Energy Efficiency Potential and Goals Study for 2018 and Beyond

DRAFT BROS Appendix

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Appendix A. BROS

This appendix discusses the BROs interventions that are include in the PG model. It describes each intervention and discusses data sources and assumptions. A separate spreadsheet is also made available for stakeholders to review the final detailed inputs for intervention specific each utility and building type.

A.1 Residential - Home Energy Reports

Summary

Home Energy Reports (HERs) are among the most prevalent and widely studied of behavioral interventions. Residential customers are periodically mailed HERs that provide feedback about their home's energy use, including normative comparisons to similar neighbors, tips for improving energy efficiency, and occasionally messaging about rewards or incentives. HERs programs are generally provided to customers on an opt-out basis, although utilities in other states have conducted opt-in programs.

Estimated electric savings range from 1.0-2.3%, while gas savings are 0.6%-1.9%. Costs are set at $0.09 per kWh for PG&E, SCE, and SDG&E, with all costs allocated to electricity and zero cost for gas for simplicity for dual fuel utilities. SCG is attributed $3.06 per therm for its HERs program, which only saves gas.

Table A-1: Home Energy Reports - Key Assumptions

Sector	Type	EUL years	Savings		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
RES	Home Energy Reports (HERs)	1	1.0 – 2.3%	0.6% – 1.9%	$0.09	$3.06	0.00019058

Assumptions and Methodology

Eligibility and Participation
Although all targeted residential households may receive HERs as participants in an opt-out program, in practice, approximately 2% of customers elect to opt out. For this reason, we reduced applicability to 98% for single family homes. Applicability for multi-family homes is further reduced to 88%, dropping another 10% in order to account for multifamily homes that do not have individual meters.[1]

[1] Kate Johnson and Eric Mackres, Scaling up Multifamily Energy Efficiency Programs: A Metropolitan Area Assessment, Report Number E135, March 2013, American Council for an Energy Efficient Economy, from http://www.prezcat.org/sites/default/files/Scaling%20up%20MF%20Energy%20Efficiency%20Programs_0.pdf

While participation rates in HER programs fluctuate over time due to program opt-outs, customer moves, and changes in program implementation such as adding new waves, specific forecasts require details beyond those publicly available via 2017 IOU-filed Rolling Business Plans. For this reason, the team reviewed all formal California IOU evaluations of HERS programs to ascertain historic HER program participation rates and wave sizes and then applied a weighted average of IOU wave sizes to forecast the future cohort waves according to the number of households within a given service territory.[2,3,4,5,6,7,8,9,10] The behavioral model then applies these projected penetration rates to the number of forecasted IOU households, which increases over time from 2016-2030,resulting in an increase in the absolute number of actual HER participants over time.

Savings

The team reviewed the above-mentioned evaluations of all IOU HER programs to compile per-household adjusted savings rates for each wave of each year of each HER program, spanning from 2011-2014, depending upon each utility's first year of operation.[11,12] We then calculated weighted averages using each individual wave treatment participation numbers and per household savings percentages to derive singular values for kWh and therm savings that can be applied across the full treatment populations for each utility.

The model uses an EUL of one year for HER program participants. That is, while customers may participate in a utility HER program for more than one year, their average adjusted savings is assumed to be the same as for all other participants in that year. While some recent evaluations of HERs programs have found savings persistence of more than one year, reported savings percentages vary, with some sources citing higher later year savings and others showing a degradation of savings over time. For this model, an EUL of one year is assumed, as is standard with traditional persistence calculations for HER programs.

[2] DNV-GL, Review and Validation of 2014 Pacific Gas & Electric Home Energy Reports Program Impacts (Final Report) 04/01/2016, California Public Utilities Commission, page 4, 19

[3] DNV-GL,2013 PG&E Home Energy Reports Program Review and Validation of Impact Evaluation ED Res 3.1, April 06, 2015, California Public Utility Commission

[4] DNV KEMA, Review of PG&E Home Energy Reports Initiative Evaluation, 5-31-2013, CPUC Energy Division

[5] Freeman Sullivan and Company, Evaluation of Pacific Gas and Electric Company's Home Energy Report Initiative for the 2010–2012 Program, April 25, 2013, Pacific Gas and Electric Company, p 8, 26-31

[6] DNV-GL, Review and Validation of 2014 Southern California Edison Home Energy Reports Program Impacts (Final Report) 04/01/2016, California Public Utilities Commission, page 3, 13

[7] DNV-GL, 2013 SCE Home Energy Reports Program Review and Validation of Impact Evaluation ED Res 3.2, April 06, 2015, California Public Utilities Commission, p 3, 8

[8] August 2015 Advanced Metering Semi-Annual report provided by SCG staff. Appendix E - Nexant, Evaluation of Southern California Gas Company's 2015-2016 Conservation Campaign, August 2016, August 31, 2016, page E3

[9] DNV-GL, Impact Evaluation of 2014 San Diego Gas & Electric Home Energy Reports Program (Final Report), 04/01/2016, California Public Utilities Commission, page 3, 24

[10] DNV-GL, SDG&E Home Energy Reports Program 2013 Impact Evaluation ED Res 3.3, October 17, 2014, California Public Utility Commission

[11] KEMA, SDG&E Home Energy Reports Program Savings Results, August 23, 2013, San Diego Gas and Electric

[12] Southern California Gas Company, 2013 Program Implementation Plan, California Public Utility Commission, sourced from http://eestats.cpuc.ca.gov/EEGA2010Files/SCG/PIP/2013/Clean/1.3%20Energy%20Advisor%20Attachment.pdf

The ratio of kW to kWh savings was developed using a weighted average of adjusted kW and kWh savings as reported in DNV-GL's 2013 and 2014 evaluation findings for PG&E and SCE. SDG&E's kW demand data was not reported in its formal evaluations and thus we have applied the same value as used for PG&E and SCE.

Cost

Costs per unit of kWh and therm savings were calculated based on utility-reported HER program costs for 2013 and 2014 as found at eestats.cpuc.ca.gov. These costs were divided by the adjusted kWh and therm savings as reported in the above-mentioned 2013 and 2014 DNV-GL evaluation findings for PG&E, SCE, and SDG&E. Therm savings for multiple years of SCG HER programs were obtained from Nexant's Evaluation of Southern California Gas Company's 2015-2016 Conservation Campaign, August 31, 2016.

The costs of producing and mailing HERs are largely the same whether the reports focus on electric savings, gas savings, or both. For this reason, rather than dividing the cost of the reports across fuels for the dual fuel utilities PG&E and SDG&E, we applied all costs for the home energy reports to a single fuel—electricity—to arrive at a comprehensive per kWh cost, while leaving the cost per therm unburdened. For the single fuel utilities SCE and SCG, program costs were applied specifically to kWh and or therms, respectively.

A.2 Residential - Real-Time Feedback: In Home Displays and Online Portals

Summary

Unlike HERs that arrive in the mail on a periodic basis, real-time feedback programs change customer behaviors by delivering advanced metering data on household consumption to utility customers via an in-home display (IHD) or remotely via an online portal, such as a website or a smart phone application. While some feedback programs only provide information, others provide energy saving tips, rewards, social comparisons, and/or alerts.

Although utility behavior programs utilizing IHDs and online portals both afford feedback opportunities, we have separated our modeling inputs for the two categories to better capture differences in adoption, energy savings, and costs between the two types of programs. Of note is the higher cost typically associated with offering in-home displays, due to the need for the installation of specialized hardware, whereas online portals typically provide cloud-based information directly to the customer's smartphone, tablet, or computer.

Real-time feedback programs may also be associated with different customer rates, including time of use plans and more traditional usage based billing. Although real-time feedback is a popular behavioral intervention for demand response programs, our analysis focused on programs designed to drive energy efficiency. In all, we reviewed a total of 38 programs, including 20 providing IHDs and 18 offering online portals. Several programs offered both types of feedback. In those cases, we categorized them in the IHD category since they had associated costs for the hardware.

Table A-2: Real-Time Feedback - Key Assumptions

Sector	Type	EUL years	Savings		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
RES	Real-Time Feedback – In Home Display	1	2.3%	--	$0.26	--	0.00019058
RES	Real-Time Feedback – Online Portal	1	1.3%	1.3%	$0.07	--	0.00019058

Assumptions and Methodology

Eligibility and Participation

Both web-based and IHD real-time feedback programs are offered on an opt-in basis to customers with smart-meter equipped homes. Although most residential feedback programs are focused on providing information about electricity consumption, some natural gas savings result from these programs which are likely the result of tips and recommendations concerning thermostat settings. For modeling purposes, we assume 100% applicability for electric savings among individually metered homes and 59% applicability for gas. This latter figure is conservative given that 59% of California households use natural gas as their main source of space heating and 84.4% of CA homes use natural gas for water heating.[13]

According to the FERC, 75% of households in California have AMI meters (as of 2013). For those utilities who offer a demand response or time-based rate program, approximately 92% of residential customers receive detailed energy use information online.[14] In order to receive this information, customers need to log-in and set up their accounts. Given the opt-in nature of the program, we estimate that roughly 10% of residential customers in California are receiving real-time energy data online. Our estimates of penetration rates in 2016 assume an 80% penetration of smart meters and a 10% opt-in rate among residential customers.

We assume penetration rates for programs that use online portals to display customer information will be higher than those that rely on in-home displays. For online portals, our reference case begins with 10% market penetration and assumes an 8% increase in penetration per year, while the aggressive case starts at 10% penetration and assumes a 15% annual increase. In-home displays did not pass the cost-effectiveness screen, and so are not included in the reference case. We estimated 4% market penetration for the aggressive case,[15] growing by 15% annually. All penetration rates are based on professional judgement.

[13] U.S. EIA Residential Energy Consumption Survey (RECS). “Table CE2.5 – Household Site Fuel Consumption in the West Region, Totals and Averages.” (2009). Available at: http://www.eia.gov/consumption/residential/data/2009/index.php?view=consumption#fuel-consumption

[14] Federal Energy Regulatory Commission [FERC], “Assessment of Demand Response & Advanced Metering: Staff Report.” (December 2012), 108

[15] Mike Munsell, “Home Energy Management Systems Market to Surpass $4 Billion in the US by 2017,” Greentech Media, Sept 2013

Savings

Savings forecasts differ for online portals and IHDs. For online portals, we estimate 1.3% savings for both kWh and therms. For IHDs, we estimate 2.3% savings for kWh and no gas savings. These estimates were developed based on numerous data points for kWh savings.[16,17,18,19,20,21]

The model uses an EUL of one year, the same as we apply for HER program participants. Because insufficient demand savings data was available for real time feedback for non-demand response programs, for ratio of kW to kWh to savings, we applied 0.00019058, which is the figure used for HERs for all three electric utilities.

Cost

Hardware acquisition and installation constitute the primary cost associated with IHD programs, and they are accrued during the first year of customer participation. Sometimes these costs are paid by the utility, and other times by the customer. For modeling purposes, we assumed that the utilities will provide the hardware and that IHDs cost an average of $500.

To calculate the cost, we began with a 2014 report by the Alberta Energy Efficiency Alliance for the City of Calgary that notes the cost for a real-time direct feedback program are estimated to be about $0.30 per kWh saved for the first year, with expected reductions to $0.07 per kWh saved after five years, using a standard discount rate of 5%.[22] To simulate the same effect, we begin with the $500 hardware acquisition and installation costs, and assume financing for the IHD at 5% interest with a five year payback. Based on average savings of 4.5% and a 5-year technology life, that would be $0.37 per kwh of savings (assuming 7,000 kwh per household) including interest for the first 5 years. However, because this cost need only be bourn once, we extended the use of the device to 14 years (to match the time horizon of 2016-2030) for an overall cost of $0.255 per kWh. This cost covers kWh and therm savings for dual fuel utilities. For SCG, we calculate a cost of $4.40 per therm over the same 14-year time frame.

Estimated costs for online portal programs are based on the above mentioned $0.07 per kWh, which represents ongoing program expenses after devices are fully paid for.

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[16] Kira Ashby, 2016 Behavior Program Summary, 2016, Consortium for Energy Efficiency, from https://library.cee1.org/content/2016-behavior-program-summary-public

[17] Susan Mazur-Stommen and Kate Farley, ACEEE Field Guide to Utility-Run Behavior Programs, 2013, American Council for an Energy-Efficient Economy, from http://aceee.org/research-report/b132

[18] Illume Advising, Energy Efficiency Behavioral Programs: Literature Review, Benchmarking Analysis, and Evaluation Guidelines, Conservation Applied Research & Development (CARD) FINAL REPORT, Prepared for: Minnesota Department of Commerce, Division of Energy Resources, May 4, 2015

[19] Ben Foster and Susan Mazur-Stommen. 2012. “Results from Real-Time Feedback Studies.” American Council for an Energy Efficient Economy. Report Number B122

[20] Reuven Sussman and Maxine Chikumbo. 2016. “Behavior Change Programs: Status and Impact.” American Council for an Energy Efficient Economy. Report Number B1601

[21] Opinion Dynamics. “PY2013-2014 California Energy Efficiency and Demand Response Residential Behavior Market Characterization Study Report: Volume 1. Prepared for the California Public Utilities Commission Energy Division. July 2015.

[22] Alberta Energy Efficiency Alliance, Energy Savings through Consumer Feedback Programs, Feb 2014, City of Calgary

A.3 Residential - Competitions: Large and Small

Summary

Residential competitions are a behavioral intervention approach in which participants compete in energy-related challenges, events, or contests. The goal of such challenges is generally to reduce energy consumption either directly or by raising awareness, increasing knowledge, or encouraging one or more types of action (i.e., conservation, buying efficient light bulbs, etc.). Competitions can run for different lengths of time, ranging from a single month to multiple years. They can also include a mix of behavioral strategies, including goal-setting, commitments, games, social norms, and feedback. Our analysis does not include competitions and challenges that focus on the use of equipment upgrades as a means of generating energy savings.

It is also important to note that the way in which competitions are designed can vary depending upon the size of the targeted participant group. Small-scale competitions are typically designed to engage participants more deeply, with a higher number of touches and a broad spectrum of behaviors that generate higher savings and serve as a model to get the larger population engaged. Large-scale competitions engage greater numbers of people in a more superficial way and encourage a limited number of behaviors. For this reason, we separate our modeling calculations to estimate the savings for the two types of competitions separately.

We define small competitions as having less than 10,000 participants per year and large competitions as having more than 10,000 participants per year. In total, we reviewed 18 small competitions and 5 large competitions. Data availability varied across programs.

Table A-3: Residential Competitions - Key Assumptions

Sector	Type	EUL years	Savings		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
RES	Small Competitions (<10,000 ppl)	1	8.1%	5.2%	$0.050	$1.344	0.00019058
RES	Large Competitions (>10,000 ppl)	1	4.1%	5.2%	$0.007	$0.101	0.00019058

Assumptions and Methodology

Eligibility and Participation

All residential customers are considered eligible to participate in competitions. Estimated participation rates were determined by averaging available reported participation rates for small (6.5%) and large (1.4%) competitions. Participation data for small-scale competitions was derived from SDG&E's "Biggest Energy Saver" program, SMECO's "Energy Savings Challenge", and Minnesota Valley Electric Cooperative's "Beat The Peak" program. Large competition estimates were based upon SDG&E's "San Diego Energy Challenge" and "Manage-Act-Save" programs, as well as Puget Sound Energy's "Rock the Bulb" program. This information was supplemented with findings from program reviews conducted by the

Consortium for Energy Efficiency,[23] American Council for an Energy-Efficient Economy,[24] and Illume Advising.[25]

Penetration rates for the reference case assume that small competitions are conducted by each utility with a consistent target population of 10,000 households per year each year between 2019 and 2030. Starting saturation level is determined by dividing 10,000 by the number of residential households per utility and multiplying by the 6.5% participation rate. The aggressive case also starts in 2019. It assumes that years 1-3 are limited to two target groups of 10,000, but then increased to 5 target groups of 10,000 each in subsequent year. These groups may be small towns, neighborhoods within larger cities, or similar.

Penetration rates for large competitions are based upon a 1.4% participation rate and a percentage of utility households. The reference case for large competitions assumes that each utility targets 10% of its residential customers between 2019 and 2021; then rises to 15% of customers from 2022 to 2024 before increasing to 20% in 2025 and rising to 25% of customers in 2028. The aggressive case uses the same time intervals, but it starts at 20% of customers and rises in increments of 10% rather than the 5% of the reference scenario.

Savings

Once the available programs were sorted accordingly to size (small and large), we averaged the percentage of kWh savings reported for each to arrive at 8.1% for small competitions and 4.1% for large competitions. Gas savings of 5.3% are used for both small and large competitions and are based on an average of an ACEEE review of three programs that report gas savings between 0.4% and 10%.[26]

Because competitions can be run for different lengths of time, lasting from a few months to multiple years, we have standardized the model on an EUL of one year. (This is the same EUL that we apply for other residential interventions.) Because insufficient demand savings data was available for residential competitions, we applied a ratio of 0.00019058 kW to kWh to savings, which is the figure used for HERs for all three electric utilities.

Cost

Costs associated with competitions are largely associated with program administration and game-related prizes. We used data gathered from the 2015 ACEEE's report on energy efficiency and gamification and information from the CEE database of behavioral programs to create cost estimates for both small and large behavior-based competitions. We approached the calculations for both small and large competitions in the same way. We began by estimating total program costs and total program savings and then divided total program costs by total program savings to get average cost per kWh. We estimated total program savings by multiplying the average number of participants per competition by the cost per participant. We

[23] Kira Ashby, 2016 Behavior Program Summary, 2016, Consortium for Energy Efficiency, from https://library.cee1.org/content/2016-behavior-program-summary-public

[24] Susan Mazur-Stommen and Kate Farley, ACEEE Field Guide to Utility-Run Behavior Programs, 2013, American Council for an Energy-Efficient Economy, from http://aceee.org/research-report/b132

[25] Illume Advising, Energy Efficiency Behavioral Programs: Literature Review, Benchmarking Analysis, and Evaluation Guidelines Conservation Applied Research & Development (CARD) FINAL REPORT, Prepared for: Minnesota Department of Commerce, Division of Energy Resources, May 4, 2015.

[26] Grossberg, Frederick; Wolfson, Mariel; Mazur-Stommen, Susan; Farley, Kate; and Steven Nadel. 2015.(February) "Gamified Energy Efficiency Programs." ACEEE Report B1501.

estimated total program savings by multiplying average household electricity consumption by the average number of participants and the average savings rate per participant.

For competitions, we assumed that prizes account for 50% of program costs. We estimated the cost per kWh at $0.007 for large competitions, based on the prizes and participation reported for SDG&E's "San Diego Energy Challenge" and Puget Sound Energy's "Rock the Bulb" program. We estimated the cost per kWh at $0.050 for small competitions based on the prizes and participation reported for SMECO's "Energy Savings Challenge" and Minnesota Valley Electric Cooperative's "Beat The Peak" program.[27]

A.4 Commercial - Strategic Energy Management

Summary

Strategic Energy Management (SEM) is a process for evaluating and implementing opportunities to optimize energy use in the commercial and industrial sectors. SEM is a continuous improvement approach that focuses on changing business practices to enable companies to save money by reducing energy consumption and waste. In California, pilot SEM programs are currently being administered in the industrial sectors. Customers that benefit the most from SEM, typically fall under one of the following categories:

- Campuses with multiple buildings and building types
- Customers with a large portfolio of buildings and a range of building types
- Buildings with complex energy systems

SEM allows for continuous energy performance improvement by providing the processes and systems needed to incorporate energy considerations and energy management into daily operations. While SEM applications vary depending on customer specific needs, program participants generally implement the following policies and activities:

- Measure and track energy use to help inform strategic business decisions
- Drive managerial and corporate behavioral changes around energy
- Develop the mechanisms to track and evaluate energy optimization efforts
- Implement ongoing operations and maintenance practices
- Reduce total annual energy costs between 5% and 10%
- Identify and prioritize capital improvements or process changes that lead to more savings
- Justify additional resources to energy management as a result of demonstrated success
- Overcome barriers to efficiency
- Boost employee engagement to contribute to sustainability goals
- Embed SEM principles into a company's operations.

[27] Grossberg, Frederick; Wolfson, Mariel; Mazur-Stommen, Susan; Farley, Kate; and Steven Nadel. 2015.(February) "Gamified Energy Efficiency Programs." ACEEE Report B1501.

The model inputs for electric and natural gas shown in Table A-4 represent savings associated with operational and behavioral changes. Savings are estimated at 3% of customer segment consumption (kWh or therms per year) and are applied consistently by building and fuel type across utilities. Costs for electricity and natural gas are $0.29 per kWh and $3.65 per therm, and are also applied consistently by building type across utilities.

Table A-4: Commercial Strategic Energy Management - Key Assumptions

Sector	Type	EUL years	Savings		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
COM	Strategic Energy Management	5	3.0%	3.0%	$0.29	$3.65	0.000114

Assumptions and Methodology

Eligibility and Participation

Segments of the commercial market are considered suitable for SEM type program approaches. Customers that benefit the most from SEM typically operate portfolios or campuses with multiple buildings, building types, and a variety of complex energy systems, each with its own unique set of energy management requirements. The market defined for the PG BROS Model therefore includes the following segments:

- Schools
- Colleges
- Healthcare
- Large Office Buildings

Depending on the segment, the model assumes that between 10% and 55% of buildings have already implemented SEM,[28] resulting in reduced applicability of any commercial SEM program. After accounting for the estimate of customers that have already implemented SEM outside of any program intervention, the PG BROS model applies an applicability factor of between 45% and 90%. A compound annual growth rate (CAGR) was used to forecast growth in participation over time. A 2% CAGR was used in the reference case, while the aggressive case used a 4% CAGR.

Savings

Estimated electric savings for all activities associated with SEM range from 5% to 10% of customer segment consumption for electricity and gas (kWh or therms per year). These savings estimates include a mix of operational savings and savings associated with capital investments (i.e., equipment retrofit and replacement projects). Because savings from capital investments are addressed in other components of the potential model, the SEM savings associated with BROS activities are constrained to estimates of

[28] Healthcare participation estimates are based on the 'Hospitals and Healthcare Initiative Market Progress Evaluation Report 7, Northwest Energy Efficiency Alliance. March 26, 2015. REPORT #E15-310. Participation estimates for other market segments are based on professional judgement.

operational savings. Based on a literature review of 16 institutional SEM plans, such as the LW Hospitals Alliance 2014 plan,[29] and market studies such as the Northwest Energy Efficiency Alliance (NEEA) Market Progress Evaluation Report,[30] operations and maintenance savings are estimated to be 3% applied consistently by building and fuel type across all utilities for the market segments considered.

The model uses an EUL of five years based on an SEM related program market persistence study.[31] A ratio of kW to kWh of 0.000114 was applied to all three electric utilities based on an analysis of several third-party programs operating in California during the 2014-2015 portfolio cycle that included some components of SEM initiatives.

Cost

Costs for electricity and natural gas savings are estimated at $0.29 per kWh and $3.65 per therm, applied consistently by building and fuel type across utilities based on an analysis of several third-party programs operating in California during the 2014-2015 portfolio cycle that included some components of SEM initiatives, including the Commercial Energy Advisor, Monitoring-Based Persistence Commissioning, and Energy Fitness programs

A.5 Commercial - Building Operator Certification

Summary

Building Operator Certification (BOC) offers energy efficiency training and certification courses to commercial building operators in the commercial sector. BOC has been modelled as a component of behavioral savings in the 2011, 2013, and 2015 Potential Studies and research conducted for those studies indicate that operations and maintenance practices mostly fell into the following categories:

- Improved air compressor operations and maintenance
- Improved HVAC operations and maintenance
- Improved lighting operations and maintenance
- Improved motors/drives operations and maintenance
- Water conservation resulting in energy savings
- Adjusted controls of HVAC systems
- Adjusted controls of energy management systems

The inputs for electric and natural gas shown in Table A-5 represent savings associated with changes in operation and behavior, estimated on a population basis of 1,000 sq. ft. of floor space. Savings vary depending on the energy intensity of facilities in each market segment, as defined in the 2009 CEUS.[32]

[29] Joint Strategic Energy Management Plan for Listowel Wingham Hospitals Alliance, 2014

[30] Hospitals and Healthcare Initiative Market Progress Evaluation Report 7, Northwest Energy Efficiency Alliance. March 26, 2015. REPORT #E15-310

[31] Commercial Real Estate Market Partners Program Savings Persistence Analysis, Northwest Energy Efficiency Alliance. March 22, 2016. REPORT #E16-329

[32] California Energy Commission (CEC), California Commercial End-Use Survey, CEC-400-2006-005, Prepared by Itron, Inc., March 2006, Final report available at: http://www.energy.ca.gov/ceus/index.html. Data available at: http://capabilities.itron.com/ceusweb/.

EUL is estimated at 6.5 years and costs for electricity and natural gas savings are $0.29 per kWh and $3.65 per therm. Cost and EUL values are applied consistently by building and fuel type across all utilities.

Table A-5. Commercial Building Operator Training - Key Assumptions

Sector	Type	EUL years	Savings (per 1,000 sq. ft.)		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
COM	Building Operator Certification	6.5	18-151	0.8-14.2	$0.29	$3.65	0.000114

Assumptions and Methodology

Eligibility and Participation

Consistent with prior studies, BOC savings apply to all commercial market segments, though the applicability factor of BOC ranges from 15% to 100%, depending on the market segment. This model assumes that SEM program interventions in the commercial market have been ongoing and a CAGR was used to forecast growth in participation through the model forecast horizon. In the reference case, a 12.5% CAGR was used to forecast growth in BOC, while the aggressive case used a 18.0% CAGR. While these growth rates appear ambitious, low initial sector engagement in BOC results in forecast market saturations of 6.52% and 12.12% for the reference and aggressive cases, respectively. While there is the potential for overlap in savings between BOC and SEM interventions, the current saturation of these measures and relatively low penetration rate forecasted indicate that the risk of double counting savings is minimal and was therefore was not considered in this model.

Savings

This model used the same average electric and natural gas savings as the 2015 Study model, 58 kWh and 5.6 therms per 1,000 sq. ft. of participating building space. Past studies applied these values consistently by building type across all utilities. The 2017 Study approach was revised and applied a market segment-specific value that adjusted these market average savings to account for differences in building energy density. For example, a grocery store with ten times the energy density of a warehouse would experience a proportionally greater savings rate per unit of conditioned space. In this example, a grocery store in PG&E territory is expected to save 151.3 kWh per 1,000 sq. ft. and 5.2 therms per 1,000 sq. ft., compared to an unrefrigerated warehouse, which would be expected to save 18.2 kWh per 1,000 sq. ft. and 0.8 therms per 1,000 sq. ft. after accounting for differences in energy density.

The 2017 Study uses an EUL of 6.5 years, based on the average staff turnover rates for nine commercial market segments. Turnover rates represent how long employees stay with a company before leaving. The underlying assumption is that when an employee leaves, the full value of BOC is lost to the organization.[33] A ratio of kW to kWh of 0.000114 was applied to all three electric utilities. This value was also used on the SEM forecast and is based on an analysis of several third-party programs operating in California during the 2014-2015 portfolio cycle.

Cost

[33] 2013 Total Employee Turnover Rate by Industry (U.S.) http://www.compensationforce.com/2014/02/2013-turnover-rates-by-industry.html

Costs for electricity and natural gas savings used the same approach employed for the SEM analysis and are estimated at $0.29 per kWh and $3.65 per therm, applied consistently by building type across utilities.

A.6 Commercial - Building Energy and Information Management Systems

Summary

The potential for building energy management and information systems (BEIMS) were first modelled by Navigant as part of the AB 802 Technical Analysis.[34] The Technical Analysis was issued in March of 2016 and not used at that time to set goals. That work has now been incorporated into this model.

As discussed in the Technical Analysis, BEIMS includes IT-based monitoring and control systems that provide information on the performance of some or all the components of a building's infrastructure, including its envelope, heating and ventilation, lighting, plug load, water use, occupancy, and other critical resources. A BEIMS primarily consists of software, hardware (such as dedicated controllers, sensors, and sub-meters), as well as value-added services (including outsourced software management, building maintenance contracts, and others). This model focuses on the potential for BIEMS to change energy consumption associated with the operation of building HVAC systems as the result of several applications of BEIMS technology, including the following:

- Energy visualization
- Energy analytics
- Operational control and facility management
- Continuous commissioning and self-healing buildings.

The model inputs for electric and natural gas for BEIMS are shown in Table A-6 based on customer segment consumption (kWh or therms per year). Electricity savings range from 1.1% to 4.2% and natural gas savings range from 0.2% to 7.4%. Variations between utilities are due to differences in segments' energy densities and differences in climate. Costs for electricity and natural gas savings also varied by utility between $0.20 and $0.46 per kWh and between $0.18 and $0.46 per therm.

Table A-6. Building Energy and Information Management Systems - Key Assumptions

Sector	Type	EUL years	Savings		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
COM	Building Energy and Information Management Systems	5	1.1% - 4.2%	0.2% - 7.4%	$0.20 - $0.46	$0.18 – $0.46	0.000138

Assumptions and Methodology

[34] AB802 Technical Analysis, Potential Savings Analysis. Navigant Consulting, Inc., Reference No.: 174655. March 31, 2016

Eligibility and Participation

The technologies that enable BEIMS are primarily associated with energy management systems (EMS) that are broadly applicable across all market sectors, though the existing market saturation of these technologies, which cannot be claimed by IOU programs moving forward, ranges across market segments from 1% to 80%. In general, segments that operate larger facilities (e.g., large offices) or facilities that are energy intensive (e.g., grocery stores) will have a higher existing saturation of BEIMS-enabling technologies. A CAGR was used to forecast growth in BEIMS technology penetration over time. A 12% CAGR was used in the reference case, while the aggressive case used a 24% CAGR. The same CAGR was applied to all commercial market segments and utilities. Based on estimates of existing market saturations, these growth rates result in BEIMS forecasted penetrations of 5.6% and 20.9% for the reference and aggressive cases, respectively.

Savings

As discussed in the AB 802 Technical Analysis, energy savings associated with BEIMS are calculated using the following equation:

> Energy Savings, BIEMS = Starting Saturation of EMS by Building Type x Total Annual Consumption x % End Use Consumption for HVAC x % End Use Savings by Building Type.

This equation resulted in a range of unit energy savings (UES) values associated with BEIMS. While there is the potential for overlap in savings between BEIMS, BOC, and SEM interventions, the current saturation of these measures and relatively low penetration rates forecasted indicate that the risk of double counting savings is minimal and was therefore was not considered in this model. Additionally, BEIMS often requires capital investment while BOC and SEM are typically not capital investments, thus providing some differentiation in the market penetration models and potential to mitigate the risk of double counting savings.

The model uses an EUL of five years based on various studies reviewed for the AB 802 Technical Analysis. A ratio of kW to kWh of 0.000138 was applied to all three electric utilities based on an analysis of several statewide and third-party programs operating in California during the 2014-2015 portfolio cycle that included BEIMS-related initiatives.

Cost

Costs for electricity and natural gas savings are estimated based on research referenced in the AB 802 Technical Analysis.[35]

A.7 Commercial - Business Energy Reports

Summary

Business Energy Reports (BERs) are the commercial sector equivalent to the HERs sent to residential customers. BERS (and other similar programs) typically share reports (via mail or electronic format) with small and medium-sized businesses at specific intervals (often monthly). The objective is to provide feedback about their energy use, including normative comparisons to similar businesses, tips for improving energy efficiency, and occasionally messaging about rewards or incentives. BERs and other similar programs typically send reports to customers on opt-out basis. BER-type programs are a relatively

[35] AB802 Technical Analysis, Potential Savings Analysis. Navigant Consulting, Inc., Reference No.: 174655. March 31, 2016

new addition in the emerging field of behavior change programs and are now in pilot testing at PG&E and other non-California utilities.

Although PG&E had a BER pilot underway at the time that this report was being prepared, final third party evaluation findings were not yet publicly available. Given the nascent nature of the PG&E program, Navigant's modeling estimates are primarily based on two sources: 1) a Cadmus review of a BER pilot with Xcel Energy business customers (smaller than 250 kW service) in Colorado (10,000 participants) and Minnesota (20,000 participants) that was conducted between June 2014 and June 2015, and 2) a commercial customer behavior change pilot conducted by Commonwealth Edison and Agentis Energy in Illinois beginning in 2012. In the first instance, Xcel Energy provided BERs to a sample of businesses operating in the following sectors: small office, small retail trade, small retail service, and restaurants.[36] In the Commonwealth Edison pilot the utility engaged 6,009 medium sized (100-1,000 kW) commercial customers in Illinois.[37] While the Commonwealth Edison customers represented numerous sectors, only those businesses in the "lodging" and "other" categories showed significant savings.

Table A-7: Business Energy Reports - Key Assumptions

Sector	Type	EUL years	Savings		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
COM	Business Energy Reports (BERs)	2	1.6% - 2.2%	0.9% for restaurants	$0.20	$6.12	0.0001261

Assumptions and Methodology

Eligibility and Participation

BERs typically target small and/or medium sized businesses. In addition, utilities may use BERs to target businesses across all business sectors or only a select set of business sectors. As the number of BERs pilots continues to grow, a greater amount of information about the effectiveness of BERs programs in different business sectors will become available. As information concerning the effectiveness of these programs in different business sectors becomes more readily available, we assume that utilities will be more likely to limit the use of BERs to those sectors for which significant savings have been documented. Therefore, the model presented here constrains our savings estimates to those business sectors that have already achieved significant energy savings by means of business energy feedback programs such as BERs.

The model includes businesses in the following sectors: retail, restaurants, lodging, and "other." Within each of these business sectors, the applicability of savings is further constrained by the estimated proportion of business customers in each of the relevant sectors that may be classified as either small or

[36] Jim Stewart, Energy Savings from Business Energy Feedback [for Xcel Energy], Cadmus, October 21, 2015, Behavior, Energy, and Climate Change Conference 2015

[37] Gajus Miknaitis, John Lux and Deb Dynako, Mark Hamann and William Burns, Tapping Energy Savings from an Overlooked Source: Results from Behavioral Change Pilot Program Targeting Mid-Sized Commercial Customers, 2014 ACEEE Summer Study on Energy Efficiency in Buildings, Commonwealth Edison and Agentis Energy, from: http://aceee.org/files/proceedings/2014/data/papers/7-153.pdf

medium sized enterprises (given that BER type programs are typically limited to small to medium sized businesses). Based on data from the Commercial Building Energy Consumption Survey (CBECS), we estimated that roughly 63% of retail customers can be considered to be small or medium businesses given that approximately 63% of retail space is shown to be under 100,000 sq ft.[38] Given the small size of restaurants, we assume 100% applicability for this sector.

The Commonwealth Edison study specifically targeted medium sized businesses in the lodging and "other" sectors. Therefore, our savings estimates are only calculated for medium sized customers in the lodging and "other" categories based on relevant data from CBECS. For lodging, for example, we assume that 50% of lodging establishments can be considered medium-sized establishments based on CBECS data indicating that 50% of lodging establishments have an average annual energy consumption of 500,000 kWh or more per year. For businesses in the "other" category, we look at CBECS data to estimate the proportion of establishments that fall in the medium sized category (<1m kWh per year). We estimate that 25% of buildings in the "other" category are using an average of 400,000 kWh per year.

Our projected penetration rates assume a delayed start for BERs with formal utility programs launching in 2019. Our reference scenario assumes 1% penetration in 2019 and ramps up at an additional 1% per year, reaching 12% by 2030. Under the aggressive scenario, penetration begins at 2% in 2019 and ramps up at 2% per year, reaching 24% by 2030. Future iterations of the model will include savings for sectors and building types beyond the four business sectors identified above as statistically significant findings are reported in other trial locations.

Savings

Our team's forecasted kWh and gas savings calculations for retail and restaurants are based on the Cadmus review of a BER pilot for Xcel Energy. That study reports electricity savings of 1.6% for retail trade, which was the only sector with statistically significant sector savings. Likewise, gas savings were found to be 0.9% for restaurants, again the only viable finding. We applied no gas savings for retail and no electric savings for restaurants. For lodging and "other" buildings we estimate 1.8% and 2.2% savings respectively, based on reported kWh savings from the Commonwealth Edison pilot. No other sectors in our model receive savings estimates at this time.

The model uses an EUL of two years per CPUC Decision 16-08-019. Because no demand savings data was available for BERs, we averaged the ratio of kW to kWh savings calculated for BEIMS, BOC, and Strategic Energy Management. This yielded 0.0001261, which is the figure used for all four utilities.

Cost

Because BER programs are new and in pilot phases, data regarding utility costs is scant. Furthermore, the limited availability of statistically significant adjusted savings percentages reported to-date indicates that BER-related savings are lower among businesses than household savings produced by HERs. For these reasons, we modeled BER costs that are double those of HERs. We project $0.20 per kWh (2 x $0.10) for electric savings for PG&E, SCE, and SDG&E. Meanwhile, for restaurants we assigned $6.12 per therm (2 x $3.06) for PG&E, SCG, and SDG&E. No kWh savings are modeled for restaurants.

[38] U.S. Energy Information Administration, Commercial Building Energy Consumption Survey, http://www.eia.gov/consumption/commercial/data/2012/index.php?view=consumption#c13-c22

A.8 Commercial - Benchmarking

Summary

Building benchmarking scores a business customer's facility or plant and compares it to other peer facilities based upon energy consumption. It also often includes goal-setting and rewards in the form of recognition. Benchmarking is generally an opt-in activity, although some municipalities, such as San Francisco, have passed ordinances requiring it for buildings of certain types and sizes.

Estimated electric savings range from 1.1% to 2.2%, while gas savings are 0.7% to 1.3%. These are applied consistently by building and fuel type across utilities. Costs were estimated to be $0.0396 per kWh and $0.2352 per therm and are not utility specific.

Table A-8: Benchmarking - Key Assumptions

Sector	Type	EUL years	Savings		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
COM	Building Benchmarking	2	1.1%-2.2%	0.7%-1.3%	$0.0396	$0.2352	0.0001261

Assumptions and Methodology

Eligibility and Participation

In San Francisco, there is a benchmarking ordinance for any building over 10,000 sq. ft. According to the EIA, approximately 20% of all commercial buildings are under 10,000 sq. ft. While any building and business type may be subject to benchmarking, reliable savings data exists for the following: colleges, healthcare, lodging, large offices, retail, and schools. For these sectors, we applied CBECS data to determine applicability.[39,40] For instance, we applied 100% applicability for both fuel types to colleges, while for retail we estimated 35% applicability since CBECS data indicates that roughly 35% of all retail buildings exceed 10,000 sq. ft. For healthcare, we used CBECS data to ascertain the proportion of electricity and natural gas consumed by large inpatient facilities. This information suggests that roughly 69% of all electricity and 83% of natural gas used in the healthcare sector is consumed by large healthcare facilities. School applicability is assumed to be 90% after a 10% reduction to account for smaller private learning centers.

Projected penetration rates for the reference scenario assume a constant 0% for SCE, SCG, and SDG&E, while PG&E begins with and maintains a penetration of 7.5% to reflect eligible San Francisco building stock as a percentage of overall commercial buildings within PG&E's service territory. For the aggressive scenario, PG&E begins with the same 7.5%, but then climbs to 15% in 2020 and 22.5% in 2025. The aggressive scenario for the other three utilities are targeted for 7.5% by 2019 and 15% by 2024.

[39] U.S. EIA. Commercial Building Energy Consumption Survey (CBECS) "Table C1. Total energy consumption by major fuel, 2012." (May 2016).

[4040] U.S. EIA. Commercial Building Energy Consumption Survey (CBECS) "Table B6. Building size, number of buildings, 2012." (May 2016).

Savings
Estimated electric savings range from 1.1% to 2.2%, while gas savings range from 0.7% to 1.3% and are applied consistently by building and fuel type across utilities. Savings estimates are based on actual savings levels from city benchmarking reports.[41,42,43,44,45] We divided reported savings in half because we are assuming that half of the savings come from technologies and half from operation-related behaviors. Furthermore, we have applied a consistent split of 60% electric savings and 40% gas savings. This likely varies by building type, but as these data were not available we have not made this calculation based on specific building-type consumption information.

The model uses an EUL of two years per CPUC Decision 16-08-019.

Because no demand savings data was available for Benchmarking, we averaged the ratio of kW to kWh savings calculated for BEIMS, BOC, and Strategic Energy Management. This yielded 0.0001261, which is the figure used for all three electric utilities.

Cost
Available data suggest that benchmarking programs often include a utility in concert with a municipality. Our estimates used PG&E's estimated 3-year program budget of $2.3 million.[46] Attributing all costs to either electricity or gas, this utility program cost was divided by estimated savings to calculate a per unit savings cost. Costs amounted to $0.0396 per kWh and $0.2352 per therm and are not utility specific.

A.9 Commercial - Competitions

Summary

Commercial competitions are a behavioral intervention approach in which participants compete in events, contests, or challenges to achieve a specific objective or the highest rank compared with other individuals or groups as they try to reach goals by reducing energy consumption. Competitions can run for varying time periods ranging from a single month to multiple years. They can include a mix of behavioral strategies, including goal-setting, commitments, games, social norms, and feedback. Those designed to produce energy savings via equipment upgrades were not included in our analysis.

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[41] SF Environment and ULI Greenprint Center for Building Performance. "San Francisco Existing Commercial Buildings Performance Report: 2010-2014." (2015)

[42] Katherine Tweed. "Benchmarking Drives 7 Percent Cut in Building Energy. (October 2012) Greentech Media

[43] City of Chicago. "City of Chicago Energy Benchmarking Report 2016."

[44] Jewel, Amy; Kimmel, Jamie; Palmer, Doug; Pigg, Scott; Ponce, Jamie; Vigliotta, David; and Weigert, Karen. "Using Nudges and Energy Benchmarking to Drive Behavior Change in Commercial, Institutional, and Multifamily Residential Buildings." 2016. Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings.

[45] Navigant Consulting. "New York City Benchmarking and Transparency Policy and Impact Evaluation Report." (May 2015). Prepared for the U.S. Department of Energy by Navigant Consulting, Inc., Steven Winter Associates, Inc., and Newport Partners, LLC.

[46] CPUC, Statewide Benchmarking Process Evaluation, Volume 1, CPU0055.01, Submitted by NMR Group and Optimal Energy, April 2012.

Competitions may be designed differently depending upon the size and nature of the targeted participant group. Smaller scale competitions are designed to engage people in a deep way with a higher level of touches and a broad spectrum of behaviors that generate higher savings and serve as a model to get the larger population engaged. Large scale competitions engage greater numbers of people in a more superficial way and encourage a limited number of behaviors. Because we had limited data for this type of behavioral intervention all commercial competitions are considered as a single category.

In additional to overall summary data available through the ACEEE[47] and the CEE,[48] we considered 10 different challenges, including the EPA's Energy Star Building Competition, NEEA's Kilowatt Crackdown, Chicago's Green Office Challenge, and PG&E's Step Up and Power Down pilot.[49,50] The completeness of data available on each program varied with some of the most robust data coming from Duke Energy's Smart Energy Now effort in Charlotte, NC.[51]

Table A-9: Commercial Competitions - Key Assumptions

Sector	Type	EUL years	Savings		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
COM	Competitions	2	4.5%-6.0%	--	$ 0.04	--	0.0001261

Assumptions and Methodology

Eligibility and Participation

Eligibility for commercial competitions is defined by the program administrator. Competitions can focus on occupants within an individual building or across a single company, but more often they embrace wider audiences at the municipal level, in which groups of tenants within large buildings or across campuses or neighborhoods compete with one another. Nonetheless, certain business sectors and business types constitute more receptive customer types than others.

For this model, we focused on savings in those building types that have been targeted by PG&E's Step Up and Power Down campaign that is currently being carried out in San Francisco and San Jose. This effort is focused on the following five building types: large offices, small offices, retail, restaurants, and

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47 Kira Ashby, 2016 Behavior Program Summary, 2016, Consortium for Energy Efficiency, from https://library.cee1.org/content/2016-behavior-program-summary-public

48 Susan Mazur-Stommen and Kate Farley, ACEEE Field Guide to Utility-Run Behavior Programs, 2013, American Council for an Energy-Efficient Economy, from http://aceee.org/research-report/b132

49 Edward Vine and Christopher Jones, A Review of Energy Reduction Competitions. What Have We Learned?, 2015 (May), California Institute for Energy and Environment. Report sponsored by the California Public Utilities Commission. Available at: http://escholarship.org/uc/item/30x859hv

50 Edward L. Vine and Christopher M. Jones. Competition, carbon, and conservation: Assessing the energy savings potential of energy efficiency competitions. 2016. Vol 19: 158-176. *Energy Research and Social Science*.

51 TecMarket Works, Impact Evaluation of the Smart Energy Now Program (NC) (Pilot) for Duke Energy, February 21, 2014.

lodging.[52,53] The applicability factor was defined in terms of potential program reach as it applies to larger and smaller types of buildings. We assume an applicability of 90% for large offices and lodging and a lower applicability factor of 20% for small to medium businesses - small offices, restaurants, and retail.

At the time this model was prepared, PG&E was the only California IOU running a commercial competition, but they were not claiming savings. Because of this, our penetration forecast for PG&E shows 0% until 2019, at which point we anticipate they will begin to claim savings for 20% of one city with full ramp up within that city occurring over a five-year period, at which point the savings hold steady through 2030. SCE and SDG&E follow a similar pattern but do not begin claiming savings until 2021. We do not anticipate that SCG will run commercial competitions given that we currently do not have sufficient data with which to model gas savings. For the aggressive scenario PG&E, SCE, and SDG&E all begin to claim savings in 2019 and ramp up at the same 20% per year. However, in 2024, they add a second city-size competition and it ramps up at the same rate through 2028, at which point savings hold constant to 2030.

The penetration rates for each utility assume that they will target the largest cities within their service territories, such as San Francisco, San Jose, Anaheim, and San Diego, or that groups of smaller communities - the size of Walnut Creek, Santa Barbara, or Oceanside - may be pooled together within a service territory to reach a similar number of businesses.

Savings
Savings estimates are based on a combination of the Envision Charlotte - Smart Energy Now effort and Step Up and Power Down using Save Energy Now for large office buildings (6.0% kWh) and Step Up and Power Down for the other building types (4.5% kWh). No gas savings are modeled.

The model uses an EUL of two years to maintain consistency with CPUC Decision 16-08-019.

Because no demand savings data was available, we averaged the ratio of kW to kWh savings calculated for BEIMS, BOC, and SEM. This yielded 0.0001261, which is the figure used for all three electric utilities.

Cost
Costs of $0.04 per kWh are drawn from Smart Energy Now.

A.10 Commercial - Retrocommissioning

The potential for Retrocommissioning (RCx) was modelled as a component of behavioral savings in the 2013 and 2015 Studies and this update refines several of the underlying assumptions and inputs used. RCx continues to be defined as commissioning performed on buildings that have not been previously commissioned. The model focuses on RCx activities that impact HVAC system operations and includes, for example, measures such as the following:[54]

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[52] Linda Dethman, Brian Arthur Smith, Jillian Rich, and James Russell. Engaging Small and Medium Businesses in Behavior Change through a Multifaceted Marketing Campaign. 2016. Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings.

[53] Kat A. Donnelly. Workplace Engagement: Finding and Filling the Gaps for Fruitful Energy Savings. 2016 (October). Presentation at the 2016 Behavior, Energy and Climate Change Conference. Baltimore, MD.

[54] 2016 Statewide Retrocommissioning Policy & Procedures Manual, Version 1.0. Effective Date: July 19, 2016

- Correct actuator/damper operations
- Correct economizer operations
- Adjust condenser water reset
- Adjust supply air temperature reset
- Adjust zone temperature deadbands
- Adjust equipment scheduling
- Adjust duct static pressure reset
- Adjust hot or cold deck reset
- Optimize Variable Frequency Drives on fans or pumps
- Recode Controls HVAC airflow rebalance/adjust
- Reduce simultaneous heating and cooling
- Adjust boiler lockout schedule

The model inputs for electric and natural gas for RCx, shown in Table A-10, are based on customer segment consumption (kWh therms per year). Electricity and natural gas savings range from 2.3% to 12.7%, and are applied consistency at the market segment level for all utilities. Costs for electricity and natural gas savings are also constant across utilities at $0.39 per kWh and $0.29 per therm.

Table A-10. Commercial Retrocommissioning - Key Assumptions

Sector	Type	EUL years	Savings		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
COM	RCx	5	2.3% - 12.7%	2.3% - 12.7%	$0.39	$0.29	0.000138

Assumptions and Methodology

Eligibility and Participation

Consistent with previous Studies, RCx savings are applied to select commercial market segments, and the applicability factor ranges from 18% to 70%, depending on the market segment. Some market segments with low energy densities, such as warehouses, are not considered to have significant or cost-effective HVAC potential and therefore have an applicability factor of 0%. This model also adjusted the eligibility and participation estimates for RCx to exclude BEIMS market potential, and to exclude buildings built after 2011 when commissioning became a requirement under CalGreen. It is estimated that approximately 92% of commercial building stock was constructed before 2011. The exclusion of market savings from BEIMS is intended to reduce the risk of double counting savings because the EMS technologies inherent in the BEIMS measure allow for continuous commissioning that would exclude commissioning activities defined in the RCx measure. The model assumes that RCx program interventions in the commercial market have been ongoing since the 2015 Study, and a CAGR was used to forecast growth in participation through the model forecast horizon. In the reference case, a 3% CAGR was used to forecast growth in RCx, while the aggressive case used a 5% CAGR. Low initial penetration of RCx results in forecasted penetrations of 1.9% and 2.3% for the reference and aggressive cases, respectively, over the forecast horizon.

Savings
Energy savings associated with RCx are calculated using the following equation:

> Energy Savings, RCx = Penetration of RCx by Building Type x Total Annual Consumption x % End Use Consumption for HVAC x % End Use Savings by Building Type

The percent of end use consumption for HVAC systems impacted by RCx is based on CEUS, while the end use savings by building type is based on literature reviewed for the 2015 Study. The model uses an EUL of 5 years, also based on various studies reviewed for the 2015 Study. A ratio of kW to kWh of 0.000138 was applied to all three electric utilities based on an analysis of several statewide and third-party programs operating in California during the 2014-2015 portfolio cycle that included RCx related initiatives.

Cost
Costs for electricity and natural gas savings are estimated based on an analysis of the same programs reviewed and referenced in the 2015 Study.

A.11 Other Data Sources and References

Where possible, estimates and forecasts were calculated based on formal evaluated performance of California IOUs between 2011 and 2014, and footnoted in each individual methodology description. The model inputs and other resulting calculations were compared with professional judgement of relevant findings regarding participation rates, gross and adjusted savings, persistence, cost, and interactive effects as reported in a variety of sources as specified in the footnotes. Additional sources are listed below.

- Brown, R. “Bringing It All Together: Design and Evaluation Innovations in the Alameda County Residential Behavior Pilot.” In BECC 2014 Conference Proceedings. beccconference.org/wp-content/uploads/2014/12/presentation_Brown.pd
- Stern, S., and D. Bates. “Achieving Residential Energy Savings: Combining Behavior Change and Home Upgrades.” In Proceedings of the 2014 ACEEE Summer Study on Energy Efficiency in Buildings 7: 317–27. Washington DC: ACEEE. aceee.org/files/proceedings/2014/data/papers/7-925.pdf - page=1
- Malatest. Greater Sudbury Hydro 2014 Electric Space Heating and Occupancy Load Feedback Program Evaluation. 2014. Prepared for Ecotagious Inc. Victoria, BC