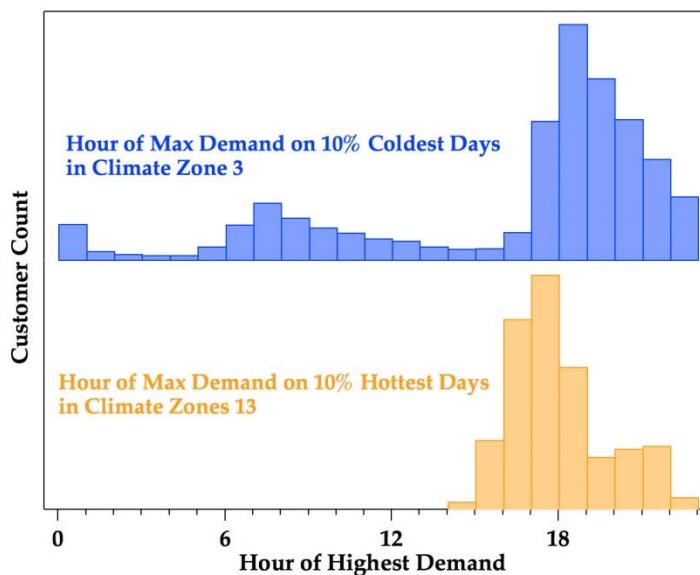
Figure G.6: Outside Temperature at Hour of Max Demand



The pattern is bimodal with strong peaks around 50 °F and a less pronounced peak near 95 °F. This is an indication that heating may be an important contributor to instances of high demand for roughly half of the residences PG&E serves. When parsed by climate zone (middle and upper panels of Figure G.6), it is apparent that the peak centered at lower temperature originates from the Coastal regions while the higher temperature peak is largely due to hot days in the Central Valley regions. The reason the full territory plot shows a more pronounced peak at the lower temperature is due to the large Bay Area population, which results in a higher portion of randomly sampled residences.

But is heating the main driver of peak demand for residential customers in coastal regions? If this were the case, one might expect that times of peak demand would overlap strongly with the coldest hours of the year. The top panel of Figure G.7 shows this is not true. In fact, during the coldest days of the year, the hours of highest demand in coastal areas actually occur in the early evening, with the distribution showing a peak from 6 – 7 pm. By comparison, the early morning hours are the coldest on average. This does not negate a contribution from heating, but demonstrates that other factors are likely more important. In fact, the coldest months of the year in both San Francisco and Oakland are December and January, which are also the shortest for daylight. Therefore, lighting needs along with plug load usage are also likely to push the low temperature peak of in the bottom and middle panels of Figure G.7.

Figure G.7: Hour of Max Demand on 10% of Coldest Days (Climate Zone 3) and 10% of Hottest Days in Climate Zone 13



The bottom panel of Figure G.7 shows the hour of highest demand for inland region households during the hottest days of the year. In this instance, the case is much clearer. The peak in the distribution occurs precisely slightly after the hottest hour of the summer months (2 – 3 pm).

A much deeper dive into all of these data reveals more details, more answers, and more questions. Analysis of gas usage data also offers important lessons. Above all, this brief tour of residential data highlights the incredible customer diversity that defines PG&E. The dramatic disparity in energy usage patterns among different customers in different areas showcases that energy efficiency programs must become more tailored to the unique requirements that different regions, climates, and lifestyles demand, something we discuss in detail throughout this document.

Appendix H. EM&V Lessons Learned in the Residential Sector

Lessons Learned in the Residential Sector

With 13.7 million single- and multi-family homes that house more than 38 million Californians, the residential sector accounts for approximately one third of the state's electric and gas usage and a large portion of overall energy savings potential. Residential energy efficiency programs are responsible for approximately 55 percent of total evaluated portfolio energy savings and the diverse programs offered to residences have reached out to hundreds of thousands of Californians to spur them to take action to improve efficiency. Statewide energy efficiency programs are designed to achieve energy savings through the adoption of energy efficient products, whole house retrofits, and behavior change using rebates, incentives, contractor training, and education. Evaluation studies completed to date provide the following general findings that can be used to inform future residential program design and implementation.

Overarching Findings

- 1) Some residential sectors, such as plug load, would benefit from a transition from traditional downstream rebate programs to market transformation-centered programs that more effectively address plug load barriers. One such program that embodies this approach is the Retail Products Platform midstream incentive market transformation program.¹⁷⁴
- 2) Uptake of energy efficiency upgrades would be improved by increased customization of energy efficiency measure and practice recommendations to participants. This could include information on an individual's estimated payback period associated with energy efficiency upgrades.¹⁷⁵
- 3) To help address gaps in effective program performance, training for retailers and contractors should be aligned and improved across various residential programs such as Home Energy Efficiency Rebate, Business and Consumer Electronics, Multifamily Energy Efficiency Rebate, and Energy Upgrade California.¹⁷⁶
- 4) There are still savings to be realized in residential lighting. Lighting accounts for a significant percentage of residential energy consumption, 17% according to recent estimates.¹⁷⁷ With more than half of residential sockets in California still containing inefficient incandescent or halogen lamps, residential lighting still represents a major savings opportunity.¹⁷⁸

¹⁷⁴ See Program and Technology Review of Two Residential Programs: Home Energy Efficiency Rebate (HEER)/Business and Consumer Electronics (BCE), September 2012, at <http://calmac.org/publications/HEER%5FBCE%5F083012%5FFINAL%2Epdf>

¹⁷⁵ See 2010-2012 CPUC HEES Impact Evaluation, July 2013, at <http://calmac.org/publications/HEES%5FFinal%5FReport%5F20130708%2Epdf>

¹⁷⁶ See Program/Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER)/Business & Consumer Electronics (BCE), September 2012, at <http://calmac.org/publications/HEER%5FBCE%5F083012%5FFINAL%2Epdf>;

See also SCE and PG&E Whole House Process Evaluation, Opinion Dynamics and SBW, May 2012, at <http://www.energydataweb.com/cpuc/search.aspx>

¹⁷⁷ Goebes, M. TRC Energy Services. 2016. ACEEE. *Clearing the Path to Market Transformation in the Rapidly Evolving World of Residential Lighting.*

¹⁷⁸ Ibid.

- 5) Targeted demand response is an emerging energy efficiency tool that uses smart meter data to realize previously inaccessible savings. Utilizing a targeted energy efficiency framework allows for increased identification of savings opportunities and more tailored energy savings approaches that can result in greater program cost effectiveness.¹⁷⁹
- 6) Zero net energy homes (ZNE), while technically feasible, face significant challenges to widespread adoption such as builder and consumer education, consistent tracking and labeling methods, inclusion of real estate agents and lenders in the ZNE marketing process, and community-scale solutions for homes that cannot reach ZNE on an individual basis. Technologies and strategies that can be applied across a significant subset of the building volume will likely show the greatest overall gains in moving the state toward its ZNE goals.¹⁸⁰

Combined Findings

Homes and consumer preferences in the residential sector are evolving in response to significant advances in technology. These advances are resulting in a multitude of new residential product offerings that are in turn influencing a shift in the energy consumption profiles of new and existing homes. Residential energy efficiency programs require significant customization to effectively address this shift; however, since the residential sector encompasses such a diverse array of users, homes, and technologies, the prospect of individual customization at any scale is an extremely difficult proposition. In order to address this challenge, the traditional provision of downstream rebate programs should be transitioned to a midstream-based incentive structure. For energy efficiency programs aimed at plug load use and growth, this might entail using market transformation such as in the Retail Products Platform program. Under a market transformation framework, the program administrator provides midstream incentives to retailers that are tied to the assortment and sales of efficient products. The goal of such a program is to induce a permanent change in the availability of energy efficient products. For residential sectors that depend on contractors for program implementation, this transition might be accomplished through financing-based program offerings. Financing could take the shape of loans, such as in property assessed clean energy loans that allow the consumer to choose the appropriate energy efficiency upgrades, or direct payments to contractors based on meter-observed savings, such as the Residential Pay for Performance program that allows contractors to choose the most effective suite of efficiency upgrades.

Detailed Findings

¹⁷⁹ See 2013 “PG&E Home Energy Reports Program Review and Validation of Impact Evaluation,” CalMAC ID CPU0096.00, “Behavioral Demand Response Study - Load Impact Evaluation Report,” CalMAC ID PGE0367.01, and “Focused Impact Evaluation of the 2013-2014 Home Upgrade Program,” CALMAC Study ID CPU0118.01

¹⁸⁰ Refer to the report “Residential ZNE Market Characterization” available at http://www.calmac.org/publications/TRC_Res_ZNE_MC_Final_Report_CALMAC_PGE0351.01.pdf and the report “The Technical Feasibility of Zero Net Energy Buildings in California” available at http://www.energydataweb.com/cpucfiles/pdadocs/904/california_zne_technical_feasibility_report_final.pdf

Key Learnings from Recent EM&V Reports of California's Single Family and Multifamily Home Upgrade Programs

Single Family (SF) Home Upgrade Program

Introduction/Background

Home Upgrade is a statewide retrofit program targeted at improving the energy efficiency of existing SF homes. The program offers rebates to customers to encourage comprehensive energy efficiency upgrades at the whole house level. Program participation is primarily contractor-driven, with contractors conducting the majority of the marketing activities on behalf of the program.

Homeowners have two options for participation: Home Upgrade (HU) and Advanced Home Upgrade (AHU). The HU pathway provides incentives for multi-measure, whole-home projects. It offers a limited set of deemed measures. The AHU pathway is a custom approach that requires a “test-in” and “test-out” assessment and energy simulation model to develop savings estimates. An expanded group of measures is available compared to the HU pathway.

Key Learnings from Recent Evaluations

- The 2013-14 Home Upgrade Program is more effective at saving gas and reducing demand than saving electric energy¹⁸¹. The findings are encouraging given the high Green House Gases reduction potential of both therm savings and peak demand savings, and the high value of the grid of demand reduction at peak hours¹⁸².
- Inland climate zones show higher electric energy savings and demand reductions.¹⁸³ Climate zones with more defined seasons should be targeted. In 2013-14 PG&E targeted marketing to inland climate zones, resulting in increased participation¹⁸⁴.
- Research is needed to better understand drivers for participants' big reductions, increases, and little change to energy use in order to create programs such as Pay for Performance that pays only for savings achieved.^{185 186} Past process evaluations have shown that negative or neutral savers experienced take-back due to behavior changes primarily consisting of additional persons residing in the home, new or increased HVAC use when HVAC use was low or not present previously, and addition of plug loads or appliances.¹⁸⁷
- The cost of equipment continues to be a major barrier to participation, particularly among households with an annual income below \$100,000¹⁸⁸. Training participating contractors on the available energy efficiency and income-qualified options for homeowners can mitigate the first-cost barrier.
- Continuation of focus on pre-1978 homes will likely continue to provide a greater opportunity for energy savings due to the adoption of California's Building Energy Efficiency Standards¹⁸⁹. Increasing the frequency with which the program serves homes built prior to 1978 will likely increase the realized energy savings per home, further increasing the cost-effectiveness of the program.

Multifamily (MF) Home Upgrade

Introduction/Background

PG&E offers the MF Energy Efficiency Rebate (MFEER) program along with whole building incentives through the MF Upgrade Program (MUP), also known as MF-Whole Building (MF-WB).

Key Learnings from Recent Evaluations

¹⁸¹ DNVGL, Focused Impact Evaluation of the 2013-14 Home Upgrade Program for the California Public Utilities Commission, May 2, 2016, CALMAC Study ID CPU0118.01, p. 24.

¹⁸² RTR for the Focused Impact Evaluation of the 2013-2014 Home Upgrade Program, Utility responses to recommendations in the Focused Impact Evaluation of the 2013-2014 Home Upgrade Program (DNV GL, ED WO #ED_D_Res_5, Calmac ID #CPU0118.01), September 19, 2016. CALMAC Study ID CPU0118.02, p. 1.

¹⁸³ Op. Cit., CALMAC Study ID CPU0118.01, p. 24.

¹⁸⁴ Op.Cit., CALMAC Study ID CPU0118.02, p. 1.

¹⁸⁵ Op. Cit., CALMAC Study ID CPU0118.01, p. 24.

¹⁸⁶ Op.Cit., CALMAC Study ID CPU0118.02, p. 2.

¹⁸⁷ Op.Cit., CALMAC Study ID CPU0118.02, p. 2.

¹⁸⁸ EMI Consulting, Energy Upgrade California – Home Upgrade Program Process Evaluation 2014-2015, Final Report, September 12, 2016, pp. 65-66 and 69-70.

¹⁸⁹ Ibid., pp. 68-69

- Most MUP projects have been brought to the program by energy raters hired by MF building owners and operators¹⁹⁰. Raters¹⁹¹ have been an aspect of MUP since its pilot stage in 2013 and perform comprehensive whole-building ASHRAE Level 2 assessments. Raters then work with the property owner to develop a scope of work that improves a building's energy efficiency by at least 10%. Raters also prioritize measures by energy savings and incentive earnings, and they check the work once it is complete. The role of energy raters needs to be recognized and supported.
- The MF market segment typically does not proactively perform early replacement of equipment. Instead, the market segment is more likely to "repair indefinitely."¹⁹² The use of a dual baseline on a WB program impacts program efforts negatively. Programs should be able to use the more favorable single baseline approach¹⁹³.

PG&E has provided national leadership in the design and evaluation of its Home Energy Reports program and built the program to its current state of having over 1.5 million households receiving these reports. Two key initiatives have extended the utility of Home Energy Reports program:

- The deployment of Smart Meter technology has enabled PG&E to collect residential electric usage data at one-hour intervals throughout its service territory. In 2013, PG&E pioneered a methodology for estimating energy savings coincident with periods of high electricity demand by taking advantage of this hourly data. The kW savings have led to an increased focus on the utility of energy efficiency programs to curtail load at peak demand (see 2013 PG&E Home Energy Reports Program Review and Validation of Impact Evaluation, CalMAC ID CPU0096.00, by DNV GL). PG&E continues to estimate kW savings for this program and the other California IOUs have followed suit.
- Following this peak demand research, PG&E, in partnership with Opower, conducted a behavioral demand response study during the summer of 2015 to investigate the load impacts that could be produced by engaging customers using communications and social comparisons prior to designated "Summer Saving Days". The study targeted residential customers in 31 substations within PG&E's system that have been identified as high priority areas for reducing peak loads. The study found a 2.4% reduction in peak usage for Home Energy Reports control customers and a 1.8% reduction for HER recipients and represents a viable synergy between achieving energy efficiency as well as peak load curtailment (see Behavioral Demand Response Study - Load Impact Evaluation Report, CalMAC ID PGE0367.01, by Nexant).

¹⁹⁰ September 19, 2016, I. Bran in-person conversation with PG&E MF Program Manager K. Contreras.

¹⁹¹ SBW Consulting, Inc., Process Evaluation for PG&E's Energy Upgrade California™ Multifamily Pilot Program, submitted to PG&E, CALMAC Study ID PGE0339.01, May 2014, p. 3

¹⁹² RTR for the 2013-2014 Multifamily Focused Impact Evaluation Study (Apex Analytics and DNVGL, Calmac ID #CPU0119.02), including the Multifamily Energy Upgrade California and the Multifamily Energy Efficiency Rebate Programs, May 25, 2016.

¹⁹³ For detailed information on dual baselines for the MF sector (Early Replacement and Replace on Burnout), see 2013-2014 Residential Roadmap, Multifamily Focused Impact Evaluation – Final, Prepared by Apex Analytics for the California Public Utilities Commission, February 29, 2016, p. 13.

Key Learnings from Recent EM&V Studies of California's Residential Lighting Sector

Introduction/Background

There have been many changes in the California residential lighting market over the past several years. The Energy Independence Security Act (EISA) banned the production and import of traditional incandescent bulbs for common lamp types. The IOUs have significantly reduced the number of CFL rebates in their Upstream Lighting Programs, while focusing LED incentives on driving quality instead of pushing high sales volumes. Less efficient halogen lamp availability and sales have increased dramatically.

Following are key learnings from recent EM&V efforts that provide insights into the residential lighting market and future program design.

- There are still savings to be realized in residential lighting. Lighting accounts for a significant percentage of residential energy consumption, 17% according to recent estimates.¹⁹⁴ With more than half of residential sockets in California still containing inefficient incandescent or halogen lamps, residential lighting still represents a major savings opportunity.¹⁹⁵
- California has made progress toward Assembly Bill 1109, but still has a way to go. AB 1109 legislation sets a goal to reduce residential lighting electricity use in California by 50% by 2018 from a 2007 baseline. The combination of utility-sponsored programs, technology improvements, and AB 1109 regulations has made a major difference. However, recent analysis suggests that California is still well short of the 50% target¹⁹⁶.
- LED prices are unstable and on a downward trend. IOUs should stay on top of LED prices. LED prices have not stabilized for any high-priority LED product category and average LED lamp prices will decrease by 21% per year and luminaires by 20% per year, according to a 2015 Navigant study¹⁹⁷. The IOUs should use the updated costs data from the study for the next 2 to 3 years only, and continue to track LED prices in 2017 or 2018 and beyond.
- Halogen lamp availability and sales have increased dramatically, which is a barrier toward deeper lighting savings. In a 2014 study, DNV GL reported that EISA and AB 1109 drove increases in halogen lamps' market presence between 2012 and 2013¹⁹⁸.
- Low availability of CEC-spec LEDs another barrier. Despite rapid growth of total LED sales, CEC-Spec lamp availability remains very low, less than 5% in most retail channels,¹⁹⁹ and CEC-Spec

¹⁹⁴ Goebes, M. TRC Energy Services. 2016. ACEEE. *Clearing the Path to Market Transformation in the Rapidly Evolving World of Residential Lighting*.

¹⁹⁵ Goebes, M. TRC Energy Services. 2016. ACEEE. *Clearing the Path to Market Transformation in the Rapidly Evolving World of Residential Lighting*.

¹⁹⁶ Analysis indicates that California is 31% of the way to the 50% target. 19% remains in the next two years.

¹⁹⁷ Navigant. 2015. *California LED Workpaper Update Study*. August 28, 2015.

¹⁹⁸ DNV GL. 2014. *California Residential Replacement Lamp Market Status Report: Upstream Lighting Program Market Activities in California through 2013*. September 10, 2014.

bulbs remain significantly more expensive than competing LEDs.²⁰⁰ TRC Energy Services recommends the following strategies for California IOUs:

- Rebate ENERGY STAR LEDs, at least temporarily in California, particularly for lamp types where there are no CEC-spec products available, and where the cost of CEC-spec products are high enough that even their rebated price may exceed the price of low efficacy lamps.²⁰¹
- Temporarily continue CFL rebates, particularly in market channels where customers are likely to be driven primarily by first costs (e.g., discount stores, small grocery stores).²⁰²
- Research consumer preferences to guide lamp quality requirements. The CEC-spec was inspired by lessons learned from early CFL rebates, when product quality was not prioritized. More research is needed on what level of performance consumers consider preferable and their willingness to pay for this performance, to inform requirements for rebates and code.²⁰³ The IOUs are partially addressing this in their upcoming Statewide Residential Lighting Customer Decision Study.
- Future Upstream and Residential Downstream Lighting Impact Evaluations must distinguish between program-qualified CEC-Spec LEDs and other LEDs in the NTG analysis. The 2013-14 Upstream and Residential Downstream Lighting Impact Evaluation made no distinction between CEC-Spec and other LEDs in the NTG analysis, resulting in a Statewide ex post NTG of 0.30 for ULP LED measures.²⁰⁴ This has contributed to statewide Upstream Lighting program cost effectiveness challenges.

¹⁹⁹ Memorandum from TRC to PG&E: “Availability of CEC-Specification LEDs”, October 2015. Analysis of 2014 – 2015 DNV GL California Shelf Survey data reveals that in most market channels CEC-Spec LED availability is 0 - 5%.

²⁰⁰ Navigant. 2015. *California LED Workpaper Update Study*. August 28, 2015.

²⁰¹ M. Goebes. TRC Energy Services. 2016. ACEEE. *Clearing the Path to Market Transformation in the Rapidly Evolving World of Residential Lighting*.

²⁰² M. Goebes. TRC Energy Services. 2016. ACEEE. *Clearing the Path to Market Transformation in the Rapidly Evolving World of Residential Lighting*.

²⁰³ M. Goebes. TRC Energy Services. 2016. ACEEE. *Clearing the Path to Market Transformation in the Rapidly Evolving World of Residential Lighting*.

²⁰⁴ DNV GL. 2016. *Impact Evaluation of 2013-14 Upstream and Residential Downstream Lighting Programs*