

2019 Energy Efficiency Potential and Goals Study

Public Draft Report

Prepared for:

California Public Utilities Commission



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EXECUTIVE SUMMARY

Navigant and its partners, Tierra Resource Consultants LLC, Jai J Mitchell Analytics, Cadmus, Opinion Dynamics, and Lumina Decision Systems (collectively known as the Navigant team), prepared this study (2019 Potential and Goals Study or 2019 Study) for the California Public Utilities Commission (CPUC). The purpose of this study is to develop estimates of energy and demand savings potential in the service territories of California's major investor-owned utilities (IOUs) during the post-2019 energy efficiency (EE) rolling portfolio planning cycle. This report includes results for Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Southern California Gas (SCG). A key component of the 2019 Study is a modeling platform that estimates various levels of EE potential and enables a variety of what-if scenarios. These what-if scenarios represent alternative futures that reflect the complex interactions between numerous data inputs and policy drivers.

Background and Approach

This study is primarily an update to the most recent potential and goals study completed in 2017 (2017 Study¹). That study informed the goal-making process for the 2018 and beyond rolling portfolio cycle. During the 2 years since the 2017 Study was completed, several market and policy changes have taken place. These changes are reflected in the 2019 Study. The project kicked off in December 2018 and was followed by a series of stakeholder workshops held January through March 2019 that helped to shape and guide the direction of the results presented in this report.

Study Objectives

The 2019 Study supports several objectives:

- Inform the CPUC as it proceeds to adopt EE savings goals and targets, providing guidance for the next IOU EE program portfolios
- Guide the IOUs in EE program portfolio planning and the state's principal energy agencies in forecasting for procurement, including the planning efforts of the CPUC, California Energy Commission (CEC), and California Independent System Operator (CAISO)
- Inform strategic contributions to SB350 targets
 - The CEC has historically used the potential study to develop its forecast of additional achievable energy efficiency potential (AAEE); SB350 requires doubling AAEE by 2030
 - The CEC will continue to rely on the potential study as an input to AAEE; the potential study will also serve as an input to SB350 target setting
- Identifies new EE savings opportunities

The 2019 Study forecast period spans from 2020 to 2030 based on the direction provided by the CPUC and focuses on current and potential drivers of energy savings in IOU service areas. Analysis of EE savings in publicly owned utility service territories is not part of the scope of this effort.

¹ Navigant, *Energy Efficiency Potential and Goals Study for 2018 and Beyond*, September 2017.

Consistent with previous CPUC potential studies and common industry practice, the 2019 Study forecasts EE potential at three levels for rebate programs:

- **Technical potential:** Technical potential is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve EE were taken regardless of cost.
- **Economic potential:** Economic potential represents total EE potential available when limited to only cost-effective measures.² All components of economic potential are a subset of technical potential.
- **Market potential:** The final output of the potential study is a market potential analysis, which calculates the potential EE savings based on specific incentive levels and assumptions about existing CPUC policies, market influences, and barriers. All components of market potential are a subset of economic potential. Market potential has historically been used by the CPUC to inform the goal setting process.

This 2019 Study forecasts the potential energy savings from various EE programs as well as codes and standards (C&S) advocacy efforts for the following customer sectors: residential, low income, commercial, agricultural, industrial, mining, and street lighting. The 2019 Study does not set IOU goals, nor does it make any recommendations as to how to set goals. Rather, it informs the CPUC's goal setting process.

Scenarios

The 2019 Study considers multiple scenarios to explore how EE potential might change based on a number of alternative assumptions about policies, measures, and market response. This study considers scenarios primarily built around policies and program decisions that are within the sphere of influence of the CPUC and its stakeholders collectively. Table ES-1-1. summarizes the various scenarios considered for the 2019 Study.

² The model default is to use the total resource cost (TRC) test as defined by the California Standard Practice Manual. The TRC threshold for what constitutes a cost-effective measure varies by scenario.

Table ES-1. Scenarios for EE Market Potential

Lever	Reference	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Cost-Effectiveness (C-E) Test	TRC	TRC	TRC	TRC	TRC
C-E Measure Screening Threshold	1.0 for all measures	0.85 for all measures	1.25 for all measures	1.0 for all measures	0.85 for all measures
Incentive Levels	Capped at 50%*	Capped at 50%*	Capped at 50%*	Capped at 50%*	Capped at 75%**
Marketing and Outreach	Default calibrated value	Default calibrated value	Default calibrated value	Increased marketing strength	Increased marketing strength
Behavior, Retrocommissioning, and Operational (BRO)s Program Assumptions	Reference	Reference	Reference	Aggressive	Aggressive
Financing Programs	No modeled impacts	No modeled impacts	No modeled impacts	No modeled impacts	IOU financing programs broadly available to res and com customers

*Incentives are set based on a \$/kWh and \$/therm basis consistent with existing IOU programs; incentives are capped at 50% of incremental cost.

**Incentives are assumed to be 1.5 times higher than what current IOU programs are offering on a \$/kWh and \$/therm basis, capped at 75% of incremental cost.

Changes from Previous Study

While the 2019 Study framework mirrors past PG studies, several changes were implemented for this study that result in substantially different results than observed from these previous efforts. Table ES-1-2. highlights the key changes implemented for the 2019 Study with an indication as to what directional impact each change had on the overall results.

Table ES-2. Key Changes Relative to 2017 Study

Category	Update Relative to Previous Study	Directional Impact
Baseline Policy	Recent Database for Energy Efficient Resources (DEER) Resolution E-4952 deemed non-residential lighting standard practice baseline to be LED.	↓ Significantly cuts non-residential lighting savings.
BROs Measures	Updated data and one measure added relative to 2017 Study (online audits).	↑ Increase savings specifically from home energy reports (HERs), benchmarking, and strategic energy management (SEM).
DEER/ Workpapers	DEER 2020 was used (previously DEER 2017).	↓ Majority of weather-sensitive measures were updated, decreasing savings and thus decreasing potential.
Cost-Effectiveness	2019 avoided costs being used with approved greenhouse gas (GHG) adder.	↓ Slight decrease in avoided costs due to updates to GHG adder, decreases C-E results in the 2020-2030 range.
Cost-Effectiveness	TRC threshold varies by scenario whereas previous study did not.	↓ Scenarios offer more stringent interpretations of C-E threshold.
Rebate Program Measures	New measures relative to 2017 Study: smart connected power strips and connected LEDs.	↑ Increase residential savings potential but not enough to backfill loss of non-residential LED savings.
Custom Programs	Using 2 more years of program data that was not previously available (2015-2017).	↓ Custom programs show a downward trend over time; previously, the Navigant team saw a flat trend. Potential is decreasing over time.

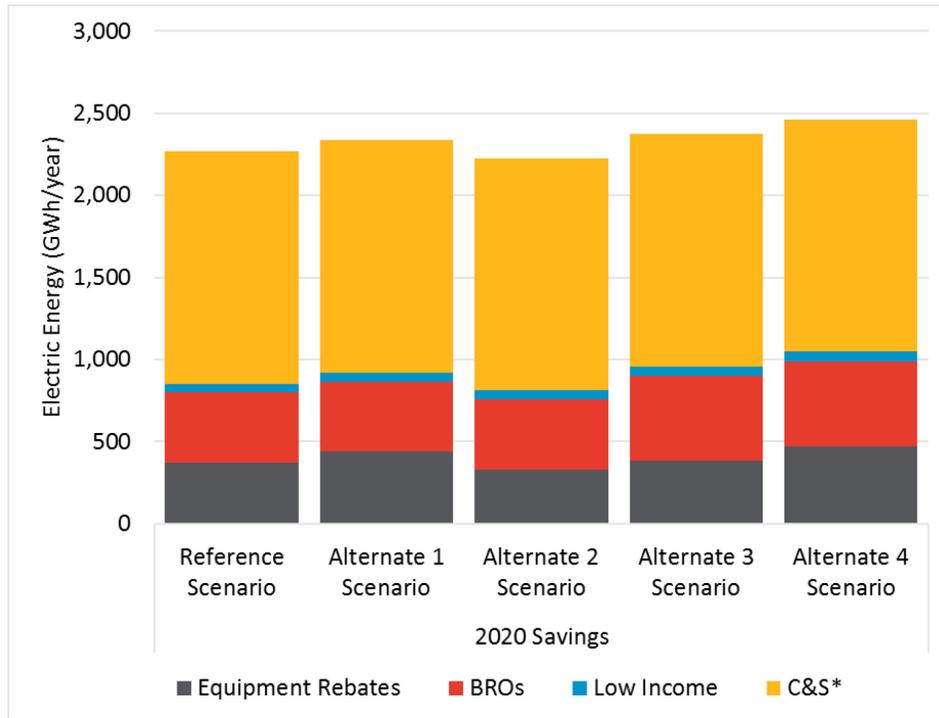
Results

Total Electric Market Potential

Figure ES-1 shows the total 2020 (first year) electric market potential for each type of EE program delivery approach.³ The figure illustrates the magnitude of market potential for each EE program type for each of the five scenarios listed in Table ES-1-1..

³ Note that this study categorizes the following EE program areas: equipment rebates; behavior, retrocommissioning, and operational efficiency (BROs); low income; and codes and standards (C&S).

Figure ES-1. 2020 Net Statewide Incremental Electric Savings by Scenario



*Includes interactive effects

Some notable takeaways from the electric results include the following:

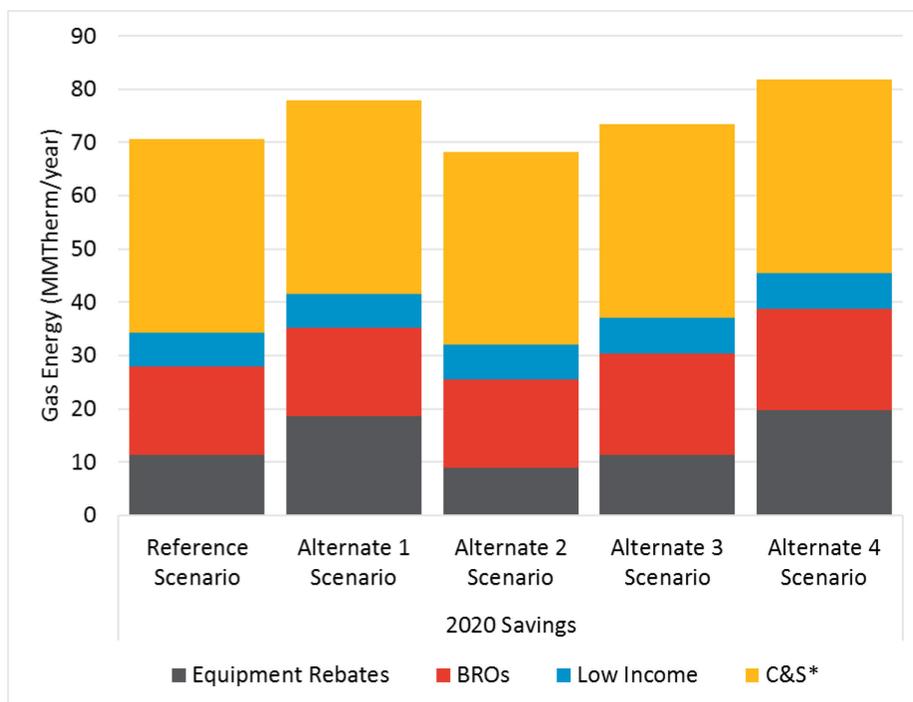
- The overall electric savings are largely comparable to the total savings observed from the previous PG study. While the total is comparable, there is a significant shift in savings from equipment rebate programs to BROs programs.
- Savings from equipment rebate programs dropped about 35% relative to the previous PG study. This drop is primarily driven by the loss of non-residential lighting savings due to CPUC baseline policy changes.
- It is important to note that while non-residential lighting savings are no longer represented in the potential estimates, they are not lost. Rather, non-residential lighting savings are captured through naturally occurring EE, which was not quantified as part of this study or claimable by IOU programs.
- Savings from BROs programs increased approximately 40% in 2020 relative to the previous PG study. This increase is mainly driven by revised data on HERs and building benchmarking and the addition of online audits.
- Consistent with past PG studies, the largest contributor to savings comes from C&S programs. It should be noted that C&S advocacy efforts have historically been provided as a separate goal from incentive programs.

- The Alternative 4 scenario appears to yield the highest electric savings potential. This scenario assumes the most permissive C-E threshold at 0.85 for all measures and highly ambitious efforts aimed at increasing customer uptake of various EE programs. These efforts include high rebate amounts, stepped-up marketing and outreach efforts, aggressive BROs interventions, and innovative financing approaches targeted to the residential and commercial sectors.

Total Gas Market Potential

Figure ES-2 shows the total 2020 (first year) gas market potential for each type of EE program delivery approach. The figure illustrates the magnitude of market potential for each EE program type for each of the five scenarios listed in Table ES-1.

Figure ES-2. 2020 Net Statewide Incremental Gas Savings by Scenario



*Includes interactive effects

Some notable takeaways from the gas results include the following:

- The overall gas savings are substantially lower than the total savings observed from the previous PG study. Reductions are seen in virtually every program category, except BROs.
- Savings from equipment rebate programs dropped more than 20% relative to the previous PG study. The reductions for equipment rebate programs are primarily driven by updated data on IOU-claimable savings.
- Savings from BROs programs increased approximately 15% in 2020 relative to the previous PG study. This increase is mainly driven by revised data on SEM and building benchmarking programs.

- Consistent with past PG studies, the largest contributor to savings comes from C&S programs. It should be noted that C&S advocacy efforts have historically been provided as a separate goal from incentive programs.
- The Alternate 4 scenario appears to yield the highest gas savings potential. This scenario assumes the most permissive C-E threshold at 0.85 for all measures and highly ambitious efforts aimed at increasing customer uptake of various EE programs. These efforts include high rebate amounts, stepped-up marketing and outreach efforts, aggressive BROs interventions, and innovative financing approaches targeted to the residential and commercial sectors.

1. INTRODUCTION

1.1 Context of the Goals and Potential Study

Navigant and its partners, Tierra Resource Consultants LLC, Cadmus, Opinion Dynamics, Jai J Mitchell Analytics, and Lumina Decision Systems (collectively known as the Navigant team), prepared this study (2019 Potential and Goals Study or 2019 Study) for the California Public Utilities Commission (CPUC). The purpose of this study is to develop estimates of energy and demand savings potential in the service territories of California's major investor-owned utilities (IOUs) during the post-2019 energy efficiency (EE) rolling portfolio planning cycle. This report includes results for Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Southern California Gas (SCG). A key component of the 2019 Study is the Potential and Goals Model (PG Model), which provides a single platform in which to conduct robust quantitative scenario analysis that reflects the complex interactions among various inputs and policy drivers.

The 2019 Study is the fifth consecutive potential study conducted by the Navigant team on behalf of the CPUC. The last study published was the 2017 Study, which informed goals for 2018 and beyond.⁴

The 2019 Study is primarily an update of the 2017 Study. The project kicked off in December 2018 and followed with a presentation of the draft workplan to stakeholders on January 11, 2019. This is a significantly compressed timeline relative to past CPUC Potential and Goals (PG) studies; as such, the opportunities to update methodologies, add measures, and deeply engage stakeholders was limited. This is not to say no progress was made on these fronts, but rather a truncated effort was needed given the timeline.

The 2019 Study supports multiple related efforts:

- Inform the CPUC as it proceeds to adopt goals and targets, providing guidance for the next IOU EE portfolios. The potential model is a framework that facilitates the stakeholder process. The model helps build consensus for goals by soliciting agreement on inputs, methods, and model results.
- Inform strategic contributions to SB350 targets. The California Energy Commission (CEC) has historically used the PG study to develop its forecast of additional achievable energy efficiency potential (AAEE). SB350 targets a doubling of the AAEE by 2030. The CEC will continue to rely on the PG study as an input to AAEE; the PG study will also serve as an input to SB350 target setting.
- Inform Integrated Resource Planning (IRP). In late 2017 and early 2018, Navigant supported CPUC staff in examining methods to integrate EE procurement practices into the IRP optimization process. Those efforts leveraged outputs from the 2017 Study to develop input to the IRP model. The results of this study will continue to inform future IRP modeling efforts under subsequent analysis not contained in this report.
- Guide the IOUs in portfolio planning and the state's principal energy agencies in forecasting for procurement, including the planning efforts of the CPUC, CEC, and California Independent System Operator (CAISO). Although the model cannot be the sole source of data for IOU

⁴ Navigant, *Energy Efficiency Potential and Goals Study for 2018 and Beyond*, September 2017.

program planning activities, it can provide critical guidance for the IOUs as they develop their plans for the 2020 and beyond portfolio planning period. The study is also providing California's principal energy agencies with the tools and resources necessary to develop outputs in a manner that is most appropriate for their planning and procurement needs.

The study period spans from 2020 to 2030 based on the direction provided by the CPUC and focuses on current and potential drivers of energy savings in IOU service areas. Analysis of EE savings in publicly owned utility service territories is not part of the scope of this effort.

1.2 Types of Potential

Consistent with the 2017 Study and common industry practice, the 2019 Study forecasts EE potential at four levels for rebate programs:

- **Technical potential:** Technical potential is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve EE were taken, including retrofit, replace on burnout, and new construction measures. Technical potential represents the immediate replacement of applicable equipment-based technologies regardless of the remaining useful life of the existing measure. Technical potential is undefined for codes and standards (C&S), low income, whole building, and behavior, retrocommissioning, and operational efficiency (BROs) programs.
- **Economic potential:** Using the results of the technical potential analysis, the economic potential is calculated as the total EE potential available when limited to only cost-effective measures.⁵ All components of economic potential are a subset of technical potential. Like technical potential, economic potential can be represented as instantaneous or annualized.
- **Market potential:** The final output of the potential study is a market potential analysis, which calculates the EE savings that could be expected in response to specific levels of incentives and assumptions about existing CPUC policies, market influences, and barriers. All components of market potential are a subset of economic potential. Some studies also refer to this as achievable potential. Market potential is used to inform the utilities' EE goals, as determined by the CPUC. Market potential has historically been used by the CPUC to inform the goal setting process. Market potential is primarily reported as a net savings value (CPUC shifted to setting goals based on net savings in 2017), though gross values are also produced by the model.
- **Below code potential** is a subset of the market potential. These savings are defined as the opportunities for EE that program administrators can claim through accelerated replacement programs. These savings reflect additional claimable impacts allowed after the passing of AB802.

Market potential is represented in the 2019 Study two different ways; each is based on the same data and assumptions, though each serve separate needs and provide necessary perspectives.

- **Incremental savings** represent the annual energy and demand savings achieved by the set of programs and measures in the first year that the measure is implemented. It does not consider the additional savings that the measure will produce over the life of the equipment. A view of

⁵ The model default is to use the total resource cost (TRC) test as defined by the California Standard Practice Manual. The TRC threshold for what constitutes a cost-effective measure varies by scenario.

incremental savings is necessary to understand what additional savings an individual year of EE programs will produce. This has historically been the basis for IOU program goals.

- **Cumulative savings** represent the total savings from EE program efforts from measures installed since 2020 (including the current program year) and that are still active in the current year. It includes the decay of savings as measures reach the end of their useful lives and the continuation of savings as customer re-install high efficiency equipment that has reached the end of its effective useful life (EUL). Cumulative savings also account for the timing effects C&S that become effective after measure installation.

Many variables drive the calculation of market potential. These include assumptions about the way efficient products and services are marketed and delivered, the level of customer awareness of EE, and customer willingness to install efficient equipment or operate equipment in ways that are more efficient. The Navigant team used the best available current market knowledge to calibrate market potential for voluntary rebate programs.

1.3 Scope of this Study

This study forecasts the potential energy savings from the EE programs and C&S across all customer sectors: residential, low income, commercial, agricultural, industrial, mining, and street lighting. This study does not set IOU goals, nor does it make a recommendation as to how to set goals. Rather, it informs the CPUC's goal setting process.

The study builds upon the 2017 Study; notable updates to the 2019 Study relative to the 2017 Study include the following:

- **Refresh measure inputs:** The 2019 Study conducted a prioritized refresh of measure input data. The study continued to use the same measure list as the 2017 Study, making a few additions where warranted. The 2017 Study conducted a comprehensive process involving stakeholders to develop the measure list for both equipment rebate programs and BROs. During this data refresh, the Navigant team reflected the new definition of peak demand savings as codified in the Database for Energy Efficient Resources (DEER), vintage 2020.
- **Improve low income sector methodology:** The 2019 Study conducts a bottom-up forecast of savings from the residential low income sector. This is a major departure from the 2017 Study in which a top-down analysis was conducted. The new bottom-up analysis uses data for individual measures and incorporates low income market characterization data.
- **Revise scenarios to inform goal setting:** The 2019 Study solicited feedback from stakeholders on scenarios to consider. The 2017 Study also included scenarios but did not seek significant stakeholder feedback in the process selecting the final scenarios to run.

The initial workplan for this study included considering multiple additional topics. These topics explore further policy questions or provide more granularity of results. However, their outcome does not inform the goal setting process. Due to the short timeline to conduct the 2019 Study and the need for more input from stakeholders and CPUC staff, the following topics will be discussed and explored in a second volume to be published later in 2019.

- **Fuel Substitution:** The Navigant team did not examine fuel substitution but will conduct research to set a foundation to integrate fuel substitution into a future potential study cycle. This research

will identify candidate measures, identify available data and data gaps, and document a framework for modeling.

- **EE/demand response (DR) co-modeling:** The model used in the 2019 Study is not set up to forecast both EE and DR potential. The Navigant team will conduct research to set a foundation for how EE/DR co-modeling could be integrated into a future potential study cycle. The team expects to coordinate with other DR potential modeling efforts funded by the CPUC in the foundational research step.
- **Savings within disadvantaged communities (DACs):** The Navigant team proposed a high level approach to parsing out savings in DACs to stakeholders in January 2019; little feedback was provided. The team expects this analysis to be largely a post-processing step that will aim to size the market potential attributable to DACs. Since program goals are set on an aggregate basis and are not specific to DACs, this research will be conducted later in 2019.
- **Savings within RENs/CCAs:** The Navigant team proposed a high level approach to parsing out savings in Regional Energy Networks (RENs) and Community Choice Aggregators (CCAs) to stakeholders in January 2019. The team expects this analysis to be largely a post-processing step that will aim to size the market potential attributable to RENs and CCAs. However, uncertainty around the planned growth of RENs and CCAs as well as the expected use of these results requires additional discussion with CPUC staff and input from stakeholders. Since program goals are set on an aggregate basis and are not specific to RENs or CCAs, this research will be conducted later in 2019.

1.4 Changes Since the Previous Study

Several impactful market and policy updates have occurred in the last 2 years, driving key changes to the results of the PG study. They are described in Table 1-1..

Table 1-1. Changes and Impacts Relative to 2017 Study

Category	Change	Impact on Study
Baseline Policy	Recent DEER Resolution E-4952 deemed non-residential lighting standard practice baseline to be LED.	Significantly cuts non-residential lighting savings (commercial and industrial), which were a large part of past IOU programs and goals. These savings are above code and, therefore, do not appear in forecast IOU C&S claims. Savings lost from IOU programs because of this policy move to a category of naturally occurring savings not forecast by this study (or claimable by IOU programs).
BROs Measures	Updated impact evaluation data was used and new measures added relative to the previous PG study (online audits).	Increase incremental first-year savings from BROs, specifically from home energy reports (HERs), online audits, strategic energy management (SEM), and building benchmarking.

Category	Change	Impact on Study
DEER/ Workpapers	DEER 2020 is a primary source of measure input data (the previous study relied on DEER 2017).	Majority of weather-sensitive measures were updated, decreasing savings and thus decreasing potential. DEER 2020 also implements the new definition of peak demand savings.
Cost- Effectiveness	This study uses avoided costs published in 2018 after the CPUC-approved greenhouse gas (GHG) adder went into effect. The previous study used a higher estimate of the GHG adder.	Slight decrease in avoided costs due to updates to the GHG adder, which decreases cost-effective market potential results in the 2020-2030 range.
Rebate Program Measures	New measures were added to this study relative to the 2017 Study: smart connected power strips and connected LEDs.	Increase in residential savings potential but not enough to backfill the loss of claimable non-residential LED savings.
Custom Project Savings	This study used more recent years of program data not previously available; this recent data shows a downward trend in savings.	Industrial and agriculture custom project savings are projected to decrease in the forecast range.

1.5 Stakeholder Engagement

The Navigant team engaged with stakeholders through multiple public workshops, in part supported by the Demand Analysis Working Group.⁶ These workshops were used to request data, collect feedback on scope, discuss methodology, and discuss key assumptions. Table 1-2. provides the schedule of meetings that were held. After each meeting, stakeholders were provided a period in which they could submit informal comments to the Navigant team and CPUC. The team reviewed all comments received and incorporated appropriate edits/changes into the study.

Table 1-2. Stakeholder Meeting Schedule

Date	Topics of Discussion
January 11, 2019	Overview of the scope of the 2019 Study
February 4, 2019	(Webinar) AIMS Emerging Tech and Generic Custom Methodology
February 21, 2019	(Webinar) Scenarios
March 21, 2019	Calibration Workshop

⁶ <http://demandanalysisworkinggroup.org/>

1.6 Content of this Report

This report documents the data relied upon by and the results of the 2019 Study.

- **Section 2** provides an overview of the methodology for each key area of the study.
- **Section 3** provides details on the input data used for each key area of the study. It describes the data sources and process taken to incorporate the data into the PG Model.
- **Section 4** provides the study's results on a statewide basis.
- **Appendices** provide additional details for key topic areas.

Aside from this report, the following supporting deliverables are available to the public via the CPUC's website:⁷

- **2019 PG Results Explorer:** A web-based tool that allows readers to dynamically explore the results of the study, including all five scenarios. Available at: <https://bit.ly/2019-CA-Energy-Efficiency-PG-Study>
- **2019 PG MICS:** A spreadsheet version of the Measure Input Characterization System documenting all final values for all rebated technologies forecast in the model.
- **2019 PG BROs Inputs:** A spreadsheet version of all measure-level inputs for BROs measures.
- **2019 PG Measure Level Results Database:** A spreadsheet of technical, economic, and market potential for each measure in each sector, end use, and utility.
- **2019 PG Model File:** An Analytica-based file that contains the PG Model used to create the results of this study.
- **2019 PG Model Users Guide:** Document that helps advanced users who want to open and run the PG Model file in Analytica.

⁷ <http://www.cpuc.ca.gov/General.aspx?id=6442452619>

2. STUDY METHODOLOGY

The primary purpose of the 2019 Study is to provide the CPUC with information and analytical tools to engage in goal setting for the IOU EE portfolios. In addition, this study informs forecasts used for procurement planning. The study itself does not establish any regulatory requirements.

The 2019 Study forecasts potential energy savings from a variety of sources within seven distinct customer sectors: residential, low income, commercial, agricultural, industrial, mining, and street lighting. These sectors are also used in the CEC's Integrated Energy Policy Report (IEPR) forecast. Within some or all the sectors, sources of savings include the following:

- **Rebated technologies:** Discrete mass market technologies that are incentivized and provided to IOU customers in the residential, commercial, industrial, agricultural, mining, and street lighting sectors. These sectors are modeled using individual measures for specific applications.
- **Residential low income:** The 2019 Study conducts a bottom-up forecast of savings from the residential low income sector. This is a major departure from the 2017 Study in which the Navigant team conducted a top-down analysis. The new analysis uses low income-specific market characterization data and applies the same measure list as the residential sector.
- **Whole building approaches:** In the case of whole building initiatives, the measure is characterized for the building retrofit or house retrofit rather than for specific technology or end uses. Whole building initiatives are modeled for the residential and commercial sectors.
- **Custom measures and emerging technologies:** This study defines custom measures as improvements to processes specific to the industrial and agricultural sectors; the measures themselves are not individually defined and rather represent a wide array of niche technologies. Similarly, emerging technologies are represented as a wide array of technologies and not individually defined.
- **Behavior, retrocommissioning, and operational efficiency (BROs):** For the purposes of this study, the Navigant team defines behavior-based initiatives as those providing information about energy use and conservation actions rather than financial incentives, equipment, or services. Savings from BROs are modeled as incremental impacts of behavior and operational changes beyond equipment changes.
- **Codes and standards (C&S):** Codes regulate building design, requiring builders to incorporate high efficiency measures. Standards set minimum efficiency levels for newly manufactured appliances. Savings are forecast from C&S that went into effect starting in 2006.
- **Financing:** Financing has the potential to break through several market barriers that have limited the widespread market adoption of cost-effective EE measures. The PG Model estimates the effects of introducing EE financing on market potential and how shifting assumptions about financing affect the potential energy savings.

The modeling methodology leverages much of what was used in the 2017 Study. The rest of this section discusses the 2019 Study methodology.

2.1 Modeling Methods

Table 2-1. summarizes the modeling approach for each source of savings. Each approach is discussed in more detail in the subsequent subsections.

Table 2-1. Overview of Modeling and Calibration Approach

Savings Source	Summary of Modeling Approach	Summary of Calibration Approach	Methodology Change Relative to 2017 Study?
Rebated technologies	Bass diffusion forecast competes below code, at code, and above code technologies against each other.	Calibrated to historic program spending.	No
Residential low income	Bass diffusion forecast competes below code, at code, and above code technologies against each other.	Calibrated to historic low income program accomplishments.	Yes
Whole building packages	Bass diffusion forecast competes below code, at code, and above code technologies against each other.	Calibrated to historic program spending.	No
Industrial/Agriculture custom measures and emerging technologies	Trend forecast based on recent IOU custom project savings in these sectors. Emerging technologies can ramp up the trend in the future.	Forecast is anchored in IOU program history and thus inherently calibrated to current market conditions.	No
BROs	Interventions are limited to the applicable customers and markets. For the applicable markets, Navigant assumptions are made regarding reasonable penetration rates.	Starting penetration rates are based on current penetration rates.	No
C&S	Model replicates the algorithms of the CPUC’s Integrated Standards Savings Model (ISSM).	Calibration not needed as evaluated results are used.	No
Financing	Financing is applied to rebated technologies and whole building approaches. It reduces upfront barriers, increasing consumer adoption, and supplements Bass diffusion modeling framework.	No program data to calibrate to.	No

2.1.1 Rebated Technologies

Rebated technologies make up the majority of historic program spending and savings claims. Thus, they are a core part of the forecast. The Navigant team’s approach to modeling rebated technologies has not changed since the 2017 Study. This methodology is documented in this section.

2.1.1.1 Types of Technologies

The PG study forecasts the adoption of more than 150 EE technologies. Each measure can be classified into one of several broad measure types. Each measure type is treated differently in terms of calculating cost-effectiveness, calculating energy savings relative to the baseline, and modeling consumer decisions and market adoption. These differences are further discussed throughout this section of the report. The types of measure installations are outlined below:

- **New Construction:** Equipment installed in a newly constructed building. In this situation, energy savings calculations are always relative to code.
- **Installation in Existing Buildings:**
 - **Equipment**
 - **Replace on burnout (ROB):** New equipment needs to be installed to replace equipment that has reached the end of its useful life, has failed, and is no longer functional. Upon failure, ROB equipment is generally not repaired by the customer and is instead replaced with a new piece of equipment. Appliance standards are applicable to some types of ROB equipment and apply to all new purchases.
 - **Accelerated replacement (AR):** Equipment that is beyond its EUL and is continuing to function in the market. The customer is not planning to replace the equipment on a regular cycle; thus, programs are targeted at the customer to accelerate the equipment's replacement. Dual baselines are applied to these measures.
 - **Retrofit (RET)**
 - **RET add-on:** New equipment being installed onto an existing system, either as an additional, integrated component or to replace a component of the existing system. In either case, the primary purpose of the add-on measure is to improve overall efficiency of the system. These measures are not able to operate on their own as standalone equipment and are not required to operate the existing equipment or building. Codes or standards may be applicable to some types of RET add-on measures by setting minimum efficiency levels of newly installed equipment, but the codes or standards do not require the measure to be installed.
 - **RET replacement:** Measures that will be replaced not due to equipment failure but rather triggered by building renovation. These measures are those that are installed to replace previously existing equipment that has either not failed or is past the end of its EUL but is not compromising use of the building (such as insulation and water fixtures). Many of these installations are subject to building code, but upgrades are not always required by code until a major building renovation (and even then, some may not be required).

2.1.1.2 Technology Groups, Efficiency Levels, and Competition

Within each technology type, multiple groups of technologies are formed and characterized. A technology group consists of multiple levels of efficiency of the same technology, an example of which is illustrated in Table 2-2.. Technologies within a technology group compete for installations. The individual technologies

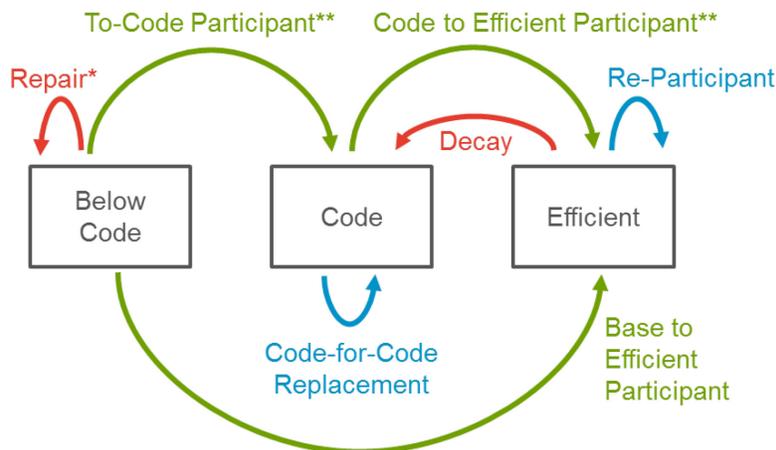
characterized within each group are designed to capture varied efficiency levels including below code units, at code units, and multiple levels of high efficiency units (up to and including emerging technologies, where appropriate.) In determining which technologies to include in a group, the Navigant team considered possible future code levels as well as popular efficiency levels historically rebated by IOU programs.

Table 2-2. Example of Technologies within a Technology Group

Technology Group	Technology	Description
Residential Central AC	Residential Seasonal Energy Efficiency Ratio (SEER) 10 AC	Average Below Code Efficiency Level
	Residential SEER 13 AC	Code Efficiency Level Pre-2015
	Residential SEER 14 AC	Code Efficiency Level 2015 and Beyond
	Residential SEER 15 AC	High Efficiency Level 1
	Residential SEER 18 AC	High Efficiency Level 2
	Residential SEER 20 AC	High Efficiency Level 3

The model simulates the flow of equipment stock across the different technologies within a technology group. Flow of stock occurs when the customer owning the equipment reaches a decision point to either maintain the existing equipment or replace it with a new unit. The decisions available to the customer in the model depend on the type of technology category (discussed in Section 2.1.1.1) the equipment in question falls in. Figure 2-1 illustrates the replacement options a customer is faced with. The model allows customers to maintain their existing equipment, upgrade to higher efficiency equipment, or downgrade from high efficiency equipment to code-level equipment. With each replacement a unit energy savings, cost, and C-E value is associated with the decision.

Figure 2-1. Stock Flow within a Technology Group



*only applicable to Accelerated Replacement measures

** only applicable when a code or standard exists

2.1.1.3 Technical and Economic Potential

Technical potential is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve EE were taken, including RET measures, ROB measures, and new construction measures. As previously discussed, technical potential can be reported in two forms: instantaneous and annualized. The following considerations are factored into the team's calculation of technical potential:

- Technical potential assumes all eligible customers within a technology group adopt the highest level of efficiency available within the technology group.
- Technical potential represents the savings from converting all equipment that is at or below code to the highest level of efficiency within a technology group.
- Total technical potential is the sum of all individual technical potential within each technology group excluding whole building packages, low income programs, and BROs. Whole building packages are excluded from the technical potential as doing so would be duplicative. Technical potential for low income programs and BROs are undefined in this study.

Using the results of the technical potential analysis, the economic potential is calculated as the total EE potential available when limited to only cost-effective measures. All components of economic potential are a subset of technical potential. In addition to the above considerations in modeling technical potential, the following considerations are factored into the team's calculation of economic potential:

- Economic potential assumes all eligible customers within a technology group adopt the highest **cost-effective** level of efficiency available within the technology group. The most efficient technology within the group may not be cost-effective.
- Various C-E screens can be applied (previously discussed in Section 1.2); thus, economic potential can vary by scenario. Meanwhile, technical potential does not vary by scenario.

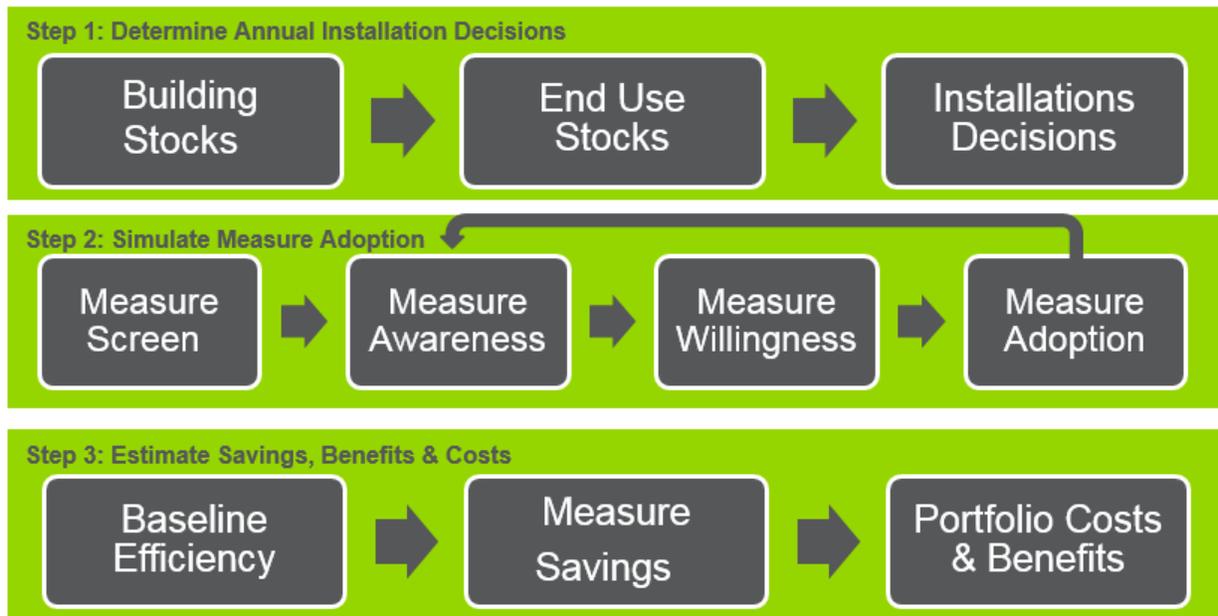
2.1.1.4 Market Potential

To estimate the market potential for rebated technologies, the model employs a three-step process, as shown in Figure 2-2. In the first step, the model calculates the number of installation decisions expected to occur for each measure in each year. The types of installation decisions vary by type of technology. For ROB technologies (e.g., residential lighting), the customer decision to adopt occurs at the end of the base measure's life. For AR where equipment is past the EUL (e.g., commercial chillers), the Navigant team models the customer decision to adopt past the EUL (based on the extended life due to repair). Finally, for RET technologies, the customer adoption decision is not governed by equipment failure and thus can occur before or after the EUL. The model simulates technology stocks for base and efficient technologies separately to account for EUL differences. The number of adoption decisions that occur in each year is considered the eligible population, which is a function of the building stocks, technology saturation, type of technology, and technology burnout rates (i.e., based on EUL).

In the second step, the model simulates the adoption of each measure that passes a C-E screen in each year. The model considers the number of installation decisions that may occur in each year, the estimated level of awareness of each measure in the eligible population, and the willingness to adopt each measure that passes the C-E screen. It is in this step that the model employs the Bass diffusion approach to simulate adoption (described in more detail below).

In the final step, the model calculates energy savings and corresponding costs and benefits resulting from measure adoption decisions in the second step. Savings are calculated relative to the appropriate baseline efficiency level depending on the type of replacement.

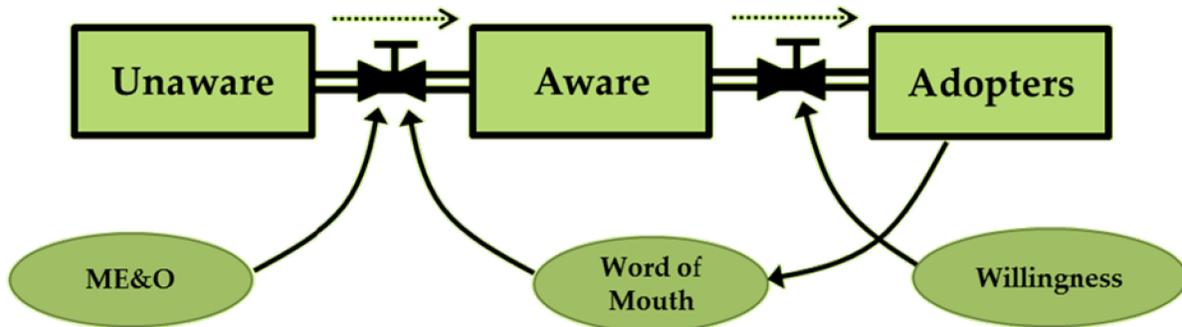
Figure 2-2. Three-Step Approach to Calculating Market Potential for Rebated Measures



The model employs a bottom-up, dynamic Bass diffusion approach to simulate the market adoption of efficient measures. The Bass diffusion model is illustrated in Figure 2-3 and contains three parameters:

- **Marketing, education, and outreach (ME&O)** moves customers from the unaware group to the aware group at a consistent rate annually. Unaware customers, as the name implies, have no knowledge of the energy efficient technology option. Aware customers are those that have knowledge of the product and understand its attributes. ME&O is often referred to as the Advertising Effect in Bass diffusion modeling.
- **Word of mouth** represents the influence of adopters (or other aware consumers) on the unaware population by informing them of efficient technologies and their attributes. This influence increases the rate at which customers move from the unaware to the aware group; the word of mouth influence occurs in addition to the ongoing ME&O. When a product is new to the market with few installations, often ME&O is the main source driving unaware customers to the aware group. As more customers become aware and adopt, however, word of mouth can have a greater influence on awareness than ME&O and lead to exponential growth. The exponential growth is ultimately damped by the saturation of the market, leading to an S-shaped adoption curve, which has frequently been observed for efficient technologies.
- **Willingness** is the key factor affecting the move from an aware customer to an adopter. Once customers are aware of the measure, they consider adopting the technology based on the financial attractiveness of the measure. The PG Model applies two distinct approaches to calculate willingness depending on the sector and need. Additional discussion of willingness follows Figure 2-3.

Figure 2-3. The Bass Diffusion Framework: A Dynamic Approach to Calculating Measure Adoption⁸



Approach to Calculating Willingness

Customer willingness to adopt is a key determinant of long-run market share—i.e., what percentage of individuals choose to purchase a technology provided those individuals are aware of the technology and its relative merits (e.g., the energy- and cost-saving features of the technology). The PG Model applies two approaches to calculating willingness depending on the sector:

- Levelized measure cost/logit approach:** For the residential and commercial sectors where information on baseline and efficient costs are available and to more appropriately capture the impacts of EE financing on market adoption, a levelized measure cost (LMC)/logit approach is applied. The LMC is based on the present value of the cost of purchasing and operating the equipment throughout its EUL, discounted using a consumer implied discount rate (iDR).⁹ The equation used to calculate the LMC is shown below.

Equation 2-1. Levelized Measure Cost Calculation

$$LMC = \text{Upfront Cost} + PV(\text{Annual Operating Cost}, iDR, EUL)$$

To calculate long-run market share or willingness as a function of the LMC for both base and efficient technologies, the Navigant team employed a logit decision maker approach.^{10, 11} This approach applies best practices in predicting consumer behavior and allows competition of multiple measures with different EULs for each end use.

Equation 2-2. Logit Decision Model¹²

$$W = \frac{e^{\beta LMC_1}}{\sum_i^n e^{\beta LMC_i}}$$

⁸ Adapted from John Sterman. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. McGraw-Hill.

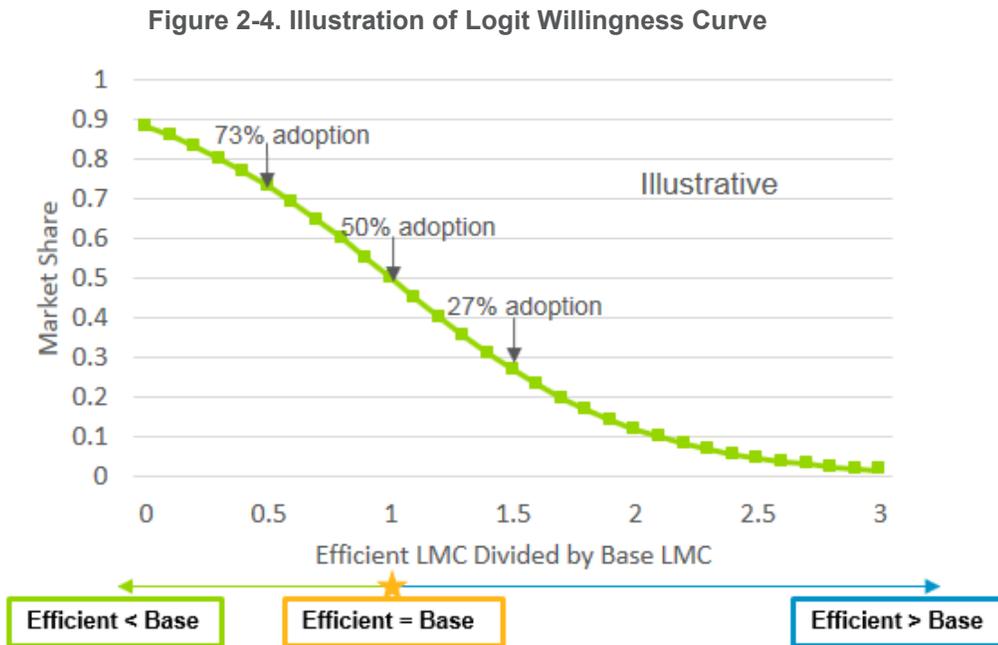
⁹ See 2015 Study for details on the iDR

¹⁰ McFadden, Daniel, Train, K. "Mixed MNL Models for Discrete Response." 2000. *Journal of Applied Econometrics*, Vol. 15, No. 5, pp. 447-470.

¹¹ Train, Ken. "Discrete Choice Methods with Simulation." 2003. Cambridge University Press.

¹² In this equation, W is the willingness, β is a sensitivity factor fit to willingness survey results, n is the number of competing technologies, and LMC is the levelized measure cost.

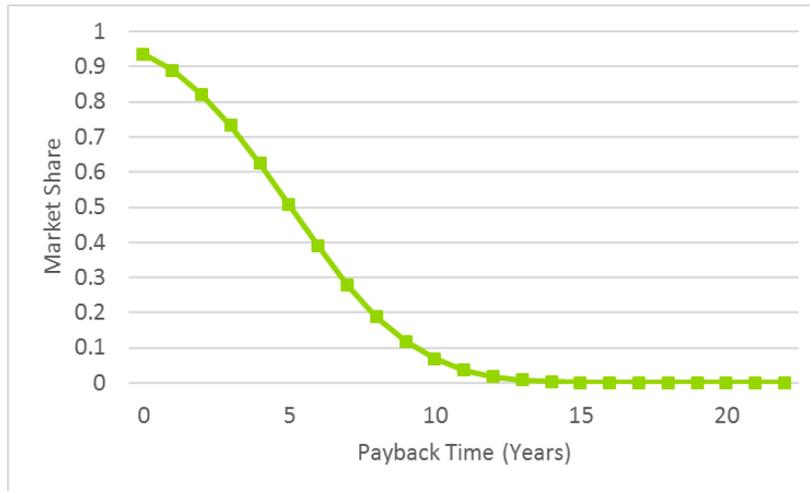
Figure 2-4 illustrates how consumer willingness changes as a function of the ratio of the efficient to base LMC. In this illustration, an LMC ratio of 1 implies both the efficient and base technologies are at parity and thus the market is split, with 50% choosing to adopt the efficient technology. For an LMC ratio of 0.5, which implies the efficient technology is cheaper than the base technology, the curve indicates that 73% would adopt the efficient technology.



- Payback-based approach:** For the agriculture, industrial, mining, and street lighting (AIMS) sectors where information on baseline technology costs is not available and where there is no need to explore the impacts of EE financing, the Navigant team used a payback-based approach to calculate willingness. Payback time reflects the length of time (years) required for an EE investment to recover the initial upfront cost in terms of energy savings. After calculating payback time, to estimate market share for the AIMS measures, the team relied on payback acceptance curves based on Navigant-led primary research in the US Midwest in 2012.¹³ Though California-specific data was not available to estimate these curves, Navigant considers that the nature of the customer decision-making process is such that the data developed using North American customers represents the best industry-wide data available at the time of this study.

¹³ A detailed discussion of the methodology and findings of this research are contained in the *Demand Side Resource Potential Study*, prepared for Kansas City Power and Light, August 2013.

Figure 2-5. Payback Acceptance Curve for AIMS Sectors¹⁴



2.1.1.5 Calculating Cumulative Market Potential

The PG study reports both incremental and cumulative savings. In the recent past, IOU goals have been based on incremental savings only, while cumulative savings was used to inform the CEC demand IRP. Cumulative savings represent the total EE program savings from measures installed since a start year and that are still active in the current year. Active savings are calculated by accounting for the following:

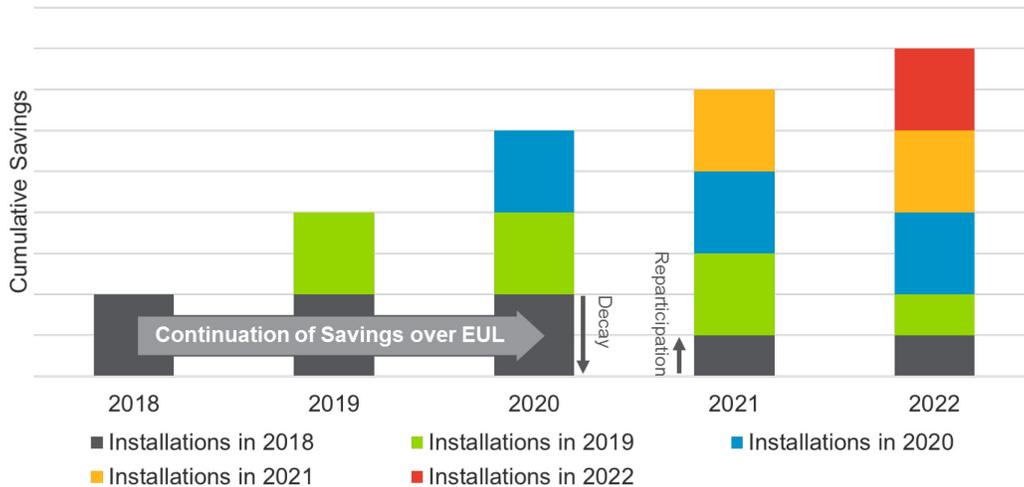
- Decay of savings as measures reach the end of their useful lives
- C&S that come into effect over time

Unlike annual savings, cumulative savings include savings from re-participants. Incremental savings only consider that from first-time adopters. Sustained savings from re-adoption need to be counted in cumulative savings for the demand forecast. The PG Model assumes re-participants re-adopt measures at the same rate as new participants, consistent with the 2017 Study. The calculation of cumulative savings is illustrated in Figure 2-6.

¹⁴ Sourced from Navigant analysis of data contained in *Demand Side Resource Potential Study* prepared for Kansas City Power and Light, August 2013.

Figure 2-6. Cumulative Savings Illustration

Cumulative Savings of a Hypothetical Measure Installed by Various Customers Over Time, EUL = 3 years



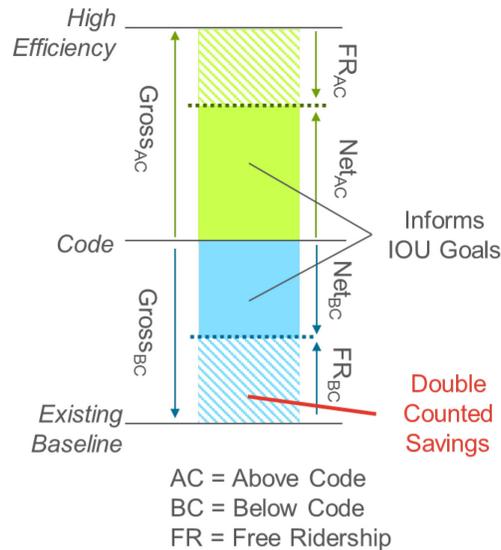
2.1.1.6 Net-to-Gross for AR Measures

The PG study is required to avoid double counted savings between C&S and below code rebate programs. These are the below code savings generated from rebated equipment that would be realized even in the absence of program administrator rebate programs. This savings would occur as equipment would naturally turn over and be replaced with code-compliant equipment. These savings are already embedded and accounted for in the CEC demand forecast; thus, further decrementing the forecast with this savings would be double counting. The PG study takes the approach of attempting to remove double counted savings from the market potential (which informs IOU goals).

The first step the PG study takes in avoiding double counting is to target old equipment when considering below code potential. This is equipment that is not turning over on a regular basis. The remainder of equipment that is turning over on a regular basis has its below code savings already captured through C&S.

The next step in avoiding double counted savings is to identify free ridership of below code savings. This is illustrated in Figure 2-7. Below code free ridership implies that customers were not necessarily influenced by the IOU rebate to come up to code but were influenced by other outside factors. This requires the PG study to apply a net-to-gross (NTG) ratio to below code savings.

Figure 2-7. Below Code NTG Illustration



Determination of the below code NTG (NTG_{BC}) is not a simple task as no data exists to inform this process. The Navigant team presented the concept of below code NTG to the Demand Analysis Working Group on November 4, 2016, while conducting the 2017 Study.¹⁵ The team estimates NTG_{BC} to be some fraction of NTG_{AC} where:

$$NTG_{BC} = NTG_{AC} \times NTG \text{ Adjustment Factor}$$

CPUC Resolution E-4952 considered this issue further. It established the following:

“...an adjustment factor of 0.75 for accelerated replacement to be applied to all NTG values for the below-code portion of savings. This is a default value, and alternative values may be proposed as part of a workpaper or for a custom project if that project is undergoing an ex ante review by Commission staff.”¹⁶

As such, the PG Model applies a default adjustment factor of 0.75.

2.1.2 Residential Low Income

The potential for EE in the low income sector is modeled after the Energy Savings Assistance (ESA) program. The ESA program is offered by all four IOUs as a no-cost, direct installation of weatherization measures. The program includes a wide range of EE equipment combined with EE education and referrals to other income-qualified programs.

The 2019 Study makes a major update to the forecast methodology for the low income sector. In the 2017 Study, the Navigant team forecast savings using a simple top-down methodology. The method multiplied expected number of future participants by overall participant unit energy savings (UES). Data for future participation and UES was obtained from the IOUs via a data request. At the time, IOUs

¹⁵ No specific feedback was provided by stakeholders at the time.

¹⁶ Approval of the Database for Energy-Efficient Resources updates for 2020 and revised version 2019 in Compliance with D.15-10-028, D.16-08-019, and Resolution E-4818. October 11, 2018.

expected all program participants starting in 2021 would be retreatments (i.e., homes that have participated in the program in years past receiving additional treatment). The expected UES for retreatments at the time was lower than first-time treatments.

In this study, the low income sector is modeled using the same methodology as rebate programs (described earlier in Section 2.1.1). This is a shift from the previous top- down approach to a measure-based bottom- up forecast. Low income is separated into its own sector apart from the residential sector in the model. Rebates applied to the low income sector are equal to 100% of equipment cost.

Historically, ESA programs were not required to pass a total resource cost (TRC) test, and they do not feed into the overall portfolio cost-effectiveness for IOU programs. Informal stakeholder comments further suggested that economic potential not be calculated for low income programs as it is largely an academic endeavor. As such, the model does not conduct any measure C-E screening for low income measures.

2.1.3 Whole Building Packages

Whole building packages are modeled the same way as rebated technologies with one exception. Technical and economic potential results are not presented as they are duplicative with the technical and economic potential of rebated technologies.

2.1.4 Industrial and Agriculture Custom Measures and Emerging Technologies

Custom measures and emerging technologies for the industrial and agricultural sectors used Equation 2-3 to calculate incremental market potential.

Equation 2-3. General Equation for Calculating Incremental Market Potential for Generic Custom and Emerging Technologies

$$\text{Incremental Market Potential} = \text{Population} \times \text{Applicability Factor} \times \text{Unit Energy Savings} \times \text{Penetration Rate}$$

Where:

- **Population** is a global input that is represented as the total energy consumption by subsector within the industrial and agriculture sectors.
- **Applicability Factor** represents eligibility and other program-specific variables that are applied at the subsector level.
- **Unit Energy Savings** represents the percent savings expected from customers adopting technologies at the subsector level.
- **Penetration Rate** represents annual new participation and varies over time; it can also vary by scenario for emerging technologies. Penetration rate is applied at the market sector level.

Emerging technologies were screened for consideration based on an eight-level screening process considering the following factors:

- Relevance to the industrial and agricultural sectors
- Relevance by North American Industry Classification System (NAICS) segment

- End-use application
- Type of fuel savings
- Potential energy savings percentage
- Impact potential (including technical and market potential, risks, and non-energy benefits)
- Segment energy consumption trends
- Segment market trajectory

The emerging technologies that passed the screening criteria were used to derive emerging technology UES values grouped by market segment (e.g., petroleum, food processing, etc.) using the methodology defined in Appendix F. Emerging technology UES is represented as a percent savings relative to the total building energy consumption. It is meant to reflect the combination of available emerging technologies that pass the screening process for each sector and segment rather than represent individual technologies. UES is estimated based on multiple factors listed below Equation 2-4.

Equation 2-4. UES Equation for Emerging Technologies

$$UES = T_e \times E_{i,j} \times MT_j \times TW_j$$

Where:

- e = subscript indicating the specific emerging technology
- i = subscript indicating the specific end-use and fuel type
- j = subscript indicating the market subsector and NAICS segment
- T_e = technology energy savings percentage for emerging technology, e , by end-use application
- $E_{i,j}$ = percentage of total energy consumption by subsector j energy attributable to end-use i
- MT_j = market trajectory for sector j
- TW_j = segment energy consumption trend weight for sector j

The factors that make up the UES include the following:

- Each emerging technology has a unique technology energy savings percentage, T_e
- California market data defines the sector end-use percentage of total energy consumption, $E_{i,j}$
- The market trajectory for each sector, MT_j , is a value between 0 and 1, indicating if the sector is likely to move offshore (0.33), close to tipping point of moving offshore (0.67), or likely to remain in the US (1)¹⁷
- The segment energy consumption trend weight, TW_j , is a value between 0 and 1, indicating the trend of energy consumption of each sector over time based on an analysis provided by the CEC shows electricity consumption trend for various industries from 1990 through 2015

Section 3.6 discusses the data inputs for this equation.

¹⁷ Sirkin, H. et al. *U.S. Manufacturing Nears the Tipping Point*, The Boston Consulting Group, March 2012.

Industry standard practices (ISPs) are not forecast to impact the potential from custom measures and emerging technologies. ISPs are technology- and segment-specific, while custom programs and emerging technologies as forecast in this study do not contain technology-specific information to allow application of ISPs.

2.1.5 Behavior, Retrocommissioning, and Operational Efficiency (BROs)

For the purposes of this study, the Navigant team defines behavior-based initiatives as those providing information about energy use and conservation actions to drive customer actions rather than financial incentives, equipment, or services to support customer investment. The market potential modeled for these initiatives is incremental savings from equipment change-outs.

2.1.5.1 Energy and Demand Savings

Equation 2-5 is the general equation for the BROs potential model. Each of the components are described below.

Equation 2-5. General Equation for Calculating Incremental Market Potential for BROs

$$\begin{aligned} \text{Incremental Market Potential} \\ = \text{Population} \times \text{Applicability Factor} \times \text{Unit Energy Savings} \times \text{Penetration Rate} \end{aligned}$$

Where:

- **Population** is a global input that can be represented in two ways: number of homes and square feet of floor space or sector energy consumption.
- **Applicability Factor** represents eligibility and other program-specific variables, including existing saturation that precludes customers from participating in future IOU interventions.
- **Unit Energy Savings** represent the savings expected from participants and can also be represented in two ways: kWh and therms or percentage of consumption.
- **Penetration Rate** represents participation and varies over time and by scenario (reference or aggressive). This reflects both the utility-driven rollout and the customer uptake of the program, depending on the nature of the program.

The initial penetration rates are based on existing levels of participation (either for the California IOUs for existing programs or the program from which data was drawn and applied to the California IOUs' territories). The forecasts are the result of professional judgement based on program operations and whether participation is utility driven (opt out) or customer driven (opt in).

The potential for double counting among BROs programs was addressed in the characterization of programs in the same sector. The Navigant team adjusted penetration and applicability to avoid the double counting of savings.

This effort does not examine programs that focus on demand reduction (e.g., DR) but does include demand savings from the characterized BROs programs using Equation 2-6.

Equation 2-6. General Equation for Calculating BROs Demand Savings

$$\text{Incremental Market Potential (kW)} = \text{Incremental Market Potential (kWh)} \times \text{Peak to Energy Ratio}$$

2.1.5.2 Costs

Similar to demand savings, utility program costs are calculated from the energy savings in Equation 2-5. The cost factor in Equation 2-7 is a unit energy cost expressed in either dollars per kWh or dollars per therm. For programs that save both electricity and gas, it was sometimes possible to divide the costs by fuel type; however, in instances where this was not possible, all costs were assigned to one fuel type to avoid double counting costs.

Equation 2-7. General Equation for Calculating BROs Program Costs

$$\text{Program Cost} = \text{Incremental Market Potential} \times \text{Cost Factor}$$

2.1.6 Codes and Standards

C&S impacts on EE potential are modeled two ways:

- C&S impacts the code baseline for IOU-rebated measures; as C&S becomes more stringent in the future, above code savings claimable by IOU programs decrease. This is discussed further in Section 2.1.1.2.
- IOUs can claim a portion of savings from C&S that come into effect through the IOU C&S advocacy programs. This section describes the calculation of IOU-claimable savings from C&S.

This study calculates the estimated savings of C&S in multiple formats, each for a different use:

- **Net C&S savings** are the total energy savings estimated to be achieved from the updates to C&S since 2006. Net savings calculations account for naturally occurring market adoption (NOMAD) of code-compliant equipment and are used to inform demand forecasting, procurement planning, and tracking against GHG targets. This informs the CEC forecast of AAEE and SB350 target setting.
- **Net IOU C&S program savings** identifies the portion of the net C&S savings that can be attributed to the advocacy work of the IOU's C&S program. This result is used to inform the IOU's program goals.

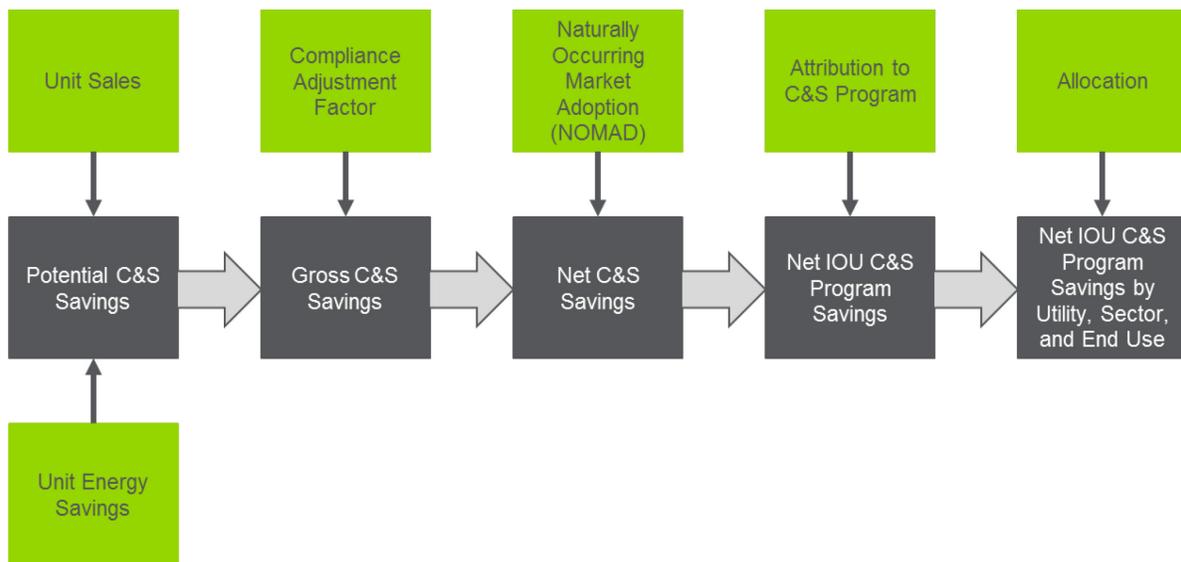
The modeling methodology of C&S savings was based on the Integrated Standards Savings Model (ISSM)¹⁸ developed by Cadmus and DNV GL and used by the CPUC in C&S program evaluation. The Navigant team replicated the methodology of ISSM in the PG Model for use in this study. The process of calculating net C&S savings and net IOU C&S program savings is illustrated in Figure 2-8. Key components of the calculation listed in Figure 2-8 include the following:

- **Unit sales:** Unit sales are the assumed baseline units sold each year for each measure. They represent the expected population of code-compliant or standard-compliant equipment adopted.

¹⁸ Cadmus and DNV GL. *Integrated Standards Savings Model (ISSM)*. 2017.

- **UES:** UES are the energy savings (in kWh, kW, or therms) relative to the previous code or standard for the new compliant equipment.
- **Compliance adjustment factor (CAF):** CAF is the baseline assumption for the rate at which the population complies with codes or standards.
- **NOMAD:** The naturally occurring market adoption is the fraction of the population that would naturally adopt the code-compliant or standard-compliant measure in the absence of any code or standard.
- **Attribution:** IOU attribution is the portion of gross C&S savings in California that can be claimed by IOU code support programs.
- **Allocation factors:** Allocation factors are the fraction of the statewide C&S savings that occur in each IOU territory. Additional allocation factors assumed by the Navigant team break down the savings into sectors and end uses.

Figure 2-8. C&S Savings Calculation Methodology



The 2019 Study continued to use no layering when analyzing net IOU attributable C&S savings from evaluated C&S. Layering issues were not addressed for unevaluated future C&S.

2.1.7 Financing

Financing has the potential to break through several market barriers that have limited the widespread market adoption of cost-effective EE measures. The PG Model is able to estimate the added effects of introducing EE financing on EE market potential and how shifting assumptions about financing affect the potential energy savings.

No updates relative to the 2017 Study have been made to the methodology or data inputs related to financing in the 2019 Study. Additional details on the methodology and data inputs can be found in Appendix G.

2.2 Calibrating Rebated Technologies and Whole Building Approaches

SB350 directed the CPUC to adopt goals based on EE potential studies that are not restricted by previous levels of utility EE savings. However, this does not mean that a potential study model should not be calibrated.

Like any model that forecasts the future, the PG Model faces challenges with validating results, as there is no future basis against which one can compare simulated versus actual results. Calibration, however, provides both the developer and recipient of the model results with a level of comfort that simulated results are reasonable. Calibration is intended to achieve the following:

- Anchors the model in actual market conditions and ensures that the bottom-up approach to calculating potential can replicate previous market conditions.
- Ensures a realistic starting point from which future projections are made.
- Accounts for varying levels of market barriers and influences across different types of technologies. The model applies general market and consumer parameters to forecast technology adoption. There are often reasons why markets for certain end uses or technologies behave differently than the norm—both higher and lower. Calibration offers a mechanism for using historic observations to account for these differences.

The calibration process is not a regression of savings or spending (not drawing a future trend line of savings based on past program accomplishments). Rather, calibration develops parameters that describe the customer decision-making process and the velocity of the market based on recent history. Once these parameters are set, the model uses them as a starting point for the forecast period.

The PG Model was calibrated in two steps. First, the Navigant team conducted a draft calibration based on historic data from 2013 through 2016. Second, the team reviewed the draft-calibrated results with stakeholders to incorporate effects post 2017 and the collective insights of stakeholders on how the future may differ from the past.

Step 1 calibrated by reviewing portfolio data from 2013 through 2016¹⁹ to assess how the market has reacted to program offerings in the past. The calibration starts in 2013 because a key input to the model (equipment saturation data) was based on data collected in the 2012-2013 timeframe. Thus, the model must begin in the same year that its equipment stock data begins.

Step 2 allows for calibration to account for more recent changes to programs. The Navigant team held a workshop on March 21, 2019 to present preliminary draft results of the residential, commercial, and industrial sectors to stakeholders. Following the presentation was a discussion of the following:

- Stakeholder impressions/reactions to the magnitude of the savings and breakdown across different end uses
- Stakeholder input on future trends not captured during the historical calibration

¹⁹ Calibration extends through 2016 rather than 2017 or 2018 due to the timeline constraints placed on this study. The 2017 model and study was set up to extract and process calibration data from the CPUC's EEstats website. EEstats provides data up through 2016. Program data (including program plans) for 2017 and beyond are housed on the CPUC's CEDARS website. Mining data from CEDARS under the short timeline of this project was not possible.

- Stakeholder insights regarding specific sectors/end uses that will be significantly impacted by program changes (positive or negative)
- Defensible reasoning to support any suggested changes

The Navigant team used inputs from this process to inform refinements to the modeling parameters that result in the final calibrated forecast. For more details on calibration, please see Appendix A.

2.3 Scenarios

This study continues to forecast multiple scenarios of market potential to inform the goal setting process. Scenario development in this study continues to follow the same framework as the 2017 Study.

The 2019 Study developed five scenarios that inform the CPUC’s goal setting process:

- One reference scenario that stems directly from the calibration process
- Four alternate scenarios (informed by stakeholder input)

Additional scenario analysis will be conducted as part of the AAEE analysis after the PG study is finalized. AAEE scenarios feed into the CEC’s IEPR and are built around the adopted IOU goals and informed by PG scenarios. AAEE scenarios are able to consider additional variables and policy context and, most importantly, do not impact IOU goals.

This study considers scenarios primarily built around policies and program decisions that are under control of the CPUC and IOUs collectively; these are referred to as internally influenced variables. Externally influenced variables were not considered in scenarios that inform the goals. External variables are those that the CPUC and IOUs collectively have no control over. A list of example internally and externally influenced variables can be found in Table 2-3..

Table 2-3. Variables Affecting EE Potential

Internally Influenced	Externally Influenced
<ul style="list-style-type: none"> • C-E test • C-E measure screening threshold • Incentive levels • Marketing and outreach • BROs customer enrollment over time • IOU financing programs 	<ul style="list-style-type: none"> • Building stock forecast • Retail energy price forecast • Measure-level input uncertainties (UES, unit costs, densities) • Non-IOU financing programs • Enacting of future C&S

Additional details on each of the internally influenced variables can be found in Table 2-4..

Table 2-4. Internally Influenced Variables Considered for Scenario Setting

Lever	Description	Potential Impact Applicability	
		Economic	Market
C-E test	Different C-E screening tests or thresholds yield different amounts of economic potential and cause the market potential model to incentivize different sets of measures. These only apply to rebate programs (excluding the low income program). Screening threshold applies to individual measures (not the portfolio as a whole).	✓	✓
C-E measure screening threshold		✓	✓
Incentive levels	Varying incentive levels will change both the C-E of measures and their value proposition to customers.	✓	✓
Marketing and outreach	Varying marketing and outreach levels impacts the rate at which technologies are adopted by customers.		✓
BROs program assumptions	Enrollment in BROs programs is an input vector. Navigant can assume a conservative rollout (reference) or an aggressive rollout of BROs programs.		✓
Financing programs	IOU financing programs help reduce the cost burden associated with efficient measure adoption.		✓

The study presented this scenario framework to stakeholders on February 21, 2019, and stakeholders were invited to provide feedback.²⁰

Based on stakeholder feedback, the Navigant team worked with CPUC staff to develop scenarios to consider in the goal setting process. Each of the internally influenced variables in Table 2-5. is expected to have an impact on the forecast of EE potential. The combined impact of these variables represents a scenario. The final selected scenarios are listed in Table 2-5..

²⁰ Slides and detailed stakeholder feedback available at: <https://pda.energydataweb.com/#!/documents/2133/view>

Table 2-5. Final Scenarios for EE Potential – Summary

Lever	Reference	Alternative 1	Alternative 2	Alternative 3	Alternative 4
C-E test	TRC	TRC	TRC	TRC	TRC
C-E measure screening threshold	1.0 for all measures	0.85 for all measures	1.25 for all measures	1.0 for all measures	0.85 for all measures
Incentive levels	Capped at 50%*	Capped at 50%*	Capped at 50%*	Capped at 50%*	Capped at 75%**
Marketing and outreach	Default calibrated value	Default calibrated value	Default calibrated value	Increased marketing strength	Increased marketing strength
BROs program assumptions	Reference	Reference	Reference	Aggressive	Aggressive
Financing programs	No modeled impacts	No modeled impacts	No modeled impacts	No modeled impacts	IOU financing programs broadly available to res and com customers

*Incentives are set based on a \$/kWh and \$/therm basis consistent with existing IOU programs; incentives are capped at 50% of incremental cost.

**Incentives are assumed to be 1.5 times higher than what current IOU programs are offering on a \$/kWh and \$/therm basis, capped at 75% of incremental cost.

The five scenarios can be interpreted as follows:

- The **Reference** scenario represents business as usual and the continuation of current policies. The C-E threshold is set to 1.0 in response to the hypothesis that highly cost-effective measures (such as commercial LED lighting) are moving to standard practice. Previously these highly cost-effective measures would balance out any measures with poor TRC and ultimately result in a portfolio that is cost-effective overall. Losing savings from commercial LEDs may bring down the overall portfolio TRC. Thus, in response, the model excludes individual measures below a TRC of 1.0 to ensure the overall portfolio has a TRC greater than 1.0.
- **Alternative 1** is like the Reference scenario except for decreasing the C-E screening threshold to 0.85 (consistent with the 2017 Study for non-emerging technologies). This would allow measures that are less cost-effective into the forecast. Current and past EE portfolios similarly included measures with low TRC. This alternate would test what would happen if reasonably cost-effective measures below 1.0 TRC were included in the forecast.
- **Alternative 2** is like the Reference scenario except for increasing the C-E screening threshold to 1.25. This would ensure the overall portfolio of resource programs will have a TRC greater than 1.25.

- **Alternate 3** builds upon the Reference scenario by simulating a more aggressive program design from program administrators. BROs programs are assumed to be aggressive, and program administrators are assumed to increase their marketing and outreach effort to better drive customers to rebate programs.
- **Alternate 4** is the most aggressive of all the scenarios modeled. It builds upon Alternate 3 by lowering the TRC threshold to 0.85, increasing incentives, and making financing broadly available to the residential and commercial sectors. The resulting portfolio simulated by this scenario may not be possible under the current policy framework (e.g., portfolio C-E targets or budget limits).

3. DATA SOURCES

The data sources relied on in the 2019 Study are vast and varied. Throughout the study, the Navigant team sought to rely on CPUC-vetted products as much as possible. However, in several cases, the team needed to seek alternate data sources where CPUC resources did not provide the necessary information. This section describes the data update process and sources for key topic areas.

3.1 Global Inputs

Global inputs are macro-level model inputs that are not specific to any measure but rather apply to market segments or sectors. The Navigant team reviewed the data source for each of these inputs to ensure that the most recent data is used for the 2019 Study. Table provides an overview of all global inputs within the 2020 model and their data source. Each item is discussed in further detail in the subsections that follow.

Table 3-1. Overview of Global Inputs Updates and Sources

Global Input (Description)	Data Source for Update
Retail Rates (\$/kWh, \$/therm)	CEC – 2017 Integrated Energy Policy Report (IEPR) Update and Demand Forecast Forms. Adopted Feb. 2017.
Consumption Forecasts (GWh, MW, and MMtherms)	Excel Demand Forecast Forms available at: http://www.energy.ca.gov/2017_energypolicy/documents/
Building Stocks (Households, floor space, consumption)	CPUC – California Energy Consumption Database (ECDMS). Accessed Oct. 2018.
Avoided Costs (Avoided energy and capacity costs)	CPUC – Cost Effectiveness Tool. Accessed Oct. 2018.
Historic Program Accomplishments (Used for calibration)	CPUC – Energy Efficiency Full Program Cycle (2013-2016) data. Download at: http://eestats.cpuc.ca.gov/Views/EEDataShelf.aspx
Non-Incentive Program Costs	CPUC – California Energy Data and Reporting System (CEDARS) (2018-2019) Data. Download at: https://cedars.sound-data.com

3.1.1 Retail Rates and Consumption Forecasts

The CEC’s IEPR, which includes a forecast that is updated annually, is the source for retail rates and consumption forecasts in the 2019 Study. The Navigant team used the 2017 IEPR for both electric and gas rates and forecasts.

Consumption forecasts in the IEPR are shown by the CEC’s eight planning areas, which differ slightly from the IOU service territory area. Some of the CEC planning areas include the territories of small publicly owned utilities (POUs) in California. Therefore, an adjustment is needed. Using data on service territory and planning area sales for 2017, the team calculated ratios to adjust the planning area consumption (found within IEPR) down to each IOU’s actual service territory consumption for both PG&E

and SCE. These ratios, with the service territory consumption based on the 2017 quarterly fuel energy reports (QFER), are referred to as service territory to planning area adjustment ratios and are detailed in Table 3-2.. The CEC planning area for San Diego directly maps to the SDG&E service territory, so there is no need to calculate an adjustment ratio for SDG&E.

Table 3-2. 2017 IEPR Electric Service Territory to Planning Area Adjustment Ratios

IOU	Residential	Commercial	Industrial	Mining	Agriculture	Street Lighting
PG&E	96.9%	86.4%	89.1%	90.1%	86.6%	90.8%
SCE	93.4%	89.0%	88.9%	95.6%	67.7%	93.7%

Source: California Energy Commission, 2018

Most POUs in California do not offer any gas service (only the City of Palo Alto and Island Energy offer natural gas service). It is estimated that California IOUs sell approximately 99% of the state’s natural gas. However, there are some exceptions, notably SMUD in PG&E territory. To obtain service territory consumption values, Navigant staff used 2016 data from the CEC’s Energy Consumption Database (ECDMS), shown in Table 3-3..²¹

Table 3-3. 2017 IEPR Gas Service Territory to Planning Area Adjustment Ratios

IOU	Residential	Commercial	Industrial	Mining	Agriculture	Street Lighting
PG&E	100.0%	98.4%	99.8%	99.8%	99.8%	N/A
SCG	100.0%	97.5%	99.6%	9.19%	97.9%	N/A

Source: California Energy Commission, 2018

While most of the adjustment ratios are close to or at 100%, SCG mining is 9.19% based on service territory sales found in the ECDMS. Many of the largest oil and gas extraction companies in SCG’s planning area purchase gas directly from the pipeline companies. The service territory to planning area adjustment calculation must remove the gas sales that are attributed to those large oil and gas companies.

These ratios were applied to both the sales forecast and the building stocks for electric and gas impacts.

3.1.2 Building Stocks

Building stocks are the total population metrics of a given sector, though represented by different metrics for most sectors. Residential building stocks are based on the number of households in an IOU’s service territory. Commercial building stocks are represented by total floor space for each commercial building type. Industrial and agricultural building stocks are represented by energy consumption. Mining and street lighting stocks are the number of pumps and street lights, respectively. The residential, commercial, industrial, and agriculture building stock metrics are derived from the CEC’s IEPR.

The model requires building stocks by sector, scenario, and utility for the timeframe 2013-2030.

²¹ California Energy Consumption Database. Accessed October 2018: <http://ecdms.energy.ca.gov/>

The IEPR organizes building stock data into the eight electric planning areas determined by the CEC. To translate these IEPR results to the PG Model and split them by utility, the Navigant team worked with the CEC to map CEC planning areas to the IOU service territories, as listed in Table 3-4..

Table 3-4. Mapping CEC Planning Areas to IOU Service Territories

CEC Electric and Gas Planning Areas to Utilities			
CEC Forecasting Climate Zones	Electric Planning Area Number	Electric Planning Area Utilities	Natural Gas Planning Area Utilities
Climate Zone 1	1 - PG&E	PG&E	PG&E
Climate Zone 2			
Climate Zone 3			
Climate Zone 4			
Climate Zone 5			
Climate Zone 6			
Climate Zone 7	2- SCE	SCE	SCG
Climate Zone 8			
Climate Zone 9			
Climate Zone 10			
Climate Zone 11	3 - SDG&E	SDGE	SDGE
Climate Zone 12			
Climate Zone 13			
Climate Zone 14	4 - NCNC	SMUD	PG&E
Climate Zone 15		TID	
Climate Zone 16		Other (Modesto, Redding, Roseville, Trinity, and Shasta Lake)	
Climate Zone 17	5 - LADWP	LADWP	SCG
Climate Zone 18	6 - Burbank/Glendale	Burbank/Glendale	
Climate Zone 19	7 - IID	IID	
Climate Zone 20	8 - Valley Electric	Valley Electric	

Source: California Energy Commission, 2017

3.1.3 Historic Rebate Program Activity

The historic rebate program achievements for each of the IOUs are important inputs for calibrating the forecast of rebate programs. The CPUC maintains the Energy Efficiency Statistics (EEStats) portal, an online resource that collects program achievement data, for public use. A spreadsheet of 2013-2015 program achievement data and a spreadsheet of 2016 achievement data are available for download on this website. These datasets include ex ante and evaluated program savings, expenditures, C-E, and emissions for EE programs statewide. For the 2019 Study, the team used this dataset to compute portfolio net and gross savings for each sector and utility.

Table 3-5. provides the 2013-2016 gross ex post savings. Some program savings were not modeled as a rebate program and those savings are excluded from this analysis. For example, residential home energy reports (HERs) and retrocommissioning fall under the definition of the BROs and were removed to prevent double counting savings.

Table 3-5. 2013-2016 IOU-Reported Portfolio Gross Program Savings

IOU	Spending (\$ Millions)		Energy Savings (GWh)		Gas Savings (MM therms)	
	RES	COM	RES	COM	RES	COM
PG&E	231.64	584.35	688.29	1,190.74	-0.63	17.93
SCE	333.27	553.45	1,080.44	1,422.96	N/A	N/A
SCG	77.83	41.06	N/A	N/A	15.28	15.77
SDG&E	82.82	158.61	229.40	363.03	-1.00	3.53

Source: CPUC – Energy Efficiency Full Program Cycle (2013-2016) Data

Additional discussion of the calibration process can be found in Appendix A.

3.1.4 Non-Incentive Program Costs

Non-incentive program costs come from the 2018-2019 Summary Reports Data on the CPUC's CEDARS portal. For the PG Model, the Navigant team determined program costs per unit of kWh or therm, by sector. This is facilitated by the EEStats data, where program costs for each program and measure line are already listed. In EEStats, program costs combine administrative costs, marketing costs, implementation (customer service) costs, overhead, and evaluation, measurement, and verification, (EM&V) costs. Note that interactive effects are excluded prior to calculating these costs.

Table 3-6. provides an overview of the non-incentive program costs based on gross reported savings. The displayed AIMS program cost is an average of the individual agriculture, industrial, mining, and street lighting costs calculated.

Table 3-6. Non-Incentive Program Costs Summary

IOU	Electric Savings (\$/Gross kWh)			Gas Savings (\$/Gross therm)		
	RES	COM	AIMS	RES	COM	AIMS
PG&E	\$0.09	\$0.10	\$0.08	\$2.59	\$2.92	\$2.38
SCE	\$0.06	\$0.22	\$0.18	N/A	N/A	N/A
SCG	N/A	N/A	N/A	\$1.15	\$1.14	\$0.72
SDG&E	\$0.14	\$0.07	\$0.04	\$4.02	\$1.15	\$1.88

Source: CPUC – California Energy and Data Reporting System (CEDARS) - 2018-2019 Program Filing Data

3.1.5 Avoided Costs

Avoided costs place an economic value on the amount of energy and GHG emissions that is saved by implementing an energy-saving measure. Avoided costs are a key input to the calculation of cost-effectiveness.

To determine avoided costs, the Navigant team used version 18.1 of the Cost-Effectiveness Tool (CET), a calculator commissioned by the CPUC.²² The team used the 2019 vintage of the avoided cost data. Post-processing of the CET calculator data resulted in a dataset that displays total avoided costs for 2018-2048 by IOU, sector, end-use category, and sub-end-use category.

Electric avoided costs for the PG Model are the sum of the avoided costs of generation, transmission and distribution (T&D), and carbon from the CET. Carbon in the CET is expressed in tons/kWh, so the Navigant team needed to multiply this data by the cost of carbon. Gas-avoided costs are the sum of the avoided costs of generation and T&D as reported by the CET. The CET embeds the cost of carbon in its valuation of gas generation avoided cost.

In March 2018, the CPUC issued a Staff Proposal that included an avoided cost calculator with costs per ton of carbon for each year from 2018 to 2030.²³ Each cost is the sum of the cap and trade allowance and the GHG adder determined by the avoided cost calculator.²⁴ The Navigant team assumed that after 2030 the real cost of carbon remained constant.²⁵

Table 3-7. Costs of Carbon, 2018-2050

Year	Carbon Cost (nominal \$/ton)	Carbon Cost (real 2016 \$/ton)
2018	\$63.01	\$60.21
2019	\$71.23	\$66.53
2020	\$79.79	\$72.86
2021	\$88.71	\$79.18
2022	\$98.00	\$85.50
2023	\$107.67	\$91.83
2024	\$117.73	\$98.15
2025	\$128.19	\$104.46
2026	\$139.07	\$110.79
2027	\$150.39	\$117.11
2028	\$162.16	\$123.43
2029	\$174.38	\$129.75
2030	\$187.09	\$136.08
2031	\$191.39	\$136.08
2032	\$195.80	\$136.08

²² CPUC. "CET Desktop The Cost Effectiveness Tool." Accessed Oct. 2018. <http://eega.cpuc.ca.gov>.

²³ CPUC. "Cost-effectiveness Air Quality Adder Data." 2018. <http://www.cpuc.ca.gov/General.aspx?id=5267>

²⁴ Horii, Brian, Eric Cutter, Zach Ming. *Avoided Costs 2018 Update*. 2018. Pg. 39. <http://www.cpuc.ca.gov/General.aspx?id=5267>

²⁵ The forecast assumes a 2.3% inflation rate when converting real 2016 dollars into nominal cost.

Year	Carbon Cost (nominal \$/ton)	Carbon Cost (real 2016 \$/ton)
2033	\$200.30	\$136.08
2034	\$204.91	\$136.08
2035	\$209.62	\$136.08
2036	\$214.44	\$136.08
2037	\$219.37	\$136.08
2038	\$224.42	\$136.08
2039	\$229.58	\$136.08
2040	\$234.86	\$136.08
2041	\$240.26	\$136.08
2042	\$245.79	\$136.08
2043	\$251.44	\$136.08
2044	\$257.22	\$136.08
2045	\$263.14	\$136.08
2046	\$269.19	\$136.08
2047	\$275.38	\$136.08
2048	\$281.72	\$136.08
2049	\$288.20	\$136.08
2050	\$294.82	\$136.08

3.2 Residential and Commercial Technology Characterization

The technology characterization step develops the essential inputs that are used in the PG Model to calculate potential. This section provides an overview of the technology selection process for the residential and commercial sectors, describes the fields along which technologies are characterized, lists the data sources and describes how these sources are used for characterization, and directs the reader to the complete database of characterized technologies.

Like the 2017 Study, the 2019 Study uses a technology-based characterization, which characterizes individual technology levels within a technology group. A **technology group** includes multiple technologies with different efficiency levels that compete for stock replacement under an end use. Technology group is also commonly referred to as competition group. For example, residential ACs with different efficiency levels (SEER 13, SEER 16, SEER 21, etc.) are considered a single technology group termed residential air conditioners.²⁶

²⁶ This is different from the 2015 version and earlier versions of the study, which classified measures defined by a base technology upgrading to an efficient level technology (e.g., SEER 13 to SEER 16 ACs and SEER 13 to SEER 21 ACs were considered two different measures).

3.2.1 Technology Selection Process

Given the constrained timeline for this study, the technology selection for the 2019 Study started with the technology list developed for the 2017 Study. The Navigant team undertook a comprehensive technology selection process for the 2017 Study, consisting of the following steps:

1. Developed a comprehensive and universal list of technology groups for consideration in the study.
2. Selected a subset of representative technology groups from the California IOUs' program portfolios that provide the bulk of the savings (98% of the total savings by end use for the residential and commercial sectors).
3. Presented the technology list to stakeholders for review and feedback.
4. Developed a final list of technology groups as well as the full list of individual technologies under each technology group.

For the 2019 Study, the team retained the technology list from the 2017 Study with the following changes:

- Removed the SEER 10 efficiency level from the residential heat pumps and residential air conditioners technology groups (new information from DEER suggests that the average installed heat pump or air conditioner is SEER 13 in the base year of the 2019 Study)
- Added residential advanced lighting controls²⁷ as an additional efficient level to certain residential lighting technology groups:
 - Lighting fixtures – indoor
 - Reflector lamps – indoor
 - Screw-in lamps – low – indoor
 - Screw-in lamps – high – indoor
 - Specialty lamps – low – indoor
 - Specialty lamps – high – indoor
- Removed residential indoor lighting controls as a separate technology group as this measure is replaced by the above described advanced lighting controls
- Added smart connected power strips as an additional efficient level to the residential advanced power strips technology group
- Added commercial HVAC energy management systems (EMS) as a separate technology group

²⁷ In the residential sector, advanced lighting controls are assumed to be embedded in the power electronics of the light bulb, and the bulb with advanced controls can be exchanged for a baseline bulb in the same socket or fixture. The embedded controls combine the functionality of four types of controls: dimmers, occupancy sensors, timers, and daylighting/ambient light sensing.

Table 3-8. shows the number of technology groups and individual technologies characterized in the study by end use for the residential and commercial sectors, including technologies under both fuel types (electric and gas).²⁸

Table 3-8. Final List of Technology Groups (with Examples) and Individual Technologies

Sector	End Use	Technology Group Examples ²⁹	Number of Technology Groups	Number of Individual Technologies ³⁰
Residential	Appliances/ Plug Loads	Refrigerators, Pool Pumps, Clothes Dryers	13	43
	Building Envelope	Weatherization, Attic Duct Insulation, Windows	13	39
	HVAC	Air Conditioners, Heat Pumps, Ceiling Fans	16	45
	Lighting	Indoor Screw-In Lamps, Specialty Lamps, Linear Fixtures	12	54
	Water Heating	Electric Water Heaters, Faucet Aerators, Showerhead	11	27
	Total			65
Commercial	Appliances/ Plug Loads	Power Strips, Servers, Vending Controls	14	43
	Building Envelope	Ceiling/Roof Insulation, Wall Insulation, Windows	6	19
	Com. Refrigeration	Display Case Motors, Strip Curtains, Anti-Sweat Heat Controls	8	19
	Data Center	Server Virtualization, High Efficiency UPS, CRAC Upgrades	5	10
	Food Service	Electric Convention Ovens, DCV Exhaust Hood, Steamers	7	14
	HVAC	Chillers, Split AC, Mini Split Heat Pumps	24	82
	Lighting	High Bay Fixtures, Lighting Fixtures (Indoor and Outdoor), Indoor Reflector Lamps	12	47
	Water Heating	Electric Storage Water Heaters, Faucet Aerators, Showerhead	3	12
Total			79	246

²⁸ Please refer to the Measure Input Characterization System (MICS) database for additional details.

²⁹ The complete list of technology groups is presented in the MICS database.

³⁰ Note that the technology list does not include whole building packages and BROs interventions. The approach used to select and characterize these measures is discussed in separate sections of this report. Please refer to the MICS database for a complete list of the technologies included in the study.

3.2.2 Technology Characterization

Characterizing selected technologies involves developing various inputs for each technology necessary to calculate potential. Table 3-9. summarizes the key items the Navigant team used to characterize the technologies along with brief descriptions.

Table 3-9. Key Fields for Measure Characterization with Brief Descriptions

Items	Brief Description
Technology Description	Specifies the following for each technology: <ul style="list-style-type: none"> • Sector • End use • Fuel type • Climate zone • Segment/building type • Replacement type
Energy Use	Specifies the following for each technology: <ul style="list-style-type: none"> • Energy use (electric and gas) • Coincident peak demand • Interactive effects
Technology Costs	Specifies the following for each technology: <ul style="list-style-type: none"> • Equipment cost • Repair cost (for AR technologies) • Installation cost
Market Information	Specifies the following for each technology: <ul style="list-style-type: none"> • Applicability by segment/building type • Density associated with the technology group • Saturation for individual technologies
Other Items	Includes the following: <ul style="list-style-type: none"> • Technology lifetime (EUL and RUL) • NTG ratio

The following subsections describe in detail how the energy use, costs, market information, and other relevant fields were developed and the associated hierarchical list of data sources for this information.

3.2.2.1 Energy Use

Energy use is a key input for technology characterization. The technology-based approach followed in this study implies that the absolute energy use associated with average below code, code, and efficient technologies need to be specified.

Unit energy use is specified in kWh for electric technologies and in therms for gas-fueled technologies. For dual fuel technologies that can achieve both electric and gas savings, such as insulation, both metrics are calculated. Additionally, some technologies have interactive effects. An example is energy efficient lighting, which produces less waste heat than incandescent bulbs and thus has additional HVAC consumption associated with it. The technology characterization template requires these interactive effects to be included.

Electric technologies also require the characterization of coincident peak demand. Effective January 1, 2020, the peak period used to calculate demand impacts in DEER changed per DEER Resolution E-4952, published October 11, 2018. The Navigant team assumed that the demand impacts in DEER 2020 already incorporated this new peak demand period. For demand data not sourced from DEER 2020, the team updated the peak demand impacts to be consistent with the new DEER definitions, leveraging available load shape data and prioritizing the use of DEER load shapes when available.

Table 3-10. lists the data sources for energy use (in hierarchical order) with brief descriptions of the sources.

Table 3-10. Hierarchy of Data Sources for Energy Use Information

Priority	Energy Consumption Source Name	Description	Author	Publication Year
1	DEER 2020	<p>Navigant used information from 2019/2020 DEER updates to obtain energy use and coincident peak demand for technologies, wherever available.</p> <p>Lighting energy use was calculated using the lighting calculator tool available at DEER.</p>	CPUC	2019
2	Non-DEER Ex Ante Database	Navigant referred to the Non-DEER ex ante database, available from CPUC staff, to characterize technologies that were not included in DEER.	CPUC	2016
3	IOU Workpapers (with CPUC Disposition)	Navigant referred to the inventory of workpapers published by the California IOUs and referred to approved workpapers for technology characterization, wherever applicable.	California IOUs	Various
4	California POU Technical Reference Manual (TRM)	Navigant referred to the CMUA TRM for energy use information for applicable technologies.	CalITF	2015
5	California IOU Emerging Technology Reports	Navigant reviewed and researched project/technology reports from the ETCC—a collaborative forum with IOUs and leading member organizations for characterization of emerging technologies.	Emerging Technology Coordinating Council (ETCC), IOUs	Various
6	IOU Program Data	Navigant referred to the 2016 EESStats database ³¹ and 2014-Q12016 program savings ³² database from CA IOUs, in case energy use information was not available from the above listed sources.	CPUC, IOUs	2014-2016
7	<p>Non-California source examples:</p> <ul style="list-style-type: none"> Regional Technical Forum (RTF) Database 	<p>In cases where California-specific sources were not available for energy use information, Navigant referred to the following sources:</p> <ul style="list-style-type: none"> Measure-level savings data from evaluated programs in the Pacific Northwest region, available through the RTF. 	Northwest Power and Conservation Council (NPCC)	2015

³¹ Available at: <http://eestats.cpuc.ca.gov/Views/EEDataPortal.aspx>

³² Navigant obtained the database of IOU programs with savings and cost information from Itron under the CPUC's directive.

Priority	Energy Consumption Source Name	Description	Author	Publication Year
	<ul style="list-style-type: none"> • Navigant Potential Study Database 	<ul style="list-style-type: none"> • Navigant's archive of characterized measure savings from potential studies and projects with other utilities. 	Navigant	2017-2018

3.2.2.2 Technology Costs

The measure characterization database requires specification of equipment costs, labor costs for installation, and repair costs for AR technologies. Information on technology costs were primarily sourced from the California Measure Cost Study, published by Itron in 2012. Some of the other cost data sources are the same as those listed under energy use. Table 3-11. summarizes the data sources used for technology costs.

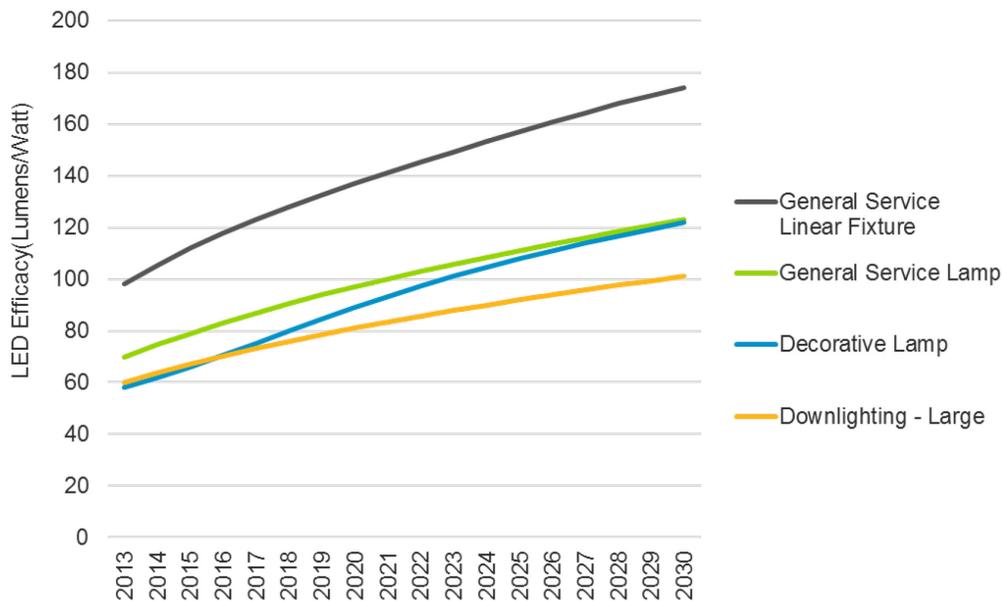
Table 3-11. Hierarchy of Data Sources for Technology Cost Information

Priority	Cost Source Name	Description	Author	Year
1	California Measure Cost Study	This served as the primary source of information for equipment and installation costs.	Itron	2012
2	DEER	Navigant used information from 2019/2020 DEER updates to obtain equipment and labor costs for technologies, wherever available. For the most part, DEER pulls cost data from the California Measure Cost Study.	CPUC	2019
3	IOU Workpaper (with CPUC Disposition)	Navigant obtained equipment and labor costs from approved California IOU workpapers in cases where the Navigant team referred to these workpapers for obtaining energy use information.	California IOUs	Various
4	CMUA TRM	Navigant obtained equipment and labor costs from the CMUA TRM in cases where the Navigant team referred to the CMUA TRM for obtaining energy use information.	Cal TF	2015
5	California IOU Emerging Technology Reports	Navigant obtained cost information on emerging technologies from ETCC technology reports, wherever available.	ETCC, IOUs	Various

Priority	Cost Source Name	Description	Author	Year
6	Non-California source examples:	For lighting technologies, Navigant referred to a US Department of Energy (DOE) report authored by Navigant for LED cost data (see discussion following table).	DOE	2016
	<ul style="list-style-type: none"> Energy Savings Forecast of Solid-State Lighting in General Illumination Applications³³ Navigant Potential Study Database 	In cases where no California-specific source was available for costs, Navigant referred to its internal database of energy efficient technologies for available cost information.	Navigant	2017-2018

The Navigant team referred to forecasts from the DOE to obtain LED costs.³⁴ This was done to incorporate cost projections into the model while maintaining consistency across years. The team used efficacy (lm/W) and price per kilo-lumen (\$/klm) projections to determine current and future costs for LEDs. Figure 3-1 and Figure 3-2 graph the projected efficacy and costs of different lamp types of LEDs, respectively, through 2030.

Figure 3-1. Projected LED Technology Improvements, 2013-2030

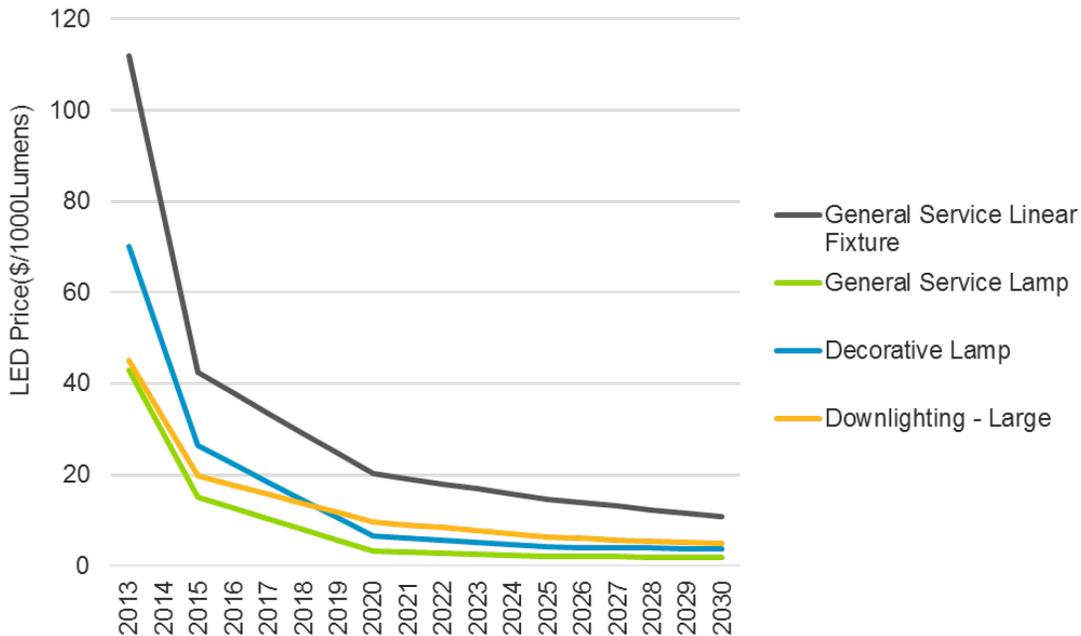


Source: Navigant analysis of DOE data

³³ Downloadable from <http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf>.

³⁴ Navigant. *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications*. Prepared for the U.S. DOE. 2016. Downloadable from <http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf>

Figure 3-2. Projected LED Cost Reduction Profiles, 2013-2030



Source: Navigant analysis of DOE data

3.2.2.3 Market Information: Density and Saturation Values

Density and saturation are two essential calculations of technology characterization.

- Density is a measure of the number of units per building. The potential model uses the density information to determine the number of applicable technology units on the appropriate scaling basis (per household for residential and per square foot for commercial) to scale up the technology stock by segment/building type. Density is specified by technology group and by individual technologies. Density can be expressed as the following (for example): units/home, bulbs/home, fixtures/1,000 square feet, tons of cooling/1,000 square feet, etc.
- Saturation is the share of a specific technology within a technology group, so that the sum of the saturations across a technology group always sums to 100%. Saturation can also be calculated by dividing the individual technology density by the total technology group maximum density.

As an example, Table 3-12. shows the densities and saturations for residential refrigerators in single-family homes in PG&E's service territory.

Table 3-12. Example of Density and Saturation Calculation

Technology Name	Base Year Efficiency Level	Unit Basis	Technology Density (Units per Household)	Technology Saturation
Average Below Code Refrigerator	Average Below Code	No. of Refrigerators	0.155	13%
Code-Compliant Refrigerator	Code	No. of Refrigerators	0.590	51%
ENERGY STAR Refrigerator	Efficient	No. of Refrigerators	0.405	35%
Total			1.15	100%

The table shows that an average single-family home in PG&E's territory has 1.15 refrigerators per home, which is the density for refrigerators in single-family homes. The saturations for average below code, code-compliant, and ENERGY STAR refrigerators for single-family homes is 13%, 51%, and 35%, respectively. The saturation changes over time with population growth and stock turnover as more below code stock gets replaced with at code and higher efficiency stock.

Table 3-13. lists the resources used to calculate density and saturation for the residential and commercial sectors in 2017, in order of priority. The Navigant team primarily used California-specific sources for density and saturation data and referred to non-California sources only in cases California-specific sources did not have the required data.

Table 3-13. Sources for Density and Saturation Characterization

Priority	Sources	Description	Author	Year
1	California Lighting & Appl. Saturation Survey (CLASS)	Residential baseline study of 1,987 homes across California.	DNV GL	2012
2	Commercial Saturation Survey (CSS)	Baseline study of 1,439 commercial buildings across California.	Itron	2012
3	Residential Appliance Saturation Study (RASS) ³⁵	Residential end-use saturations for 24,000 households in California.	DNV GL (formerly KEMA)	2009
	Non-California source examples:			
	<ul style="list-style-type: none"> Residential Building Stock Assessment (RBSA) Comm. Building Stock Assessment (CBSA) 	RBSA and CBSA survey residential and commercial building stock across the Northwest states (Idaho, Montana, Oregon, Washington).	Northwest Energy Efficiency Alliance (NEEA)	2014
4	<ul style="list-style-type: none"> Res. Energy Consumption Survey (RECS) Comm. Bldg. Energy Cons. Survey (CBECS) 	RECS and CBECS are surveys of residential and commercial building stock in the US by region. Used West regional data only.	US DOE	2009
	<ul style="list-style-type: none"> ENERGY STAR Shipment Database 	Unit shipment data of ENERGY STAR-certified products collected to evaluate market penetration and performance.	Environmental Protection Agency (EPA)	2003-2016

In addition to the density and saturation values, measure characterization requires specifying the technical suitability or applicability factor (which has a value less than or equal to 1) that defines the share of customers with the physical or infrastructural pre-requisites to install a technology. The applicability factor assumptions are based on data sources, wherever available, and the Navigant team’s industry expertise and subject matter expertise in the area.

3.2.2.4 MICS Database

The MICS database consolidates the information from the measure characterization effort in an Excel spreadsheet that serves as an input to the PG Model. It presents the various dimensions along which measures are characterized as separate fields in the database. The database is publicly available and can be downloaded through the CPUC website.³⁶

3.3 Whole Building Initiatives

Whole building initiatives aim to deliver savings to residential and commercial customers as a package of multiple efficiency measures that are all installed at the same time. The 2019 Study models whole building initiatives via the technology levels indicated in Table 3-14.. As described in Section 2.1.1.2, the

³⁵ Navigant referred to this source only in cases where CLASS and CSS did not have the required data.

³⁶ <http://www.cpuc.ca.gov/General.aspx?id=6442452619>

technology levels within the technology group include existing baseline, code baseline, and the efficient result of a whole building initiative.

Table 3-14. Whole Building Technology Levels

Technology Group	Residential Technology Level	Commercial Technology Level
New Construction	Title 24 2008 Code	Title 24 2008 Code
	Title 24 2013 Code	Title 24 2013 Code
	Title 24 2016 Code	Title 24 2016 Code
	Title 24 2019 Code	Title 24 2019 Code
	Zero Net Energy (ZNE)	ZNE
Retrofit	Existing Building – No Retrofit	Existing Building – No Retrofit
	Energy Upgrade CA – Basic	Retrofit – 15% Savings
	Energy Upgrade CA – Advanced	-

Source: Navigant team analysis, 2019

The following sections discuss the technology levels used in the 2017 Study. The final values for savings, cost, measure life, and other key model inputs can be found in the MICS spreadsheet.

3.3.1 New Construction

The 2019 Study represents each Title 24 code level as it becomes the baseline for ZNE construction as the efficient measure, with energy consumption in absolute terms and costs represented as incremental to 2008 Title 24 levels. Communications with the CEC indicate that 7% energy savings are expected for residential 2019 Title 24 over 2016 Title 24, and 2% energy savings are expected for commercial 2019 Title 24 over 2016 Title 24. Both are a decrease from the previous study assumption of 10% savings for both sectors.

3.3.1.1 Commercial

Table 3-15. provides the sources used to characterize commercial new construction whole building initiatives. These represent the best and usable datasets available to the team at the time of characterization. Of particular value was the data from the 2016 CBECC-Com software, which provided variability by climate zone.

Table 3-15. Commercial New Construction Whole Building Data Sources

Data Category	Data Items	Data Sources
Cost	Incremental Cost of 2013 Title 24 over 2008 Title 24	California Energy Commission, 2013 Standard Cost Impact Analysis: http://www.energy.ca.gov/title24/2013standards/rulemaking/documents/final_rulemaking_documents/05_Impact_Analysis.pdf
	Incremental Cost of 2016 Title 24 over 2013 Title 24	California Energy Commission, 2016 Notice of Proposed Action: http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/NOPA_title24_parts_01_06.pdf
	Incremental Cost of 2019 Title 24 over 2016 Title 24	Navigant extrapolation based on 2016 Title 24
	Incremental Cost of ZNE over 2013 Title 24	Calculated using the following: New Building Institute, <i>Getting to Zero 2012 Status Update: A First Look at the Costs and Features of Zero Energy Commercial Buildings</i> : http://newbuildings.org/getting-zero-2012-status-update-first-look-costs-and-features-zero-energy-commercial-buildings Comm. RE Specialists, Cost Per Square Foot For New Commercial Construction, 2013 Reed Construction Data Inc., RS Means Square Foot Estimator, 2013: http://www.rsmeansonline.com
Energy Consumption and Savings	2016 Title 24 Energy Consumption	CEC, CBECC-Com 2016 Std. Design Results, January 2017
	Incremental Energy Savings of 2013 Title 24 over 2008 Title 24	California Energy Commission, 2013 Impact Analysis: http://www.energy.ca.gov/2013publications/CEC-400-2013-008/CEC-400-2013-008.pdf
	Incremental Energy Savings of 2016 Title 24 over 2013 Title 24	California Energy Commission, 2016 Impact Analysis: http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/15-day_language/impact_analysis/2016_Impact_Analysis_2015-06-03.pdf
	Incremental Energy Savings of 2019 Title 24 over 2016 Title 24	Communications with the CEC, January 2019
	Incremental Energy Savings of ZNE over 2013 Title 24 (see discussion below)	ARUP, <i>The Technical Feasibility of Zero Net Energy Buildings in California</i> , December 2012

Regarding the incremental savings of ZNE over 2013 Title 24, the Navigant team adjusted the savings for ZNE to account for LEDs becoming standard practice in the commercial sector starting in 2019. This change to lighting standard practice was promulgated by DEER Resolution E-4952 in October 2018 and was not anticipated in the ARUP analysis. The Navigant team estimated the percent reduction in savings as equivalent to the percent of building consumption attributed to the lighting end use in CBECC-Com 2016 Reference Case (the most recent year for which there was CBECC-Com data). This estimate relies on two assumptions: 1) that the percent of savings attributable to lighting is equivalent to the percent of consumption attributable to lighting (i.e., between 10% and 40% depending on the building type and climate zone); and 2) the DEER resolution would eliminate lighting savings in commercial new construction. In reality, commercial new construction may still have some lighting savings due to controls and lighting types not covered by the DEER resolution, but Navigant believes this is a conservative

approach that avoids double counting of lighting savings that will naturally occur due to the DEER resolution.

3.3.1.2 Residential

Table 3-16. provides the sources for energy consumption and cost data for residential new construction.

Table 3-16. Residential New Construction Whole Building Data Sources

Data Category	Data Items	Data Sources
Cost	Incremental Cost of 2013 Title 24 over 2008 Title 24	CEC, 2013 Standard Cost Impact Analysis: http://www.energy.ca.gov/title24/2013standards/rulemaking/documents/final_rulemaking_documents/05_Impact_Analysis.pdf
	Incremental Cost of 2016 Title 24 over 2013 Title 24	CEC, 2016 Notice of Proposed Action: http://www.energy.ca.gov/title24/2016standards/rulemaking/documents/NOPA_title24_parts_01_06.pdf
	Incremental Cost of 2019 Title 24 over 2016 Title 24	Navigant extrapolation based on 2016 Title 24
	Incremental Cost of ZNE over 2013 Title 24	CEC Draft Title 24 Code Update Analysis provided to Navigant
Energy Consumption and Savings	Incremental Energy Savings of 2013 Title 24 over 2008 Title 24	CEC, 2013 Standard Cost Impact Analysis: http://www.energy.ca.gov/title24/2013standards/rulemaking/documents/final_rulemaking_documents/05_Impact_Analysis.pdf
	2013 Title 24 Energy Consumption	CEC, CBECC-Res 2013 Std. Design Results, 2015
	2016 Title 24 Energy Consumption	CEC, CBECC-Res 2016 Std. Design Results, January 2017
	Incremental Energy Savings of 2019 Title 24 over 2016 Title 24	Communications with the CEC, January 2019
	Incremental Energy Savings of ZNE over 2013 Title 24	ARUP, <i>The Technical Feasibility of Zero Net Energy Buildings in California</i> , December 2012

3.3.2 Retrofit

Characterization of both commercial and residential whole building retrofits reflects the encouragement of to code savings in existing buildings expressed in AB802.

3.3.2.1 Commercial

The 2019 Study follows the approach of the 2017 Study in using a top-down approach with a goal of saving 15% of consumption at the whole building level. This target was selected in response to feedback collected during the 2017 Study that indicated that whole building retrofits needed to achieve 15%

savings to be able to differentiate savings from noise when using normalized metered energy consumption (NMEC) methods and to reflect deeper energy savings from multi-measure approaches.³⁷

In the 2017 Study, Navigant verified that this level of savings could be achieved by addressing cooling, ventilation, lighting, and refrigeration electric end uses and heating, water heating, and food service gas end uses.³⁸ The Navigant team derived the savings distribution across the end uses by starting with the percent savings exhibited by each end use in the 2013-2015 California EE portfolio and iterating to ensure that reasonable savings were expected from each end use. Costs were applied to these energy savings using an average UES (\$/kWh or \$/therm) associated with each end use across the 2013-2015 California EE portfolio.

For the 2019 Study, the team also examined reports from PG&E's Commercial Whole Building Program. Navigant could not calculate an expected savings value from the reports due to the large variability in savings and the small sample size, but concluded that saving 15% of consumption at the whole building level is realistic as it fell within the range of the PG&E study results.

The data sources listed in Table 3-17. were used for this analysis.

Table 3-17. Commercial Retrofit Whole Building Data Sources

Data Items	Data Sources
Energy Intensity by End Use and Building Type	CEC, California Commercial End-Use Survey, March 2006
Floorspace	CEC, 2016 IEPR
Costs	CPUC, California EEStats, 2013-2015 Program Cycle

3.3.2.2 Residential

Table 3-18. provides the sources of data used in characterizing the Energy Upgrade California program. Costs were applied to the energy savings using an average UES (\$/kWh or \$/therm) as derived from the program metrics reported by all Energy Upgrade California IOU programs. The 2020 results indicate lower savings than the 2017 Study due to low realization rates in the more recent evaluation report.

Table 3-18. Residential Retrofit Whole Building Data Updates

Data Items	Data Sources
Savings	DNV GL, Final Report: <i>2015 Home Upgrade Program Impact Evaluation</i> , June 23, 2017, CALMAC ID: CPU0162.01 http://www.calmac.org/publications/RES_5.1_HUP_FINAL_REPORT_ATR_06-30-17.pdf
Costs	CPUC, California EEStats, 2013-2015 Program Cycle

³⁷ Decision Approving 2013-2014 Energy Efficiency Programs and Budgets, p. 77; AB802

³⁸ Except for gas savings at dual fuel utilities for the following building types: office, retail, school, and health.

3.4 Low Income Programs

Data for low income programs was primarily obtained from secondary data. Key sets of data include building stock and retail rates (categorized as global inputs) and measure-level data.

3.4.1 Building Stock and Retail Rates

Using data analyzed from a combination of the Low Income Needs Assessment,³⁹ eligibility statistics for the California Alternate Rates for Energy (CARE)⁴⁰ program, and county-level statistics on the multifamily market from the American Community Survey,⁴¹ the Navigant team estimated the fraction of the population in each IOU territory that would qualify for low income programs. This data is summarized in Table 3-19. and is applied to the residential building stock forecast (described earlier in Section 3.1.2) to split the total residential stock into low income versus non-low income. The fraction of single-family and fraction of multifamily are independent market estimates and, therefore, do not sum to 100%. Analysis indicates that the higher fraction of multifamily homes that are low income for PG&E compared to other utilities is likely due to higher population densities in the Bay Area and high housing prices, resulting in a higher percentage of low income residents living in multifamily units.

Table 3-19. Fraction of Households Considered Low Income

Utility	Fraction of Single-Family Homes that are Low Income	Fraction of Multifamily Homes that are Low Income
PG&E	19.4%	66.3%
SCE	29.4%	38.0%
SDG&E	19.7%	42.0%
SCG	28.6%	41.9%

The 2020 model assumes low income customers are enrolled in CARE and thus receive a discount on their energy rates. Discount factors are presented in Table 3-20..

³⁹ Evergreen Economics. *Needs Assessment for the Energy Savings Assistance and the California Alternate Rates for Energy Programs*. 2016.

⁴⁰ California Public Utilities Commission. *Compliance Filing of Pacific Gas and Electrics (U 39-M), on behalf of itself, Southern California Gas Company (U 904-G), San Diego Gas and Electric Company (U 902-M), and Southern California Edison Company (U 338-E), Regarding Annual Estimates of CARE Eligible Customers and Related Information*. February 9, 2018.

⁴¹ <https://www.census.gov/programs-surveys/acs/>, accessed January 2019.

Table 3-20. Low Income Energy Rate Discounts

Fuel	Percent Discount	Data Source(s)
Electric	35%	<ul style="list-style-type: none"> http://www.cpuc.ca.gov/general.aspx?id=976 SDG&E: Rate class E-CARE states that in 2020 and beyond effective discount will be 35% Comparison of 2019 PG&E Rate class E-1 vs. EL-1 (CARE)
Natural Gas	20%	<ul style="list-style-type: none"> http://www.cpuc.ca.gov/general.aspx?id=976 SoCalGas 2019 GR-CARE Rate Class

3.4.2 Measure-Level Data

The measure list and measure-level data for the low income sector is adapted from the residential (non-low income) sector. Three key differences are accounted for:

- Measure applicability:** Only a subset of residential measures applies to the low income sector. The Navigant team removed measures not likely to be rebated or not historically rebated by ESA. Examples include ZNE whole building new construction, drain water heat recovery, ENERGY STAR TVs, cool roofs, and clothes dryers. A full list of which measures were included in the modeling of the low income sector can be found in the 2019 MICS database (described earlier in Section 1.6).
- NTG ratio:** ESA does not apply a NTG value; rather, it assumes a NTG of 1.0. Therefore, measures in the low income sector use a NTG of 1.0 rather than the deemed or evaluated NTG that applies to residential programs.
- Measure prevalence and efficiency:** Measure prevalence refers to the ownership levels of equipment in the low income sector relative to the broader residential population. Measure efficiency refers the saturation of efficient technologies in the low income sector relative to the broader residential population. Both items are described in greater detail in the rest of this section.

The Navigant team reviewed existing sources of low income residential market data and compiled key statistics about measure prevalence and efficiency. The Navigant team sought out the following two ratios for each of the measures as shown in Table 3-21..

Table 3-21. Low Income Ratio Descriptions

Ratio Type	Ratio Calculation	Example Description
Total Density Ratio	Total density among low income sample / total density among general population sample	A ratio of 75% means that low income customers are 25% less likely to own a thermostat than the general population. ⁴²
Baseline Saturation Ratio	Average existing equipment prevalence among low income sample / average existing equipment prevalence among general population sample	A ratio of 131% means low income households with thermostats are 31% more likely to own a manual thermostat (average existing case) than the general population.

⁴² In the case of a thermostat, lack of ownership implies the homeowner does not control the temperature setpoint in the building

The Navigant team obtained information for the two ratios by reviewing the following data sources:

- Data in the 2012 CLASS webtool⁴³
- 2013 Low Income Needs Assessment (LINA)⁴⁴
- ESA Program Multifamily Segment Study ⁴⁵

The Navigant team used data from the CLASS webtool as the primary source to develop the density and saturation ratios. The team referenced the 2013 LINA and ESA study for context, particularly to understand the population of low income households across California.

The CLASS webtool provides statistical summaries of lighting and appliance prevalence. Data are presented in terms of percentages (e.g., percentage of homes with at least one piece of equipment, percentage of equipment units that are within binned ranges of efficiency values) and averages (e.g., average SEER of cooling equipment).

The 2013 LINA study showed the average low income household has approximately three people, and the CARE guidelines limit income for a three-person household to \$41,560. Therefore, the Navigant team searched for households of three or less people with a maximum income of \$40,000 in the CLASS webtool to represent the low income population.

Table 3-22. summarizes the criteria that the Navigant team used to select and extract data from CLASS and divide that data into the low income population versus the general population.

Table 3-22. CLASS Filter Criteria Used to Extract Data

Data Subset	CLASS Filter Criteria
Income Group	
General Population	Total People in Home: Any
	Income: Any
Low Income	Total People in Home: 1, 2, 3
	Income: <\$20,000, \$20,000 to <\$30,000, \$30,000 to \$40,000
Home Type	
Single-Family	Type of Residence: Single-Family Detached, Apt 2-4 Units, Duplex (Single Story), Mobile Home, Townhouse/ Rowhouse (2-4 Unit Multi-Story)
Multifamily ⁴⁶	Type of Residence: Apt 5+ Units

The Navigant team multiplied the general population density and baseline saturation values by the low income ratios to calculate the low income total density and saturations. An example of this calculation can

⁴³ <https://webtools.dnvgl.com/projects62/Default.aspx?tabid=190>

⁴⁴ Evergreen Economics. *Needs Assessment for the Energy Savings Assistance and the California Alternate Rates for Energy Programs, Final Report (Study ID: SCE0342), Volume 2: Detailed Findings.* 2013 See p. 4-21.

⁴⁵ Cadmus and Research Into Action (2013). *ESA Program Multifamily Segment Study Report.*

⁴⁶ Note that some IOUs use a slightly different criteria for their multifamily upgrade programs.

be found in Table 3-23.. Note that Code and Efficient Base Year Efficiency saturations maintain the same relative proportions to each other as they do in the general population saturations.

Table 3-23. Low Income Total Density and Saturation Example

Technology Name	Base Year Efficiency	Total Density	Low Income Total Density Ratio	Low Income Total Density	Technology Saturation	Low Income Baseline Saturation Ratio	Low Income Saturation
Manual Thermostats	Average Existing	0.97	75%	0.73	46%	131%	61%
Programmable Thermostats	Code	0.97	75%	0.73	51%	-	37%
Smart Thermostats	Efficient	0.97	75%	0.73	3%	-	2%

The Navigant team focused on collecting data for measures in order of priority. Highest priority measures were initially determined as those that have collectively contributed to the top 80% of historic ESA program savings though additional measures that were added contribute large potential savings to non-low income programs.⁴⁷ Medium and low priority measures were those that were historically part of ESA but at lower savings/participation levels. Some measures did not have discernable low income versus general population data; for these measures, the team made proxy estimates of the above described ratios. Prioritization does not imply what programs do or should prioritize, but rather the Navigant team’s data collection prioritization process. Prioritization is listed in Table 3-24..

Table 3-24. Low Income Measure – Data Collection Prioritization

High Priority	Medium Priority	Low Priority
Air Conditioners	Clothes Dryers	Attic Duct Insulation
Ceiling/Roof Insulation	Clothes Washers	Crawlspace Duct Insulation
Faucet Aerators	Lighting Fixtures	Elec Water Heaters
Furnaces	Reflector Lamps	Freezers
Gas Water Heaters	Windows	Linear Fixtures
HVAC Quality Maintenance	Room AC	Lamps – Outdoor
Refrigerators	Specialty Lamps	
Screw-In Lamps – Indoor	Water Heating Controls	
Showerheads		
Wall Insulation		

3.5 Agriculture, Industrial, Mining, and Street Lighting Technology Characterization

The 2019 Study updated the AIMS sectors, with a heavy focus on the agriculture and industrial sectors and limited focus on the mining and street lighting sectors. The Navigant team’s approach to each sector’s data sources varied. The primary effort for agriculture and industrial focused on historical program data to directly relate measures developed for the PG Model to IOU program activities. The data approaches to mining and street lighting remain largely consistent with the 2015 Study, but the Navigant

⁴⁷ Historic ESA program savings obtained from annual reports for 2017 available at: <http://www.cpuc.ca.gov/iqap/>

team reviewed and updated the existing data with new and current sources in 2018, with no update for the 2019 Study. The following sections provide additional details about the development of data for the four AIMS sectors. Additional detail on the industrial and agriculture sectors and measures can be found in Appendix D.

3.5.1 Agriculture and Industrial Sectors

Navigant identified over 2,000 records⁴⁸ in the 2016 to Q3 2017 EESStats data associated with the agriculture and industrial sectors. The team refined this list of records, focusing on the high impact measures (i.e., those contributing significant amounts of energy savings) and excluded records with negligible savings contributions or those representing niche activities. Navigant then combined similar ProgramIDs into representative technology groupings based on the team’s familiarity with the industrial market.

During the 2017 Study, the Navigant team presented the list of initial representative technologies to stakeholders, seeking feedback on whether the list appropriately represented the two sectors and whether to add or delete any of the identified technologies. Stakeholders generally agreed with the overall approach to leveraging EESStats data. For the 2019 Study, the team continued to leverage the EESStats approach. The final technology list is broken into four categories and summarized in Table 3-25:

- Discrete **identified deemed** measures referred to as **characterized custom**, readily defined and forecast using the Bass diffusion model and custom savings estimates.
- **Generic custom** measures included in projects unique to various subsectors that cannot be readily defined at the measure level or forecast using a Bass diffusion model. Navigant describes the methodology used to characterize these generic custom measures in Section 3.6. Study measures that were marked as other or contributed up to 20% of the characterized custom list were included in this category.
- **Emerging technologies** measures are considered nascent or emerging technologies and cannot be readily defined at the measure level or forecast using a Bass diffusion model. Navigant describes the methodology used to characterize these generic custom measures in Section 3.6.
- **BROs or SEM** measures that include retrocommissioning (RCx) and some optimization. This measure is modeled with the BROs measures and cannot readily be forecast using a diffusion model as described in Section 2.1.1.

Table 3-25. AIMS Modeling Methodology

Categories	Model Approach	Applicability
Emerging Technologies	Top-down approach	Ag and Ind
BROS*	Top-down approach	Ag and Ind
Characterized Custom**	Bottom-up Bass diffusion approach	Ag, Ind, Street Lighting, and Mining
Generic Custom	Top-down approach	Ag and Ind

⁴⁸ Navigant defined a record as an EESStats program identification or ProgramID field—e.g., PGE21021 and measure group combination.

* SEM is modeled as the AIMS BROs measure by allocating the historical RCx as a proxy for SEM savings.

** Mining and street lighting only have characterized custom.

3.5.1.1 Agricultural and Industrial Characterized Custom

For the 2019 Study, the Navigant team characterized 17 technology groups for the agriculture sector and 14 for the industrial sector, representing the characterized custom measures for the diffusion model. These are sourced from the EEStats technologies. The industrial and agriculture sectors of this 2019 Study are informed by 122 unique measure groups sourced from EEStats. This approach provided consistency with the methods used in the residential and commercial sectors and allowed the modeling team to calibrate the PG Model using prior program achievements detailed in EEStats and establish greater confidence in the results.

3.5.1.2 Technology Characterization

The PG Model required characterizing technology-level inputs including UES, unit costs, and the saturation or density of efficient versions of each technology existing in the marketplace. The team mined data sources to complete a comprehensive characterization of the agriculture and industrial technologies.

- **Agricultural** data sources for measure characterization included EEStats, CPUC workpapers, and data provided by the IOUs. The team also relied on DEER for information on energy savings estimates by technology.
- **Industrial** data sources were similar to those mined for the agriculture sector, including EEStats and data provided by IOUs, the CPUC, and the CEC. For energy savings estimates, the team used the Industrial Assessment Center (IAC).⁴⁹

The team then weighted the results of each source and rolled them up to estimate the technology-level inputs. For most of the measures, Navigant leveraged California-specific resources, but when not applicable or available to certain measure types, the team used other peer group jurisdictions and substituted in California-specific variables where possible.⁵⁰

Energy savings. The Navigant team used data from the national IAC database to supplement EEStats data and inform the energy savings estimates for the industrial diffusion technologies. The IAC network consists of 24 universities that have completed over 16,000 industrial assessments at industrial facilities across the nation. Each assessment completed by the IAC includes detailed recommendations for improving energy consumption at a given site,⁵¹ the specific energy savings the site can expect by

⁴⁹ <https://energy.gov/eere/amo/industrial-assessment-centers-iacs>

⁵⁰ Other sources include the Pennsylvania TRM (http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx); the Illinois TRM (<http://www.ilsag.info/technical-reference-manual.html>); the Michigan Energy Measures Database (http://www.michigan.gov/mpsc/0,4639,7-159-52495_55129---,00.html); and the Wisconsin TRM (<http://dsmexplorer.esource.com/documents/Wisconsin%20-%2010.22.2015%20-%202016%20TRM.pdf>). See the Agriculture MICS for more detail on which measures these sources informed.

⁵¹ The IAC recommendations cover upgrades to inefficient equipment, the addition of energy-reducing technologies to existing equipment, and improvements to industrial processes through controls.

implementing such improvements, and the total energy each site currently uses. Navigant notes that the PG Model study efforts have relied on IAC data since 2011.

Navigant mapped all the unique IAC recommendations to the list of characterized custom industrial technologies created from the EESStats database. The team then used NAICS coding to sum the energy savings estimates for each technology to the entire industrial sector by building type and divided it by the total energy consumption for all buildings of that type. This provided the percentage each technology saves by building type across the entire industrial sector.⁵² The team followed this process for both electric (kWh) and gas (therm) consuming industrial measures.

The IAC database included robust, informative data for all but one industrial technology. The technology not included in the IAC but identified in EESStats is wastewater aerators. Wastewater aerators are listed as energy efficient aerators in the technology list and leverages an SCE workpaper for data.

Costs. Navigant primarily used the EESStats database to calculate the incremental cost per UES for technologies included in the industrial and agriculture analysis.⁵³ The team compared the 2016-Q3 2017 data with the previous 2017 Study to ensure the costs aligned since measure costs can be variable year over year and from project to project. The team multiplied the incremental cost per unit by the technology energy savings to estimate technology costs.

EUL and NTG. Navigant used the EESStats database to calculate the EUL and NTG ratios for all technologies included in the industrial technology list. The team compared this calculation across industrial and agricultural findings and the 2017 Study. Adjustments were made as necessary.

Saturations and Densities. Technology characterization requires data on the saturation of efficient technologies currently existing in the industrial marketplace. This provides a clearer picture of how much potential energy savings still exists by upgrading remaining baseline technologies within that marketplace. For industrial technologies analyzed using the IAC database, the team assumed that every recommendation made at an industrial facility meant that this facility still had the inefficient baseline technology installed. For example, if a facility received a recommendation to upgrade its lighting system, the team assumed that this facility still used inefficient or baseline lighting technologies. This assumption allowed the team to identify the percentage of sites with baseline equipment (i.e., those receiving a recommendation for a technology).⁵⁴ The team then used this baseline percentage as one of the variables for calculating the total sector savings available for each measure defined in the Energy Savings section above.

⁵² The final percentages of savings by building type are a nationwide value. The IAC data does not contain enough assessment data points to calculate these values on a state or region level with any degree of statistical confidence. Further, Navigant's vetting of IAC data during previous PG study efforts determined that national-level IAC data is representative of California industrial sector activities.

⁵³ The costs in EESStats include labor to represent the full incremental cost of implementation. The lighting end use relied on a cost per kWh consumed rather than cost per kWh saved because the team relied on commercial data for the industrial lighting end use measures.

⁵⁴ The IAC recommendations do not provide a density of efficient equipment in the marketplace because the inverse of the assumption regarding recommendations is not true (i.e., just because an industrial facility did not receive a recommendation does not mean it already had the efficient version of the recommendation installed).

For measures not covered in the IAC database, the team used professional judgement based on data sources such as commercial sector saturation data and feedback from stakeholders to estimate a density of efficient versus inefficient technology.

3.5.2 Mining Sector

The 2019 Study approach and data inputs are unchanged from the 2017 Study. The Navigant team defined the mining sector inputs using a bottom-up approach consistent with the other AIMS sectors. The team sourced data from several sources including region-specific information on oil and gas extraction activities from the California Department of Conservation.⁵⁵ This data provided the number of active and idle wells, the amount of oil and water produced from wells, the amount of steam and hot water generated for mining operations, and the number new wells created.⁵⁶

The Navigant team also used consumption data from the CPUC and other secondary sources, including IOU program data and industry-specific reports and studies. These sources inform estimates for energy savings, costs, EUL, and NTG. Navigant also updated select model inputs such as equipment stocks, sector consumption, and efficient equipment saturations.

3.5.3 Street Lighting Sector

Like the mining sector, the PG Model and the updates for the 2018 street lighting effort rely on the inputs established in previous studies.⁵⁷ The team also used a bottom-up approach to define sector inputs. Information provided directly by the IOUs served as the primary basis for street lighting inputs, specifically the inventories of customer-owned and IOU-owned street lights included in the LS-1 and LS-2 rate classes.⁵⁸ The PG Model outputs reflect potential energy savings associated only with customer-owned lamps (LS-2 rate schedule). However, Navigant gathered data on IOU-owned lamps (LS-1 rate schedule) to aid with data vetting and quality control as well as initial saturation levels.

The IOU street lighting inventories inform several model inputs including equipment stocks, densities, and efficient equipment saturations. The Navigant team also relied on secondary sources to update equipment costs. The team revised cost forecasts for LEDs with information from the DOE's Solid-State Lighting program.⁵⁹

This study includes an update on the initial saturation of street lights per the IOU data of installed street lighting. Additionally, the team indicated that LED becomes standard practice baseline in 2019. As a result, savings from LED lamps do not appear in the forecast period and only one measure remains for this sector: advanced lighting controls.

⁵⁵ <http://www.conservation.ca.gov/dog>

⁵⁶ http://www.conservation.ca.gov/dog/pubs_stats/annual_reports/Pages/annual_reports.aspx

⁵⁷ <http://www.cpuc.ca.gov/General.aspx?id=2013>

⁵⁸ Example from SCE: <https://www.sce.com/NR/sc3/tm2/pdf/ce37-12.pdf>

⁵⁹ 2014 report: <https://energy.gov/sites/prod/files/2015/05/f22/energysavingsforecast14.pdf>; 2016 report: https://energy.gov/sites/prod/files/2016/10/f33/energysavingsforecast16_0.pdf

3.6 Industrial and Agriculture Custom Technologies Data Sources

Generic custom measures in the industrial and agriculture market sectors are projects that tend to be specific to an industry segment or production method. Generic custom measures are often listed by non-descript names such as Process-Other in publicly reported IOU tracking data,⁶⁰ and they present several challenges within a potential forecast:

- Having unique attributes that make them difficult to forecast within the diffusion-based PG Model
- Being unlikely to saturate over time due to continual process changes in the industrial and agricultural sectors
- Often consisting of emerging technologies that are in the early adoption phase, with little to no engineering details, market parameters, or workpapers

As discussed further in Appendix F, for the 2019 Study the definition of generic custom measures was revised from the 2017 Study to account for the following:

- A large number of measures that are defined but where any one measure contributes only a small percentage of portfolio savings (e.g., faucet aerator or HVAC controls) are now included in the generic custom measure class.
- The 2019 model separated out RCx savings from generic custom savings and considered RCx to be part of SEM savings.
- The agricultural sector forecast is also affected because the definition of which NAICS codes are to be included in the agricultural sector was redefined for the 2019 model to better align with the IEPR agricultural sector definition.

The 2019 model treats generic custom measures as a specific measure class. Table 3-26. provides the inputs for electricity and natural gas for these measures, and additional discussion follows the table. Navigant provides separate UES estimates for the industrial and agricultural market sectors. The team calculated the EUL for these measures at 15 years since most savings come from larger capital investments with long operating lives. Appendix F provides additional details on the generic custom analysis and forecast methodology.

Table 3-26. Generic Custom Measures – Key Assumptions

Sector	Type	EUL Years	Savings Range		Cost		kW/kWh Savings Ratio
			kWh	therm	kWh	therm	
AIMS	Generic Custom	15	0.09% (Ind) 0.20% (Ag)	0.13% (Ind) 0.9% (Ag)	\$0.33	\$2.25	0.0002

⁶⁰ Generic custom also includes a large number of discrete measures that each contribute a small amount of savings and collectively account for less than ~10% of sector savings.

The Navigant team estimated savings based on building type consumption (kWh or therms/year); however, since these technologies are forecast as a single class of measure, savings do not vary by market segment or IOU. Navigant based generic custom savings in the 2019 Study on an analysis of data available through the California EEstats portal⁶¹ for programs operating from 2013 through 2017. Data for these program years provided the level of detail necessary to separate generic custom measures from RCx and other custom measures that could be defined and modeled using a Bass diffusion approach. Table 3-27. summarizes the generic custom savings contribution to the overall sector when accounting for the removal of RCx from generic custom and the addition of the large number of smaller measures now considered part of the generic custom measure class.

Table 3-27. Generic Custom Contribution as a Percentage of Sector Savings

Sector	Electricity	Gas
Industrial	22%	49%
Agricultural	35%	41%

Based on this analysis and sector-level consumption forecasts provided by the CEC, Navigant determined that generic custom measures would save roughly 0.09% and 0.13% of annual industrial sector electricity and natural gas usage, respectively. Using a similar methodology, Navigant forecast savings from generic custom measures in the agricultural sector at 0.20% of annual electricity consumption and 0.09% of annual gas usage. These percentages are used in both the reference or aggressive cases and remain constant throughout the forecast horizon.

Navigant based costs for electricity and natural gas savings on an analysis of industrial and agricultural programs operating in California and across the nation throughout 2016, which did not vary significantly through 2017. They are estimated at \$0.33/kWh and \$2.25/therm, and are applied consistently across sectors and utilities throughout the 2019 Study forecast horizon.

Applicability and penetration rate are key inputs to the savings forecast. Applicability of generic customer measures in the industrial and agricultural sectors is 100% because these measures are considered ubiquitous to all activities in all market segments. The approach to forecasting the penetration rate for generic custom measures changed for the 2019 Study. In the 2017 Study (and prior years), penetration rates were held constant over the forecast horizon under the assumption that industrial facilities continually upgrade equipment and processes and, therefore, generic custom measures would be installed at the same rate as past program activity. Based on an analysis of EEstats data from 2013 through 2017, it was determined that generic custom savings are decreasing over time after separating out the contribution from RCx. As such, the penetration rate for generic custom was revised to show an annual decrease of approximately 2.1%.

3.6.1 Emerging AIMS Technologies

New emerging technologies to reduce energy use and energy demand are continually being introduced in the California marketplace. The 2019 Study is an update to the approach used for the 2017 Study. For

⁶¹ <http://eestats.cpuc.ca.gov/Default.aspx>

the 2017 Study, the Navigant team identified approximately 1,100 potential emerging technologies. These emerging technologies were run through a screening process to rate energy technical potential, energy market potential, market risk, technical risk, and utility ability to impact market adoption. This process yielded 169 emerging technology processes⁶² for final consideration within the model. For the 2019 Study, the team reviewed the data sources used in the 2017 Study to include measures that might have been added since the initial review and updated measures originally identified for which there might be more recent data. For a summary of the emerging technology literature reviewed and details on the screening process and how it was used to define subsector potential, see Appendix F.

Table 3-28. summarizes the resulting savings and cost factors; additional discussion follows the table. Navigant applied segment-specific electric and gas savings, as well as costs, EUL, and the kW/kWh savings ratio consistently across all utilities.

Table 3-28. Emerging Technologies – Key Assumptions

Sector	Type	EUL Years	Savings Range (Percentage of Building Energy Consumption)		Cost		kW/kWh Savings Ratio
			kWh	therm	kWh	therm	
AIMS	Emerging Technologies	10	0.93% - 9.62%	0.0% - 14.21%	\$0.42	\$2.83	0.000195

The model uses a universal EUL of 10 years to accommodate the broad range of emerging technology adoption curves. Similarly, a universal 0.000195 ratio of kW to kWh was applied to all three electric utilities. This is the same value used for SEM, and it is based on an analysis of several third-party SEM programs operating in California during the 2014-2015 portfolio cycle. Actual emerging technology-specific EULs and kW/kWh are presently unknown and can be refined during future emerging technologies market studies as additional information becomes available.

The Navigant team estimated costs for electricity and natural gas emerging technologies savings based on an analysis of industrial and agricultural programs operating throughout 2016. Costs for electricity and natural gas savings are estimated at \$0.42/kWh and \$2.83/therm and are applied consistently for all utilities and across all industrial and agricultural sectors. Additional information on the methodology used to derive UES values and costs for emerging technologies measures can be found in Appendix F.

In determining applicability, emerging technologies apply to different industrial and agricultural sectors in varying degrees, and the Navigant team assessed segment-specific technology applicability during the screening process. For emerging technologies that were determined to be feasible at the segment level, a UES estimate was completed for each emerging technology that includes adjustment for applicability. As such, the team assigned each sector a 100% applicability in the forecast model with the understanding that applicability was considered during the screening process and is embedded in the UES value for each emerging technology.

Adoption of future emerging technologies will vary by technology. Some emerging technologies will gain widespread customer acceptance and capture broad market share based on price, energy savings, and other customer-driven factors, while other emerging technologies will see a more limited adoption.

⁶² The emerging technologies represent a process for reducing energy consumption and not necessarily a specific technology.

Although the team assigned unique risk factors to each new technology during the screening process, it is impossible to definitively predetermine which technology will be successful. Therefore, the model considers all emerging technologies in aggregate and applies a consistent participation rate to all emerging technologies. As such, penetration forecasts for both the industrial and agricultural sectors begin with a saturation level of 0.1% for the reference case and follow a compound annual growth rate of 3.25%, yielding a target saturation of 8.6% by 2030. The 2030 target saturation of the portfolio of AIMS-relevant emerging technologies is an estimate that acknowledges the timeline over which new technologies move through the adoption cycle to reach 80% saturation (typically ranging from 10 to 30 years), and the relatively slow turnover of the diverse set of production equipment associated with many industrial processes.

3.7 Codes and Standards

C&S modeled in the PG study use data from multiple sources. For evaluated C&S, the study uses ISSM⁶³ as its data source. For unevaluated C&S, the study uses data provided by California IOUs via a formal data request.⁶⁴ For all other future C&S, the study uses additional data and information provided by the CEC along with additional assumptions made by the Navigant team.

Table 3-29. lists the number and type of C&S and their data source. A full list of the modeled C&S, their compliance rates, effective dates, and policy status (on the books, possible, or expected)⁶⁵ are listed in Appendix E.

⁶³ Cadmus and DNV GL. *Integrated Standards Savings Model (ISSM)*. 2017.

⁶⁴ PG&E, SCE, SDG&E, and SCG all responded to the data request on February 4, 2019.

⁶⁵ **On the books:** A code or standard that has been passed into law.

Expected: A code or standard that is in development.

Possible: A code or standard that is not actively being developed, but other policy guidance suggests these should be the next logical C&S to be developed.

Table 3-29. C&S Data Source Summary

IOU C&S Group	Number and Type of Codes and Standards	Data Source
2005 Title 20	22 appliance standards	ISSM
2006-2009 Title 20	13 appliance standards	ISSM
2011 Title 20	4 appliance standards	ISSM
Unevaluated Title 20	20 appliance standards	IOU data request
Future Title 20	6 appliance standards	CEC input and Navigant team estimates
Evaluated Federal	26 appliance standards	ISSM
Unevaluated Federal	14 appliance standards	IOU data request
Future Federal	12 appliance standards	CEC input and Navigant team estimates
2005 Title 24	19 building codes	ISSM
2008 Title 24	22 building codes	ISSM
2013 Title 24	46 building codes	ISSM
2016 Title 24	12 building codes	IOU data request
2019 Title 24	40 building codes	IOU data request
2022-2029 Title 24	6 building codes	CEC input and Navigant team estimates

Sources: Cadmus and DNV GL. ISSM. 2017.; IOU data request; California Energy Commission

The 2017 Study made several adjustments to the data obtained:

- An uncertainty factor of 80% was applied to all unevaluated C&S.
- Per guidance from Cadmus (the previous C&S evaluator), several 2013 Title 24 codes were removed from the analysis because their savings were already included in Whole Building codes.⁶⁶

For 2013 Title 24, ISSM provides the option to use either bounded or unbounded energy savings adjustment factors (ESAF), which are analogous to compliance factors for appliance standards.⁶⁷ Unbounded refers to the case where a building, project, or measure can consume less energy than the level established by the current Title 24 code, resulting in an ESAF greater than 100%. Bounded refers to limiting the ESAF values to a maximum of 100%. The 2017 Study uses bounded values from the ISSM.

The 2019 Study determined new energy savings estimates for future Title 24 codes beyond the 2019 vintage including the 2022, 2025, and 2028 cycles for the commercial sector.⁶⁸ Personal communication

⁶⁶ Cadmus and DNV GL. California Statewide Codes and Standards Program Impact Evaluation Phase Two, Volume Two: 2013 Title 24. August 2017.

⁶⁷ Cadmus and DNV GL. California Statewide Codes and Standards Program Impact Evaluation Phase Two, Volume Two: 2013 Title 24. August 2017.

⁶⁸ The future Title 24 codes were not considered in the 2017 Study forecast due to the highly uncertain nature of their savings. The Navigant team notes that these future savings are still highly uncertain. While California has a goal of all new commercial construction to be ZNE by 2030, the regulatory path toward requiring this by 2030 is uncertain.

with staff at the CEC provided insight on the path between 2019 Title 24 and 2028 Title 24, as illustrated Table 3-30..

Table 3-30. Progression of Commercial T24

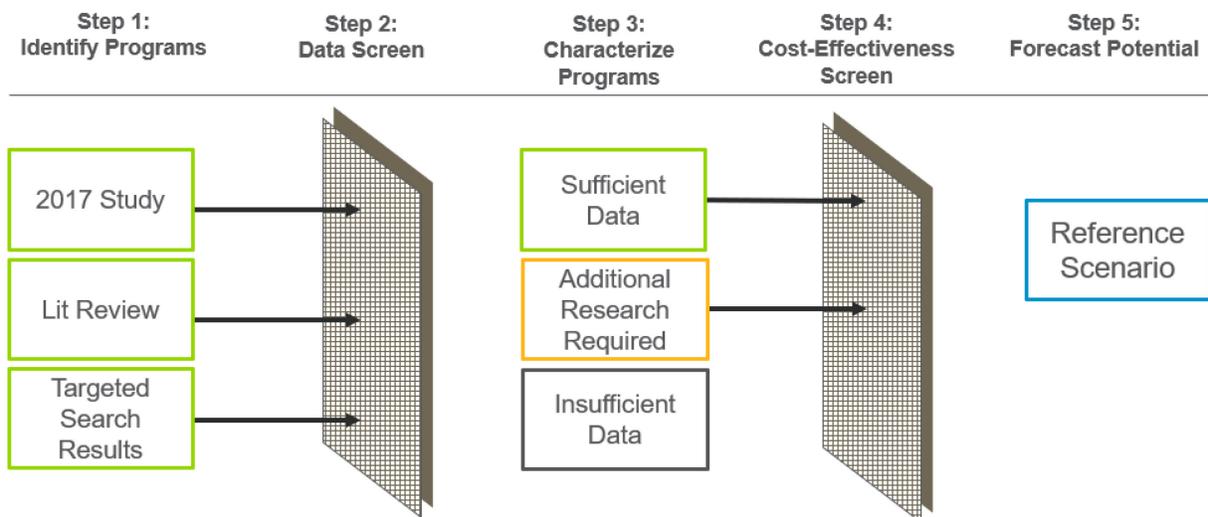
Title 24 Code Cycle	Cumulative Percentage of 2028 Savings Target	Incremental Savings toward 2028 Target
2016	0%	-
2019	33%	33%
2022	50%	17%
2025	67%	17%
2028	100%	33%

Navigant scaled 2019 Title 24 claimed savings based on the last column in Table 3-30. to develop estimates of savings for the 2022-2028 Title 24. NOMAD factors for 2022-2028 Title 24 were adapted from 2019 Title 24 and time-shifted to an appropriate start date.

3.8 BROs Energy Efficiency

To forecast customer behavioral energy savings, the Navigant team considered a wide range of behavioral intervention types for both residential and commercial customers. Because this is an uncertain area that has been getting a lot of interest from the industry and was called out in AB802 and SB350 as an emerging area for increased opportunities given NMEC, the team cast the net wide in consideration of interventions. Figure 3-3 illustrates the five-step selection process used to determine intervention types to include in the reference case scenario.

Figure 3-3. Selection Process for Residential and Commercial BROs EE Programs



Step 1: Identify programs. The first step was to identify general program categories and then to conduct a literature review to identify specific programs. The team augmented its existing knowledge base drawn

from the 2017 Study with additional findings from numerous evaluations and research studies, as well as findings from the Consortium for Energy Efficiency Database, American Council for an Energy-Efficient Economy, and various other secondary research sources. Once appropriate utility programs had been identified, the team sought out formal evaluation findings wherever possible—particularly evaluations of programs run the California IOUs—as well as other commissioned original research studies.

Step 2: Screen data. Potential programs were then organized by intervention type and screened to ensure sufficient data. This initial literature review captured all available data, including utility, program name, state, number of years, number of participants per year, participant type, participation rates, eligibility considerations, energy savings, persistence, and cost. Because findings were obtained from many sources, data was inconsistently reported and thus apples-to-apples comparisons were not always possible.

Step 3: Characterize interventions. Behavioral interventions were ultimately included in the model when a sufficiency of data was available for five primary modeling inputs:

- kWh savings
- therm savings
- Participation rates
- Persistence
- Cost

While savings and participation rates were generally readily available from formal EM&V evaluations, cost data was more often scarce. So, in some cases, the team extrapolated or estimated based on a limited number of data points.

The Navigant team calculated penetration rates based on relevant EM&V-reported program participation rates for current California IOU program offerings and reported participation in programs in other states.

The team modeled an EUL of 1 year for residential programs. Commercial programs used a 2- or 3-year EUL per CPUC Decision 16-08-019, unless evidence supported a longer duration.

Specific modeling inputs for each intervention type are discussed in detail in Appendix C.

Step 4. Cost-effectiveness screen. The C-E screen used the TRC test and the latest CPUC-approved avoided costs for each utility. This screen was used to inform the team if measures should be removed from the reference case. Even programs that were not cost-effective are included in the aggressive scenario as an indication of the data available on the potential of these programs.

Step 5. Forecast potential. The forecasts are the result of professional judgement based on program operations and whether participation is utility driven (opt out) or customer driven (opt in). The forecast penetration rates were adjusted to represent a reference scenario and an aggressive scenario.

Many intervention types were characterized to forecast potential. A more detailed description of each of the final intervention types follows in Table 3-31.; additional details can be found in Appendix C.

Table 3-31. Behavioral Intervention Summary Table

Sector	Type of Behavioral Intervention	Brief Description	EUL (Years)
RES	HERs	Residential customers are periodically mailed HERs that provide feedback about their home’s energy use, including normative comparisons to similar neighbors, tips for improving EE, and occasionally messaging about rewards or incentives.	1
RES	Web-Based Real-Time Feedback	Real-time information and feedback about household energy use provided via websites or mobile apps.	1
RES	In-Home Display Real-Time Feedback	Real-time information and feedback about household energy use provided via energy monitoring and feedback devices installed in customer homes.	1
RES	Small Residential Competitions	Small residential competitions are organized competitions with fewer than 10,000 participants per year 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.	1
RES	Large Residential Competitions	Large residential competitions are organized competitions with more than 10,000 participants per year 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.	1
RES	Universal Audit Tool	The Universal Audit Tool (UAT) is an opt-in online tool that asks residential customers questions about their homes, their use of household appliances, and occupancy patterns and then it offers EE advice regarding ways they can save money and energy.	1
COM	Commercial Competitions	Commercial competitions are organized competitions between cities, businesses, or tenants in multi-unit buildings in which participants compete in events, contests, or challenges to achieve a specific objective or the highest rank compared with other groups as they try to reach goals by reducing energy consumption.	2
COM	Business Energy Reports (BERs)	BERs are periodically mailed to small and medium size businesses to provide feedback about their energy use, including normative comparisons to similar businesses, tips for improving EE, and occasionally messaging about rewards or incentives.	2
COM	Building Benchmarking	Building benchmarking scores a business customer’s facility or plant and compares it to other peer facilities based on energy consumption. It also often includes goal setting and rewards in the form of recognition. ⁶⁹	2

⁶⁹ Stakeholders informally commented that building benchmarking may not be claimable by IOU programs given benchmarking is required by AB802. However, no data/policy was cited as definitively disallowing IOUs from claiming savings from benchmarking programs. Therefore, the Navigant team continues to include it in the potential forecast for this report.

Sector	Type of Behavioral Intervention	Brief Description	EUL (Years)
COM/IND/AG	Strategic Energy Management (SEM)	SEM is a long-term continuous improvement process that educates and trains business energy users to develop and execute long-term energy goal setting and strategic planning and to integrate energy management into business practices throughout the organization—from the corporate board office to the boiler room and the work floor. It can include consulting services, customized training, benchmarking and measurement, feedback, data analysis, and performance review.	5
COM	Building Energy Information Management Systems (BEIMS)	BEIMS enable building operations staff to achieve significant energy savings by monitoring, analyzing, and controlling building system performance and energy use. BEIMS can include benchmarking and utility bill tracking software, energy information systems (EIS), building automation systems, fault detection and diagnostic tools, and automated system optimization software, as well as value-added services and contracts.	3
COM	Building Operator Certification	Building operator certification trains and educates commercial building operators about how to save energy by encouraging them to adopt energy efficient behaviors and make building changes that reduce energy use.	3
COM	Retrocommissioning	Commissioning is a whole building systems approach to improving an existing building's performance by identifying and implementing operational improvements to save energy and increase comfort. Retrocommissioning refers to commissioning a building that has not previously been commissioned. This program also includes recommissioning, or commissioning a building that has been commissioned at least 5 years prior.	3

3.8.1 Data Rigor

Navigant conducted an extensive industry scan for data on BROs initiatives and found that many of these programs are relatively new and much learning about their effectiveness is ongoing. The published data spans a wide range in the rigor of analysis conducted on the data around energy savings resulting from these interventions. Table 3-32. provides a snapshot of the quality of data collected for this study. Across the board, demand savings data is often limited and cost data is hard to obtain. Penetration forecasts are the most uncertain because of limited historic penetration rates upon which to base a forecast.

The Navigant team recommends the industry consider pilot studies along with measurement and verification to provide better data to future potential studies. Interventions that literature claims to show large promise though limited verified data exists include prepay programs, SEM, building benchmarking, competitions, web-based feedback, and in-home real-time feedback.

Table 3-32. Qualitative Assessment of Data Quality

Sector	Program	Savings			Cost	Applicability	Participation Rate	Penetration Forecast	Data Updates
		kWh	therms	kW					
Residential	Audits ¹	●	●	●	⊗	●	●	●	✓
	Home Energy Reports	●	●	●	●	●	●	●	✓
	In Home Display RT Feedback	○	○	⊗	○	●	⊗	⊗	
	Web-Based Real-Time Feedback	○	○	⊗	●	●	●	●	
	Small Residential Competitions	○	○	⊗	○	●	○	⊗	
	Large Residential Competitions	●	●	⊗	○	●	●	⊗	
Commercial	Building Operator Certification	●	●	⊗	⊗	●	⊗	⊗	
	Business Energy Reports	●	●	⊗	⊗	●	⊗	⊗	
	BEIMS	●	●	●	●	●	●	⊗	✓
	Commercial Competitions	●	●	⊗	○	⊗	●	⊗	
	Strategic Energy Management	○	⊗	⊗	⊗	●	⊗	⊗	✓
	Building Benchmarking	○	○	⊗	●	●	⊗	⊗	✓
Retrocommissioning	●	●	●	●	●	●	⊗	✓	
Legend									
●	California program data and its derivatives								
○	Aggregated reports and non-verified savings reported by utilities outside of California								
⊗	Assumed equivalence to similar programs or other forms of professional judgment								
✓	Indicates that inputs for this program have new data available since the 2018 Potential and Goals Study								
NA	The majority of prepay programs reviewed were electric programs. While some gas programs exist, savings were excluded due to data insufficiency.								

¹ Program is newly added in the 2020 Potential & Goals Study.

4. 2019 STUDY RESULTS

The results of past potential studies have been used by policymakers as a technical foundation to set savings goals for the next regulatory cycle. The 2019 Study is the foundational basis for the CPUC’s 2020 and beyond EE goal setting process. Table 4-1 provides a summary of key findings from this study and the potential implications of each finding.

Table 4-1. 2019 Study Key Findings and Implications

 Key Finding	 Implication
1. Savings for non-residential lighting measures are substantially reduced relative to the 2017 Study.	IOUs should identify additional non-residential lighting opportunities and maintain their program offerings to harvest the remaining savings potential through accelerated replacement programs.
2. Gas savings are substantially reduced relative to the 2017 Study.	Despite decreases, the study still shows gas EE potential which will enable California to progress toward its statewide decarbonization goals.
3. Higher TRC benefit-cost thresholds reduce overall savings potential.	Based on scenario results, maintaining a 1.0 TRC cutoff at the measure-level results in an overall cost-effective portfolio, suggesting that it is not necessary for the CPUC to set the highest cutoff.
4. The combined effect of various EE policies limits the overall market potential.	IOUs and program administrators should broaden their program designs to target as many savings opportunities highlighted in this study as possible.
5. This study identifies new measures that have limited proven experience in the marketplace.	The industry should roll out pilots and demonstrations to expand the available data and better inform future programs that highlight emerging interventions.
6. The savings potential from C&S measures represents a significant portion of the potential highlighted in this study.	The industry should continue and enhance the evaluation of C&S advocacy efforts to ensure accuracy of savings forecasts and support the development of new C&S.
7. Adjustments to non-financial factors such as consumer awareness and education appear to lead to larger savings potential.	IOUs and program administrators should consider revamping their marketing and outreach efforts to target pockets of savings potential not previously considered.

4.1 Incentive Program Savings

The following subsections summarize statewide market potential results. These results are for all IOUs combined. The IOU breakdown for these savings can be found in the results viewer that accompanies this report (see Section 4.3 for details). All results are presented as net savings; all statewide results are inclusive of interactive effects. Note that the purpose of this report is to present the findings of the Navigant team’s potential study and not to establish goals—that is under the purview of the CPUC. As such, the scenario comparisons presented in the following subsection are meant to illustrate a range of potential that can be achieved based on the team’s study.

Figures in this section focus on electric and gas savings. Peak demand savings are not illustrated, though they are quantified by the model. Full results for all scenarios and all utilities are available in the results viewer (discussed further in Section 4.3).

4.1.1 Total Savings and Spending by Scenario

Table 4-2. through Table 4-4 show the total incremental market potential from all savings sources by scenario. A few important notes about these results:

- Equipment rebate program savings, which include savings from discrete equipment, whole building, and shell measures, are different for each scenario based on parameters discussed earlier in Section 2.3. Additional discussion of the variation in rebate program savings by scenario can be found in Section 4.1.3
- BROs savings vary only in terms of reference versus aggressive. Thus, BROs savings only have two possible forecasts across the five scenarios. Additional discussion of the variation in BROs savings by scenario can be found in Section 4.1.4.
- C&S savings do not vary by scenario.
- Low income savings varies only slightly across scenarios.

Total savings are led by C&S. Because C&S savings do not vary by scenario, the overall variability in total savings may appear minimal. True variability in savings originates from equipment rebate programs and BROs.

Versions of the following tables for each IOU can be found in Appendix H.

Table 4-2. Statewide Net Incremental Electric Energy Savings (GWh/Year) by Scenario

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	371	453	493	488	495	489	458	442	430	396	393
BROs	427	463	496	531	565	598	631	666	703	742	782
Low Income	55	58	59	58	52	48	43	32	30	29	27
Incentive Programs (Subtotal)	853	974	1,048	1,077	1,113	1,135	1,132	1,140	1,163	1,167	1,202
C&S*	1,415	1,427	1,402	1,409	1,340	1,293	1,205	1,121	1,005	875	742
Total	2,269	2,401	2,451	2,486	2,452	2,429	2,337	2,261	2,168	2,042	1,945
PG Alternative Scenario 1											
Equipment Rebates	438	528	539	529	532	527	494	478	462	419	414
BROs	427	463	496	531	565	598	631	666	703	742	782
Low Income	55	58	59	58	52	48	43	32	30	29	27
Incentive Programs (Subtotal)	921	1,049	1,094	1,118	1,150	1,173	1,168	1,176	1,194	1,190	1,223
C&S*	1,415	1,427	1,402	1,409	1,340	1,293	1,205	1,121	1,005	875	742
Total	2,336	2,476	2,497	2,527	2,490	2,467	2,373	2,296	2,200	2,065	1,965
PG Alternative Scenario 2											
Equipment Rebates	328	414	432	432	442	444	421	411	408	376	374
BROs	427	463	496	531	565	598	631	666	703	742	782
Low Income	55	58	59	58	52	48	43	32	30	29	27
Incentive Programs (Subtotal)	811	935	987	1,021	1,060	1,091	1,095	1,108	1,141	1,147	1,183
C&S*	1,415	1,427	1,402	1,409	1,340	1,293	1,205	1,121	1,005	875	742
Total	2,226	2,362	2,390	2,430	2,400	2,384	2,300	2,229	2,147	2,022	1,925
PG Alternative Scenario 3											
Equipment Rebates	382	466	506	499	502	494	461	444	432	397	395
BROs	515	562	618	674	748	826	889	962	1,050	1,153	1,277
Low Income	59	62	63	56	52	48	37	32	31	29	28
Incentive Programs (Subtotal)	957	1,091	1,187	1,229	1,302	1,367	1,387	1,438	1,512	1,579	1,699
C&S*	1,415	1,427	1,402	1,409	1,340	1,293	1,205	1,121	1,005	875	742
Total	2,372	2,518	2,590	2,638	2,642	2,661	2,591	2,559	2,517	2,454	2,441
PG Alternative Scenario 4											
Equipment Rebates	473	561	573	559	558	548	513	496	478	432	426
BROs	515	562	618	674	748	826	889	962	1,050	1,153	1,277
Low Income	59	62	63	56	52	48	37	32	31	29	28
Incentive Programs (Subtotal)	1,048	1,186	1,255	1,289	1,357	1,422	1,438	1,490	1,558	1,614	1,731
C&S*	1,415	1,427	1,402	1,409	1,340	1,293	1,205	1,121	1,005	875	742
Total	2,463	2,613	2,657	2,698	2,697	2,715	2,643	2,611	2,563	2,489	2,473

*Includes interactive effects

Table 4-3. Statewide Net Incremental Demand Savings (MW) by Scenario

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	82	96	99	95	96	96	91	89	88	83	83
BROs	77	83	89	96	102	108	114	120	127	134	141
Low Income	38	40	39	37	33	30	27	21	20	19	19
Incentive Programs (Subtotal)	197	219	227	228	231	234	232	231	235	236	242
C&S*	287	299	296	308	296	287	269	253	229	209	189
Total	483	518	523	536	528	520	502	484	464	446	431
PG Alternative Scenario 1											
Equipment Rebates	98	118	116	112	111	111	106	103	100	93	92
BROs	77	83	89	96	102	108	114	120	127	134	141
Low Income	38	40	39	37	33	30	27	21	20	19	19
Incentive Programs (Subtotal)	213	241	245	244	247	249	247	244	247	246	251
C&S*	287	299	296	308	296	287	269	253	229	209	189
Total	499	540	541	553	543	536	516	498	477	456	440
PG Alternative Scenario 2											
Equipment Rebates	72	88	88	86	87	88	84	83	84	79	79
BROs	77	83	89	96	102	108	114	120	127	134	141
Low Income	38	40	39	37	33	30	27	21	20	19	19
Incentive Programs (Subtotal)	187	211	217	219	222	226	225	224	231	232	238
C&S*	287	299	296	308	296	287	269	253	229	209	189
Total	473	510	512	527	518	512	495	478	460	441	427
PG Alternative Scenario 3											
Equipment Rebates	84	98	100	97	97	97	92	90	89	84	83
BROs	91	100	110	120	131	143	153	166	181	199	220
Low Income	41	42	41	37	33	31	25	22	21	20	19
Incentive Programs (Subtotal)	216	240	252	253	261	270	271	278	291	302	322
C&S*	287	299	296	308	296	287	269	253	229	209	189
Total	502	539	548	561	558	556	540	531	520	511	511
PG Alternative Scenario 4											
Equipment Rebates	104	124	123	117	116	115	110	107	103	95	93
BROs	91	100	110	120	131	143	153	166	181	199	220
Low Income	41	42	41	37	33	31	25	22	21	20	19
Incentive Programs (Subtotal)	237	266	274	273	280	289	288	294	305	314	332
C&S*	287	299	296	308	296	287	269	253	229	209	189
Total	523	566	570	582	577	575	558	548	534	523	521

*Includes interactive effects

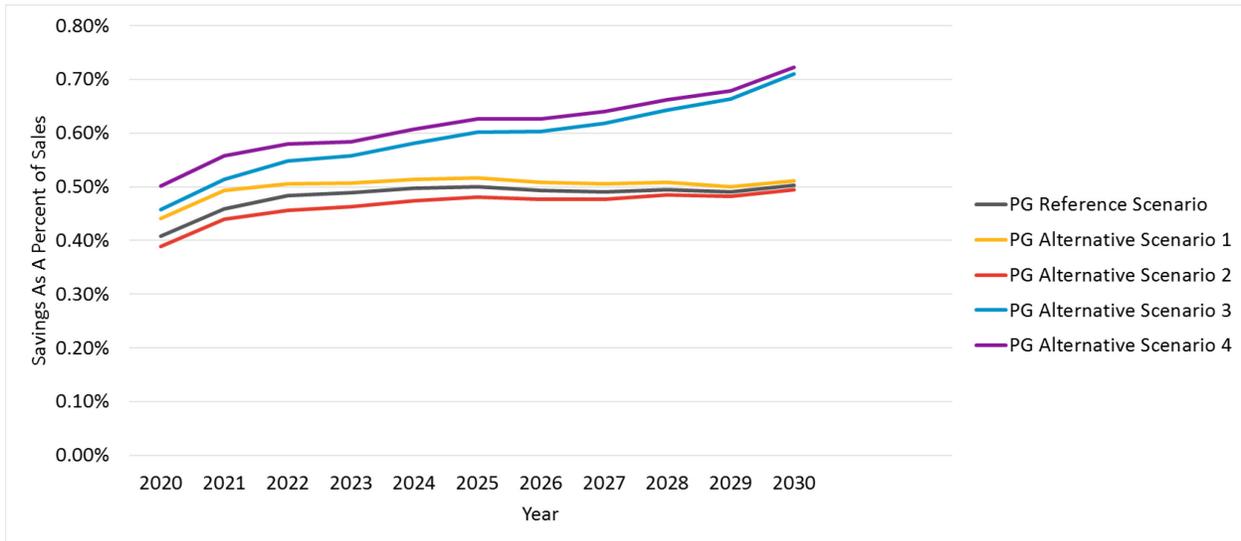
Table 4-4. Statewide Net Incremental Gas Energy Savings (MMtherm/Year) by Scenario

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	11.3	13.4	16.6	17.5	16.7	16.1	15.0	14.6	14.1	13.6	15.1
BROs	16.5	17.3	18.0	18.7	19.5	20.3	21.1	22.0	23.0	24.0	25.2
Low Income	6.5	6.6	5.1	5.0	4.9	4.8	4.7	4.6	4.4	4.3	4.2
Incentive Programs (Subtotal)	34.4	37.3	39.7	41.2	41.2	41.2	40.8	41.2	41.5	41.8	44.4
C&S*	36.3	36.9	37.2	38.1	39.6	38.5	31.9	28.5	26.5	23.3	23.5
Total	70.7	74.3	76.9	79.3	80.8	79.7	72.7	69.7	67.9	65.2	67.9
PG Alternative Scenario 1											
Equipment Rebates	18.6	20.2	19.6	18.7	18.0	20.3	18.9	18.1	18.5	17.0	17.7
BROs	16.5	17.3	18.0	18.7	19.5	20.3	21.1	22.0	23.0	24.0	25.2
Low Income	6.5	6.6	5.1	5.0	4.9	4.8	4.7	4.6	4.4	4.3	4.2
Incentive Programs (Subtotal)	41.6	44.1	42.7	42.3	42.4	45.4	44.8	44.7	45.9	45.2	47.1
C&S*	36.3	36.9	37.2	38.1	39.6	38.5	31.9	28.5	26.5	23.3	23.5
Total	78.0	81.1	79.9	80.5	82.0	83.9	76.7	73.2	72.3	68.6	70.5
PG Alternative Scenario 2											
Equipment Rebates	8.9	10.1	9.6	9.9	10.3	10.2	12.1	12.1	13.1	12.8	13.9
BROs	16.5	17.3	18.0	18.7	19.5	20.3	21.1	22.0	23.0	24.0	25.2
Low Income	6.5	6.6	5.1	5.0	4.9	4.8	4.7	4.6	4.4	4.3	4.2
Incentive Programs (Subtotal)	32.0	34.0	32.7	33.6	34.7	35.3	37.9	38.6	40.4	41.0	43.2
C&S*	36.3	36.9	37.2	38.1	39.6	38.5	31.9	28.5	26.5	23.3	23.5
Total	68.3	71.0	69.9	71.7	74.3	73.8	69.9	67.2	66.9	64.4	66.7
PG Alternative Scenario 3											
Equipment Rebates	11.4	13.5	16.6	17.5	16.6	16.0	14.8	14.5	14.1	13.6	15.1
BROs	18.9	20.1	21.6	23.1	25.2	27.6	30.1	32.9	36.4	40.5	45.3
Low Income	6.8	6.8	5.2	5.1	5.0	4.9	4.8	4.5	4.4	4.3	4.2
Incentive Programs (Subtotal)	37.1	40.5	43.4	45.6	46.9	48.5	49.7	52.0	55.0	58.4	64.7
C&S*	36.3	36.9	37.2	38.1	39.6	38.5	31.9	28.5	26.5	23.3	23.5
Total	73.4	77.4	80.6	83.8	86.5	87.0	81.7	80.6	81.4	81.7	88.2
PG Alternative Scenario 4											
Equipment Rebates	19.8	21.2	20.4	19.2	18.4	20.6	19.1	18.2	18.6	17.0	17.9
BROs	18.9	20.1	21.6	23.1	25.2	27.6	30.1	32.9	36.4	40.5	45.3
Low Income	6.8	6.8	5.2	5.1	5.0	4.9	4.8	4.5	4.4	4.3	4.2
Incentive Programs (Subtotal)	45.5	48.1	47.1	47.4	48.6	53.2	54.0	55.7	59.5	61.8	67.4
C&S*	36.3	36.9	37.2	38.1	39.6	38.5	31.9	28.5	26.5	23.3	23.5
Total	81.8	85.1	84.3	85.5	88.2	91.7	85.9	84.2	85.9	85.1	90.9

*Includes interactive effects

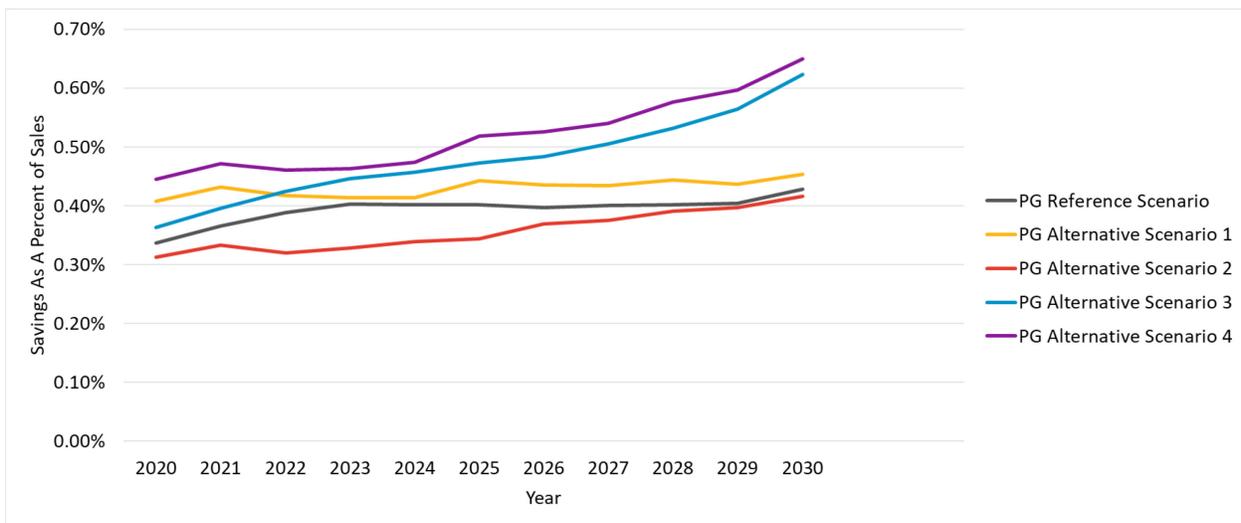
Figure 4-1 and Figure 4-2 compare the savings from all incentive programs, which includes savings from equipment rebate programs, BROs interventions, and low income programs, as a percentage of IOU sales. Savings as a percentage of sales is a common metric provided in other potential studies, and industry standard practice is to exclude savings from C&S from such calculations. Energy sales are sourced from the CEC's IEPR mid-case.

Figure 4-1. Incremental Electric Market Potential as a Percentage of Sales



Note: Excludes C&S savings

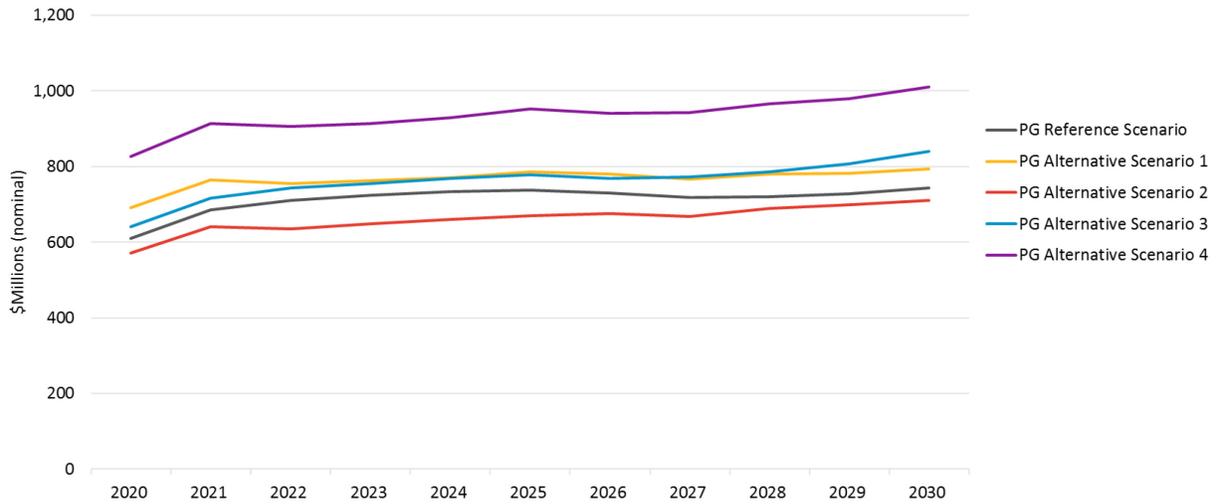
Figure 4-2. Incremental Gas Market Potential as a Percentage of Sales



Note: Excludes C&S savings

Figure 4-3 shows projected statewide spending for equipment rebate programs, BROs, and low income programs by scenario. Spending includes both incentive and non-incentive program costs, which were approximated from historic program activity spending data from the IOUs. Since overall potential is driven by electric savings, the trend generally follows that of electric potential whereby Alternative Scenario 5 produces the most expensive portfolio for equipment savings and the Reference scenario, the least. However, note that Alternative 3 requires less budget than Alternative 1 in 2020 and is similar to the Reference scenario. This is because Alternative 3 is more aggressive with BROs and other aspects of program design without increasing incentive levels. It can achieve higher first-year savings at a lower cost relative to all the other scenarios.

Figure 4-3. Statewide Spending by Scenario for IOU Incentive Programs



Note: Excludes C&S savings

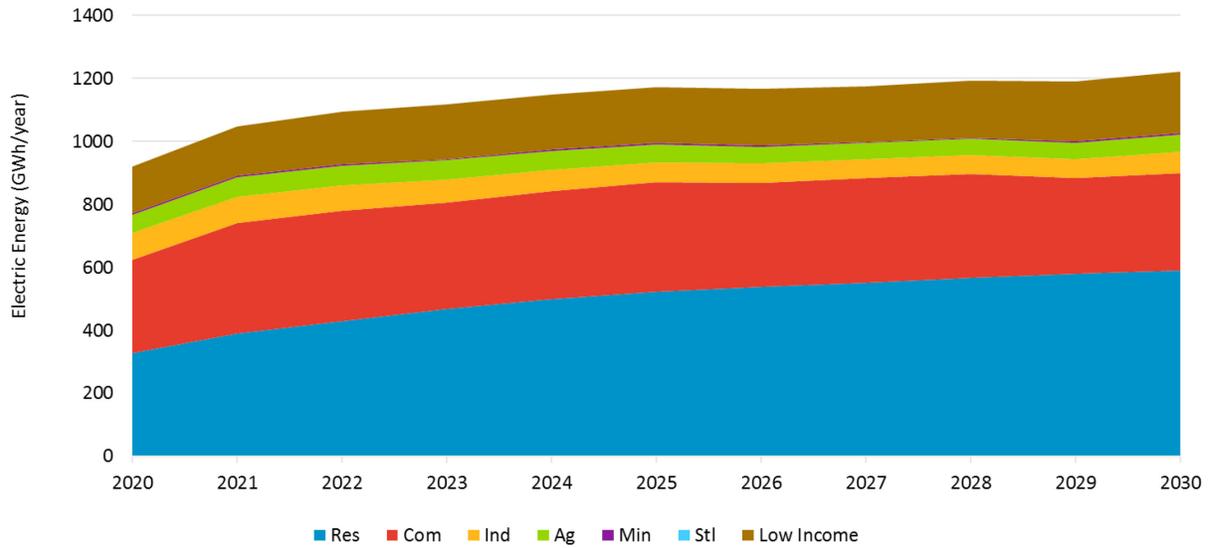
4.1.2 Total Savings and Spending by Sector

Figure 4-4 through Figure 4-12 show the breakdown of electric (GWh) and gas (MMtherms) savings, respectively, by sector for incentive programs, which includes savings from equipment rebate programs, BROs interventions, and low income programs. All figures exclude savings from re-participants.

For electric savings, the commercial and residential sectors lead the savings across all scenarios, with the residential sector showing slightly higher potential over the study horizon. The incremental savings potential grows over time for the residential, commercial, and agricultural sectors. This growth is largely attributable to greater levels of market uptake for BROs in the later years. Conversely, the incremental savings potential declines for the industrial, mining and street lighting sectors. For industrial and mining, this savings decline is highly correlated with flat or negative customer growth rates during the time horizon. For street lighting, the market potential for high efficiency measures becomes more saturated over time.

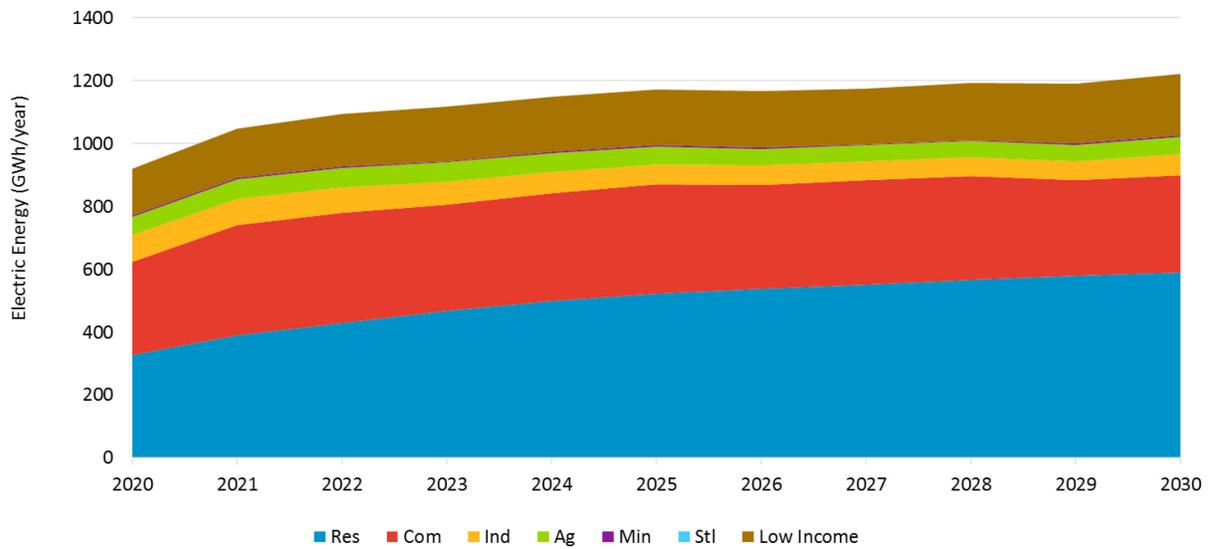
For gas savings, the largest savings potential comes from the industrial and residential sectors, followed by low income. Like electric savings, BROs contributes significantly to future growth of savings potential.

Figure 4-4. Statewide Incremental Net Electric Market Potential by Sector for Incentive Programs (Reference)



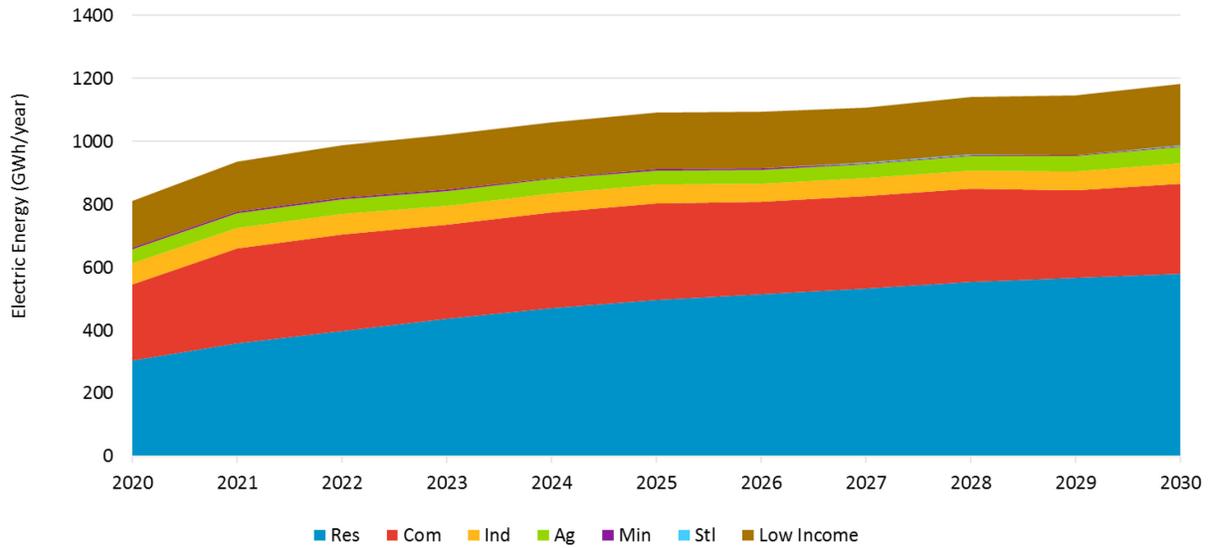
Note: Excludes C&S savings

Figure 4-5. Statewide Incremental Net Electric Market Potential by Sector for Incentive Programs (Alternative 1)



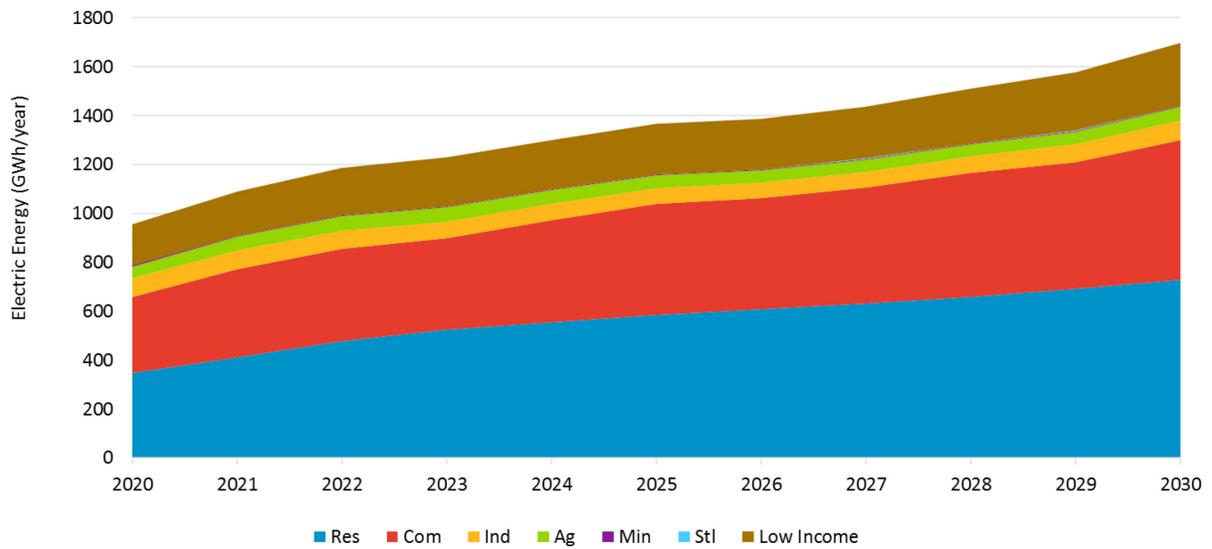
Note: Excludes C&S savings

Figure 4-6. Statewide Incremental Electric Market Potential by Sector for Incentive Programs (Alternative 2)



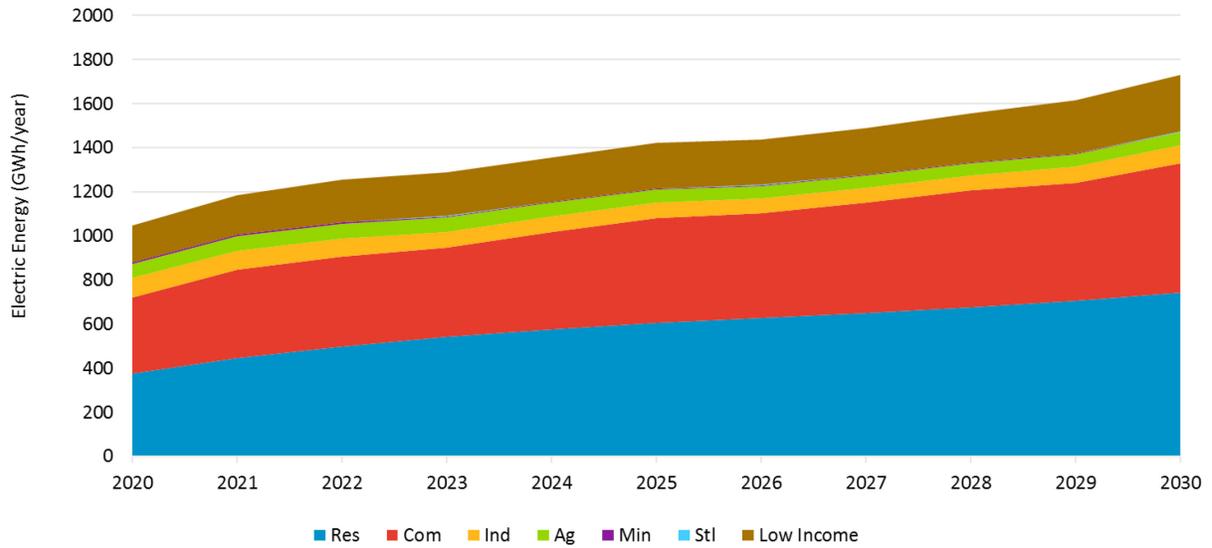
Note: Excludes C&S savings

Figure 4-7. Statewide Incremental Electric Market Potential by Sector for Incentive Programs (Alternative 3)



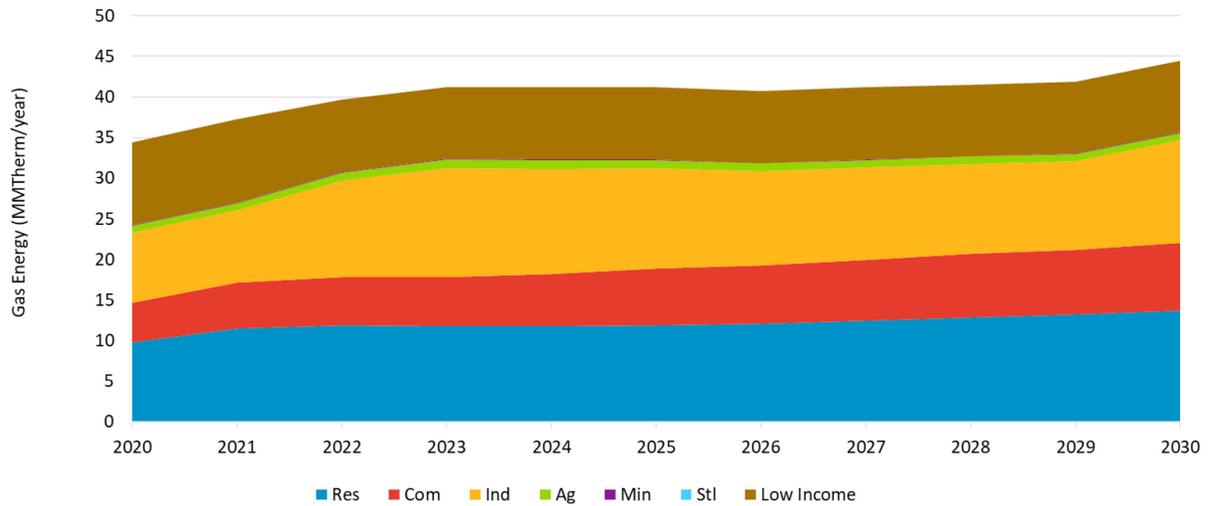
Note: Excludes C&S savings

Figure 4-8. Statewide Incremental Electric Market Potential by Sector for Incentive Programs (Alternative 4)



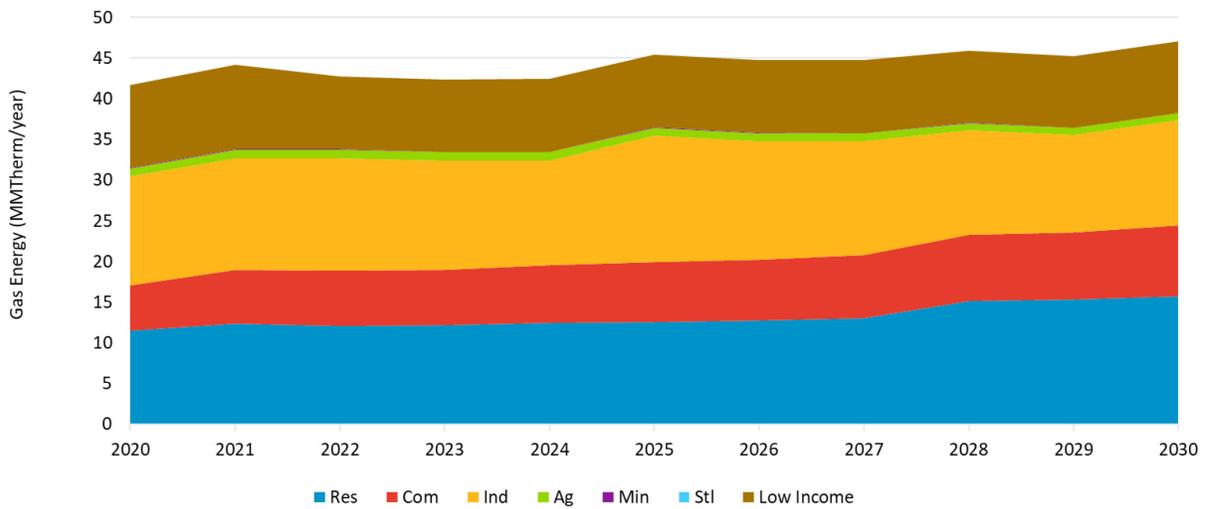
Note: Excludes C&S savings

Figure 4-9. Statewide Incremental Gas Market Potential by Sector for Incentive Programs (Reference)



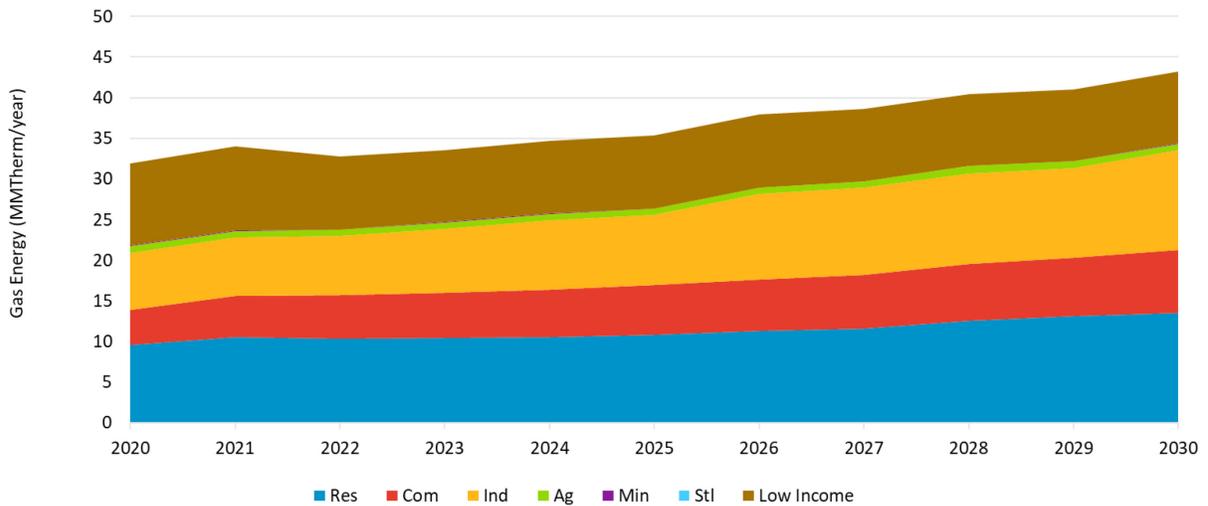
Note: Excludes C&S savings

Figure 4-10. Statewide Incremental Gas Market Potential by Sector for Incentive Programs (Alternative 1)



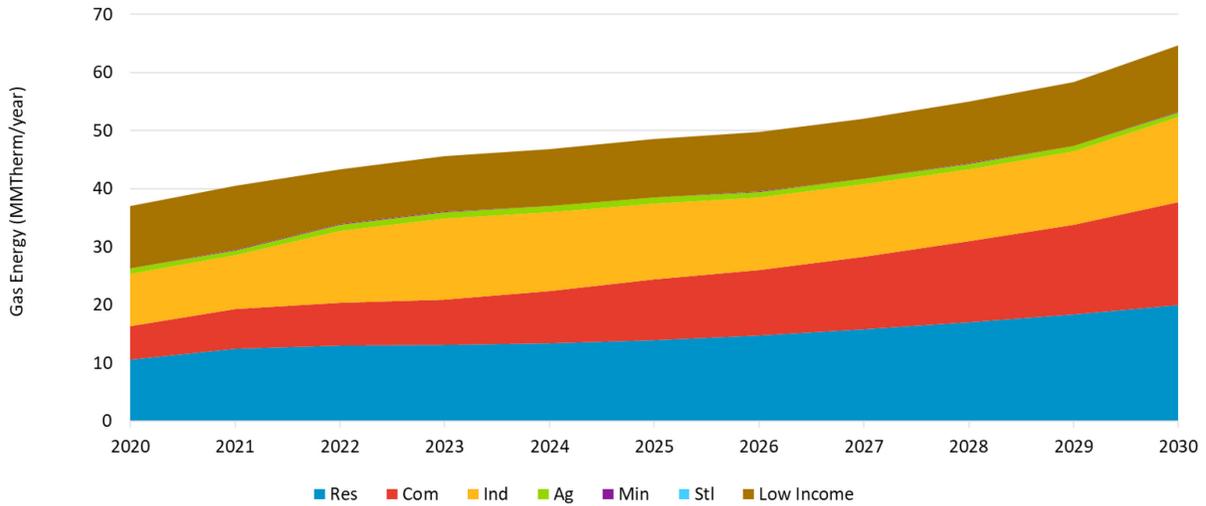
Note: Excludes C&S savings

Figure 4-11. Statewide Incremental Gas Market Potential by Sector for Incentive Programs (Alternative 2)



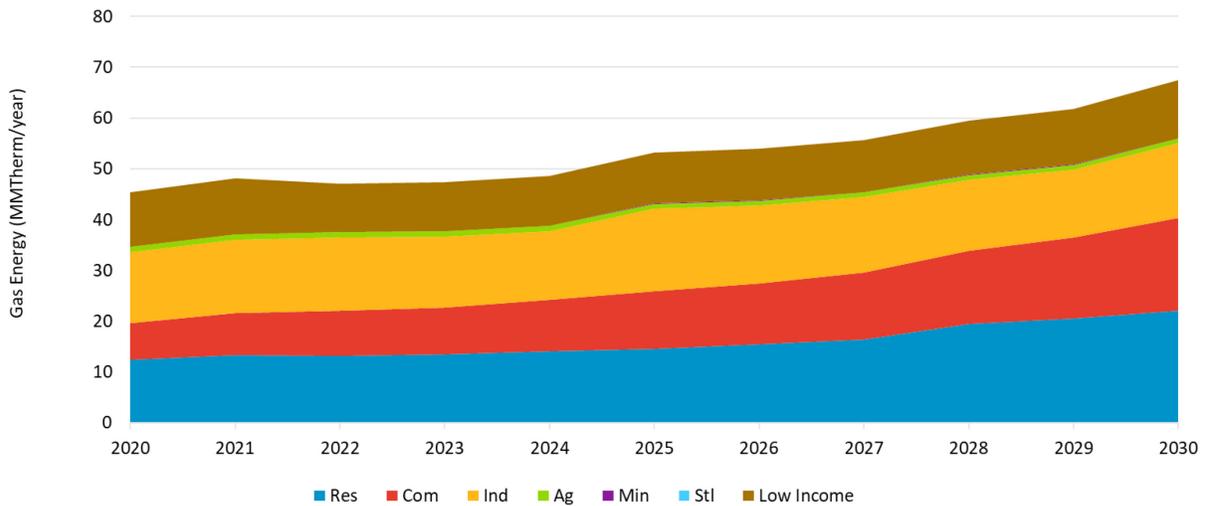
Note: Excludes C&S savings

Figure 4-12. Statewide Incremental Gas Market Potential by Sector for Incentive Programs (Alternative 3)



Note: Excludes C&S savings

Figure 4-13. Statewide Incremental Gas Market Potential by Sector for Incentive Programs (Alternative 4)



Note: Excludes C&S savings

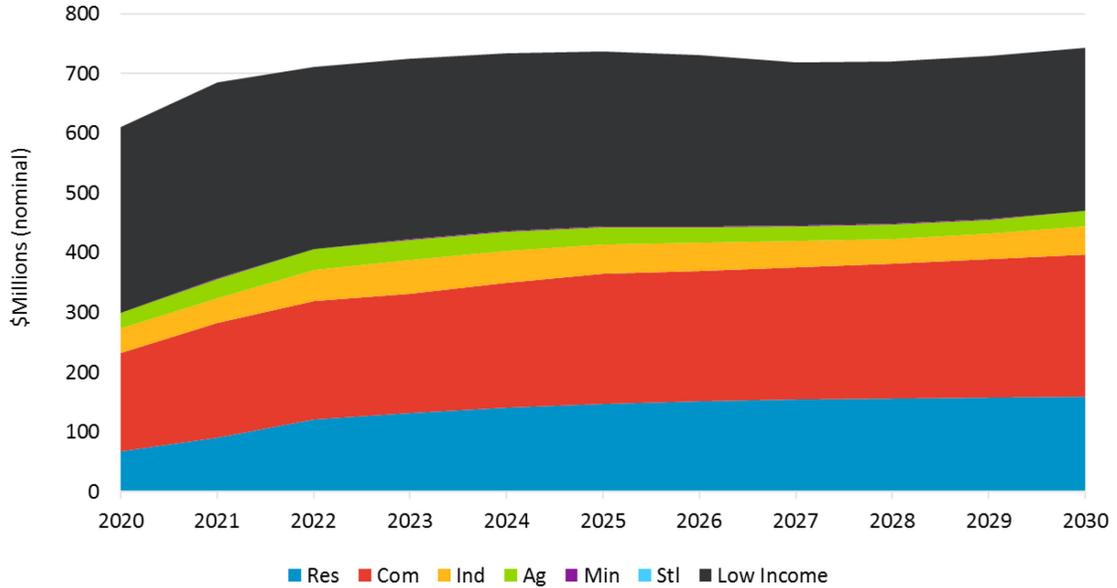
A peak demand savings version of the above figures can be found in the results viewer.

Figure 4-14 through Figure 4-18 show the breakdown of statewide spending by sector for incentive programs, which includes savings from equipment rebate programs and BROs interventions. This data does not include costs associated with non-resource programs or C&S advocacy.

Once again, a key takeaway from these figures is that the share of each sector's savings generally remains the same across scenarios. However, low income shows a significant portion of program spending in these figures. Low income programs are higher cost than traditional rebate programs, and the

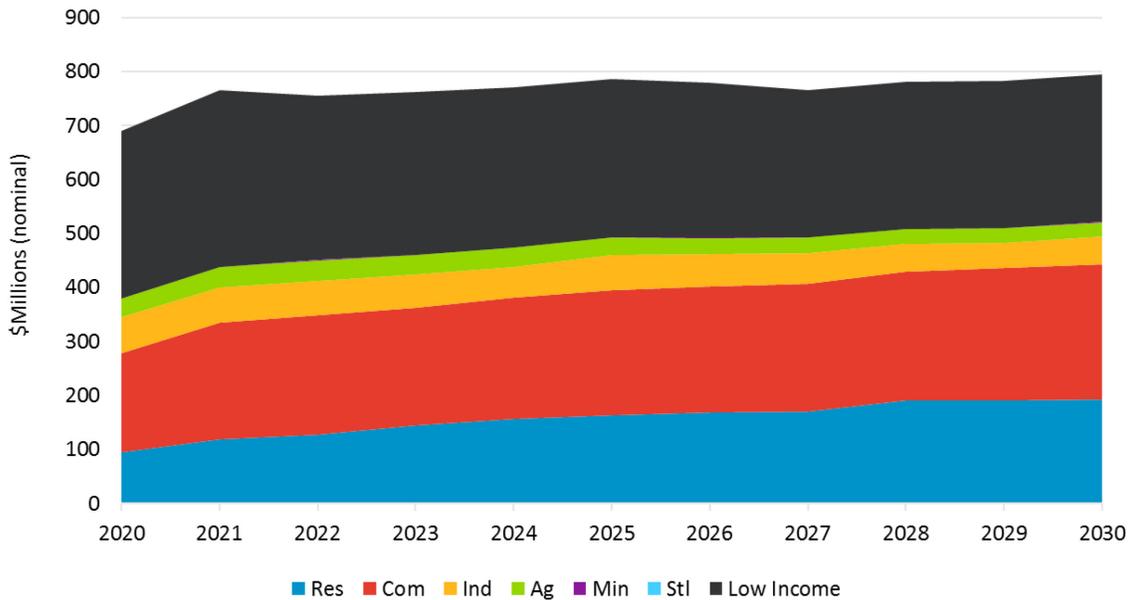
full measure cost is subsidized by the program. Low income program spending forecast in 2020 is consistent with statewide IOU program spending on low income in recent years.

Figure 4-14. Statewide Spending by Sector for Incentive Programs (Reference)



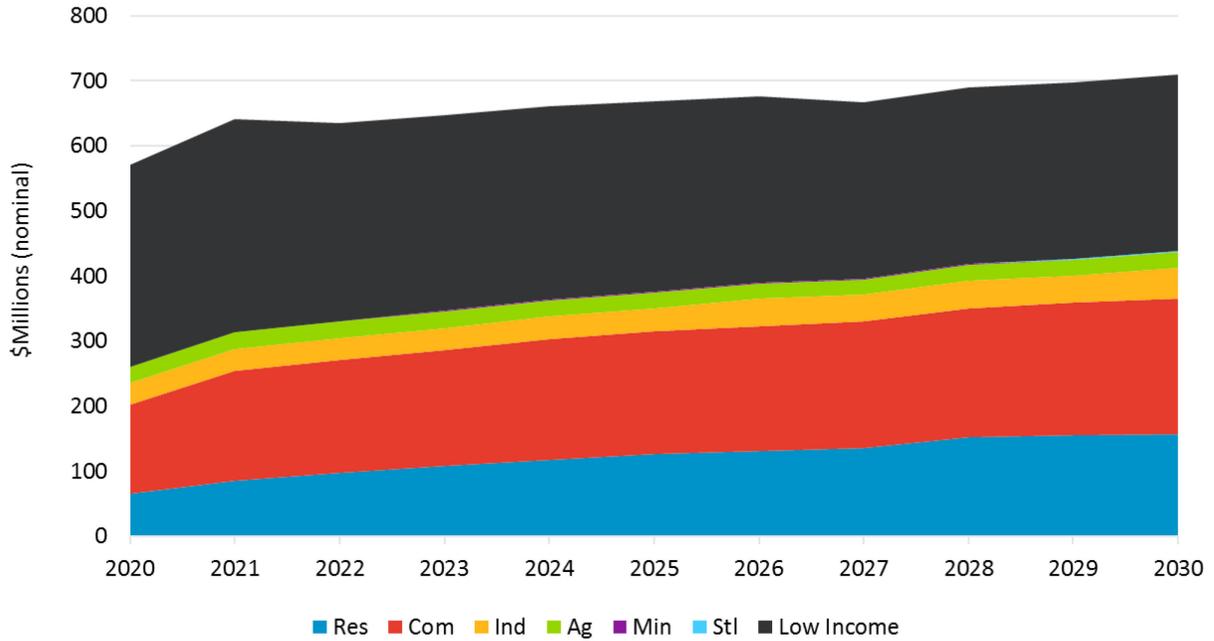
Note: Excludes C&S advocacy and non-resource program costs

Figure 4-15. Statewide Spending by Sector for Incentive Programs (Alternative 1)



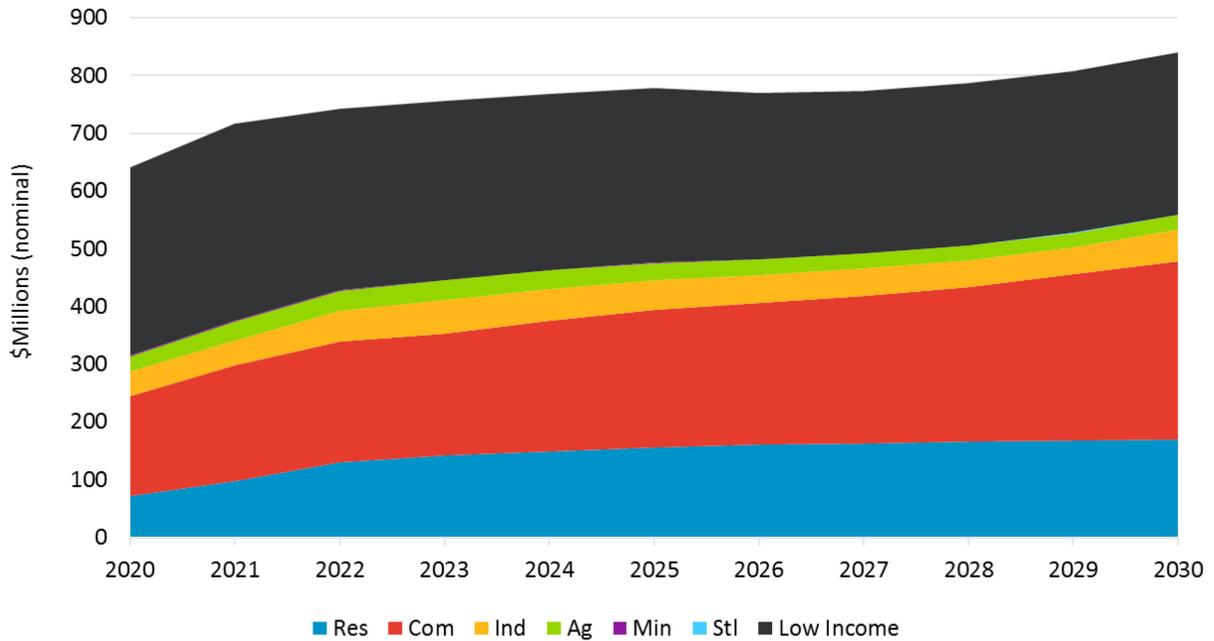
Note: Excludes C&S advocacy and non-resource program costs

Figure 4-16. Statewide Spending by Sector for Incentive Programs (Alternative 2)



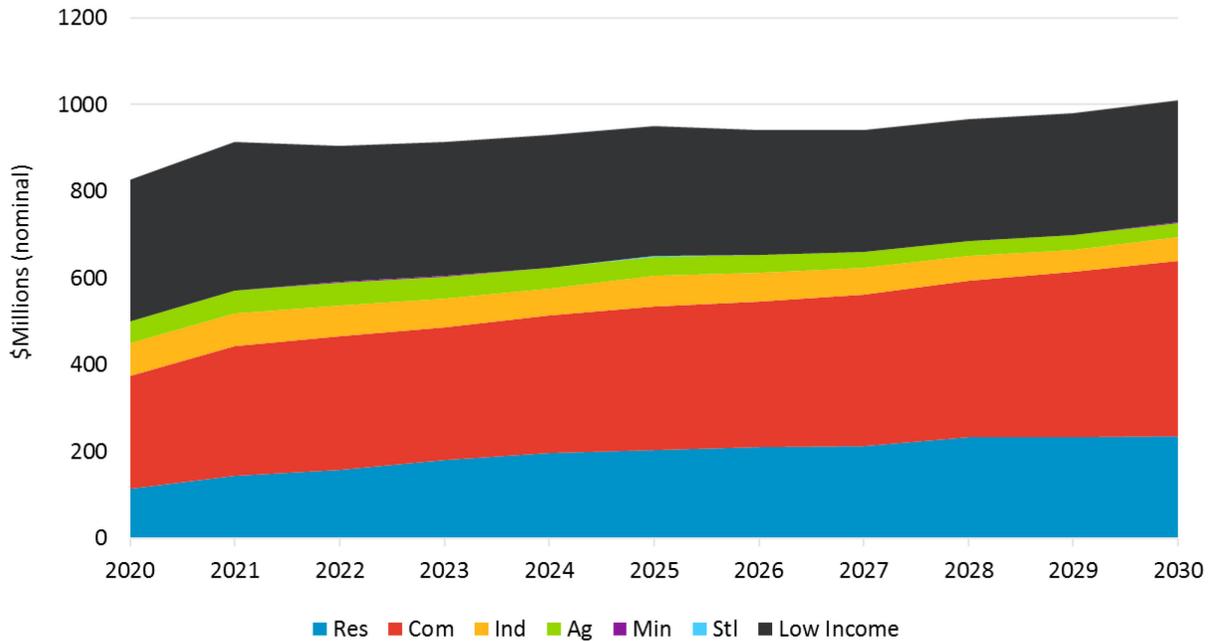
Note: Excludes C&S advocacy and non-resource program costs

Figure 4-17. Statewide Spending by Sector for Incentive Programs (Alternative 3)



Note: Excludes C&S advocacy and non-resource program costs

Figure 4-18. Statewide Spending by Sector for Incentive Programs (Alternative 4)



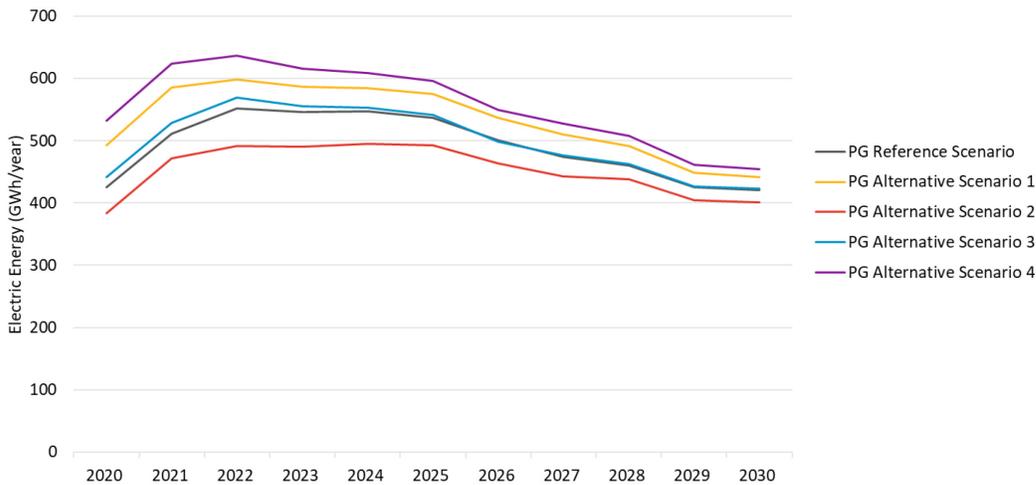
Note: Excludes C&S advocacy and non-resource program costs

4.1.3 Equipment Rebate Program Results

Figure 4-19 and Figure 4-20 illustrate the statewide incremental market potential from equipment rebate program savings, which includes savings from discrete equipment, whole building, and shell measures, by scenario for electric (GWh) and gas (MMtherms), respectively. These figures exclude IOU-claimable savings from C&S advocacy programs and BROs interventions. They also exclude savings from re-participants, as the Navigant team was tasked to assess incremental potential from first-time adopters in the market. Cumulative savings are presented in Appendix B.

Figure 4-19 shows that electric potential increases as the TRC threshold used to screen measures becomes less stringent. Alternative 1 uses the least restrictive threshold, while Alternative 2 uses the most restrictive. Alternative 4 shows slightly higher savings than the Reference scenario in early years. These two scenarios are similar except Alternate 4 assumes more aggressive program marketing and outreach, which manifests itself in a slight front loading of savings in earlier years. Overall, Alternative 4 produces about 38% more electric savings than Alternative 2 (the most conservative scenario).

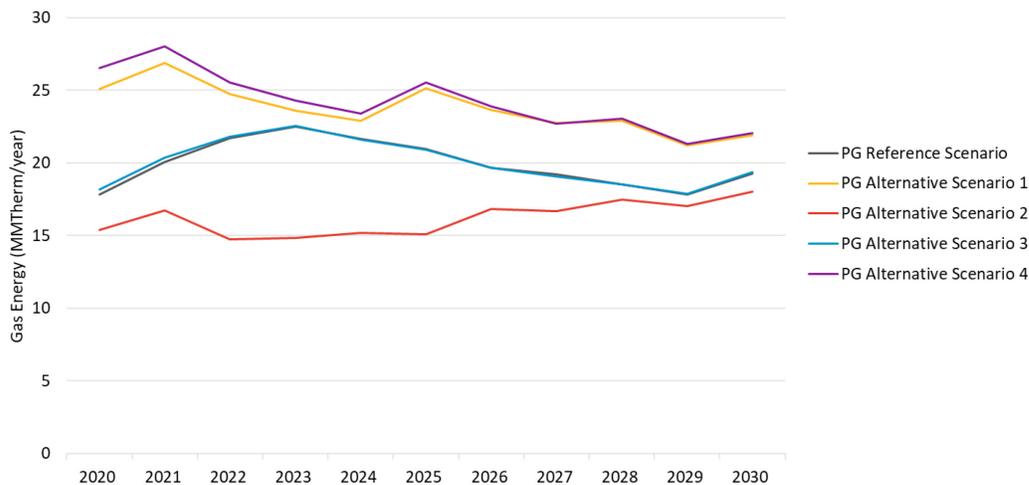
Figure 4-19. Statewide Incremental Electric Market Potential by Scenario



Note: Includes low income; excludes BROs and C&S

Like Figure 4-19, Figure 4-20 shows that gas potential generally increases as the cost test used to screen measures becomes less stringent. Alternative 1 uses the least restrictive threshold, while Alternative 2 uses the most restrictive. Overall, Alternative 4 produces about 72% more gas savings than Alternative 2 (the most conservative scenario). The spread in gas savings across the five scenarios is larger than the spread observed in electric savings. This is because there are more gas measures and savings that have measure-level TRCs in the range of 0.85 and 1.25 relative to electric measures and savings. Thus, gas savings are far more sensitive to the TRC threshold.

Figure 4-20. Statewide Incremental Gas Market Potential by Scenario



Note: Includes low income; excludes BROs and C&S

Note that the Navigant team also produced cumulative market potential as part of the study for equipment rebate program measures and compared it against technical and economic potential for all five scenarios. Details on these results can be found in Appendix B.

The following subsections discuss the statewide program and end-use-level potential results for electric (GWh) and gas (MMtherms) savings for equipment rebate programs, BROs interventions, and low income programs in different sectors. Additional versions of this figure for each IOU and for peak demand savings can be found in the results viewer. Note that measure-level results are available in a database that accompanies this report.

4.1.3.1 Residential Rebate Programs

Figure 4-21 through Figure 4-25 shows the breakdown of electric savings by end use in the residential sector for each scenario. They exclude BROs (covered in Section 4.1.4) and low income (covered in Section 4.1.3.2). Key observations from these figures include the following:

- Among end-use categories that capture potential from discrete measures, lighting leads electric potential in the residential sector, followed by appliance measures across all scenarios. Lighting potential is driven by LEDs, including those with embedded controls. There is no CPUC policy suggesting that LEDs are standard practice baseline in the residential sector (unlike non-residential applications).
- Residential whole building potential contributes somewhat significantly to potential in the later years of the forecast across all scenarios. Whole building savings are driven by opportunities for new construction EE saving above and beyond 2019 Title 24 building codes. The model does not forecast any savings from residential whole building retrofit programs (like Energy Upgrade California) as they are found to not be cost-effective across any of the five scenarios.
- There is a high degree of variation between scenarios for HVAC savings. As the C-E screening test gets less stringent, more expensive HVAC measures are included in the potential.
- Overall potential ramps up significantly toward 2024 and then gradually begins to taper off toward the end of the forecast period across all scenarios. This is due to the model simulating an increasingly saturated market over time as more customers begin adopting efficient equipment with limited remaining low efficiency equipment to convert. This behavior is primarily driven by lighting measures, which turn over at a faster rate than other equipment.

Figure 4-21. Statewide Residential Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Reference)

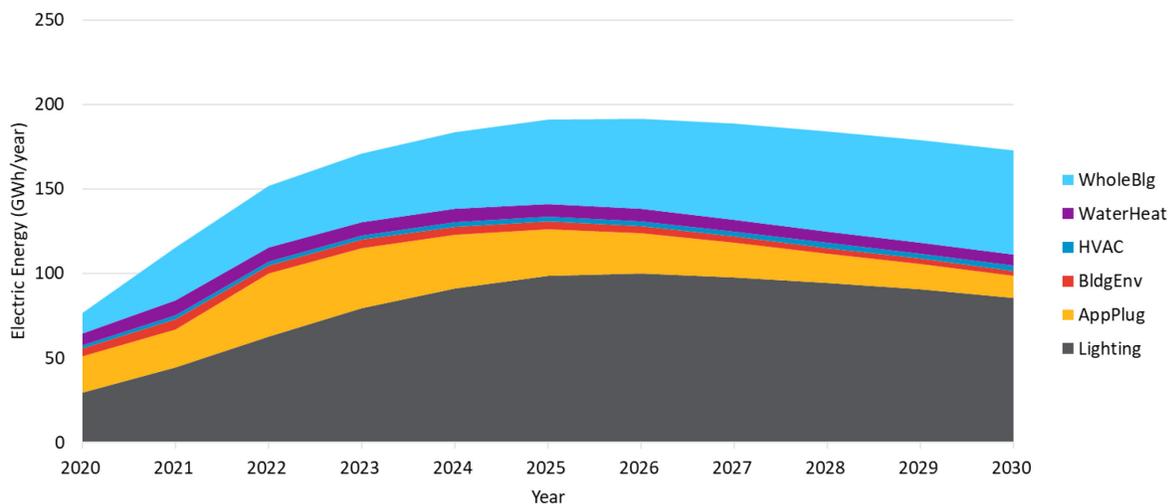


Figure 4-22. Statewide Residential Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 1)

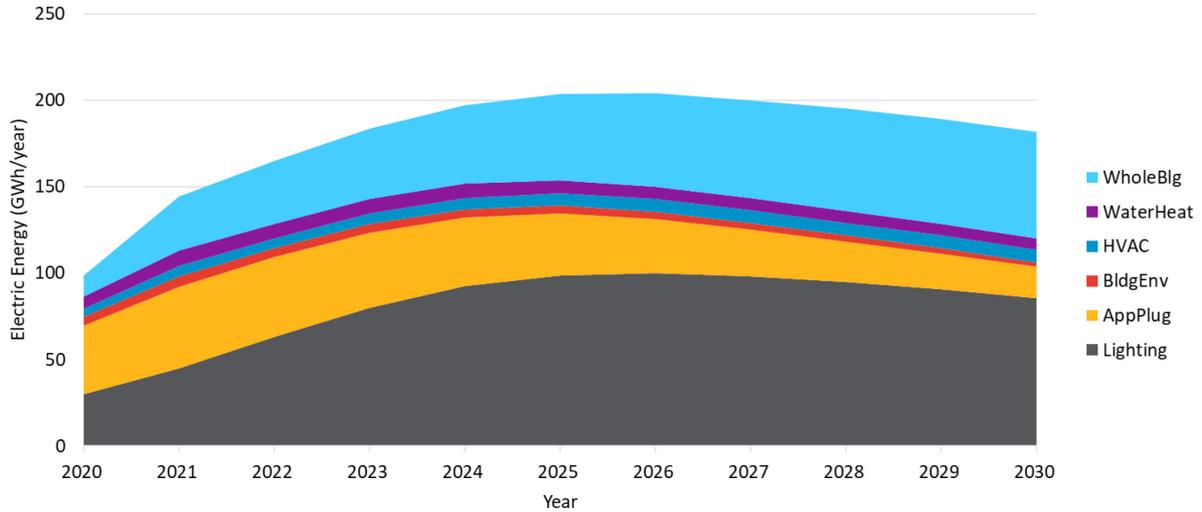


Figure 4-23. Statewide Residential Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 2)

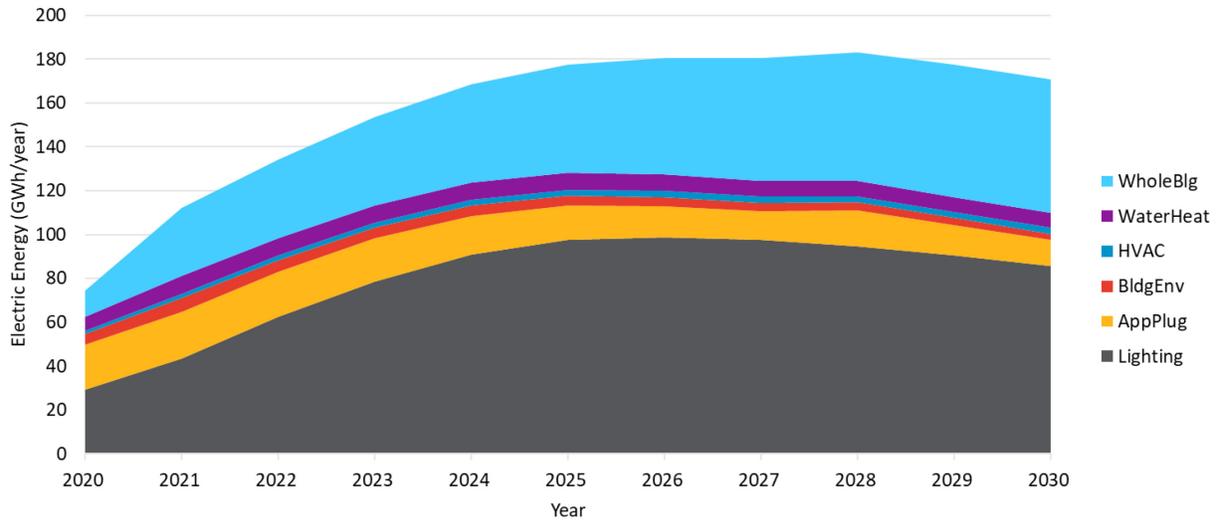


Figure 4-24. Statewide Residential Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 3)

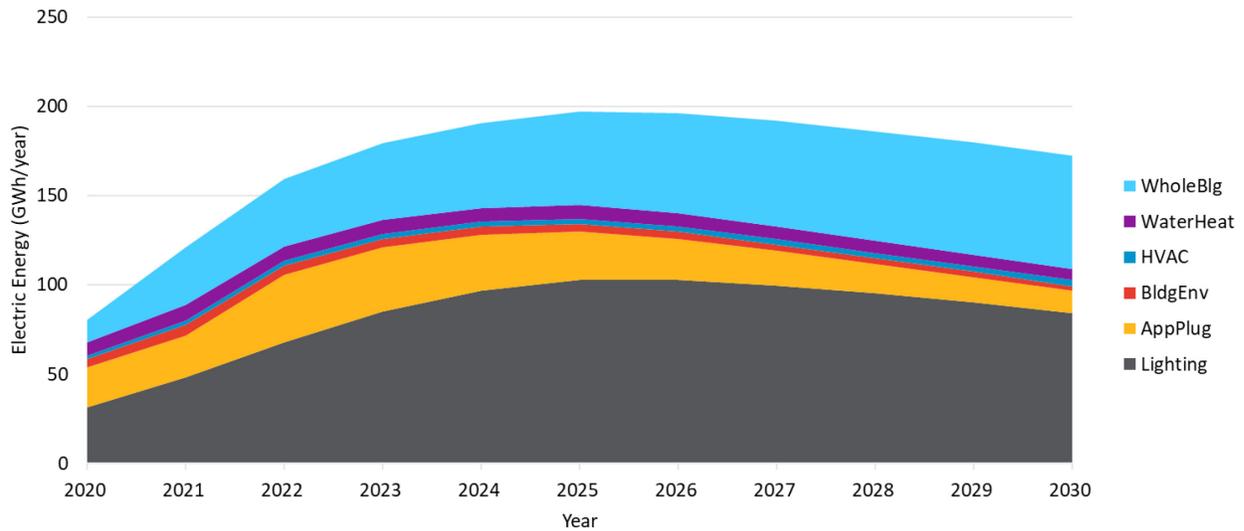


Figure 4-25. Statewide Residential Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 4)

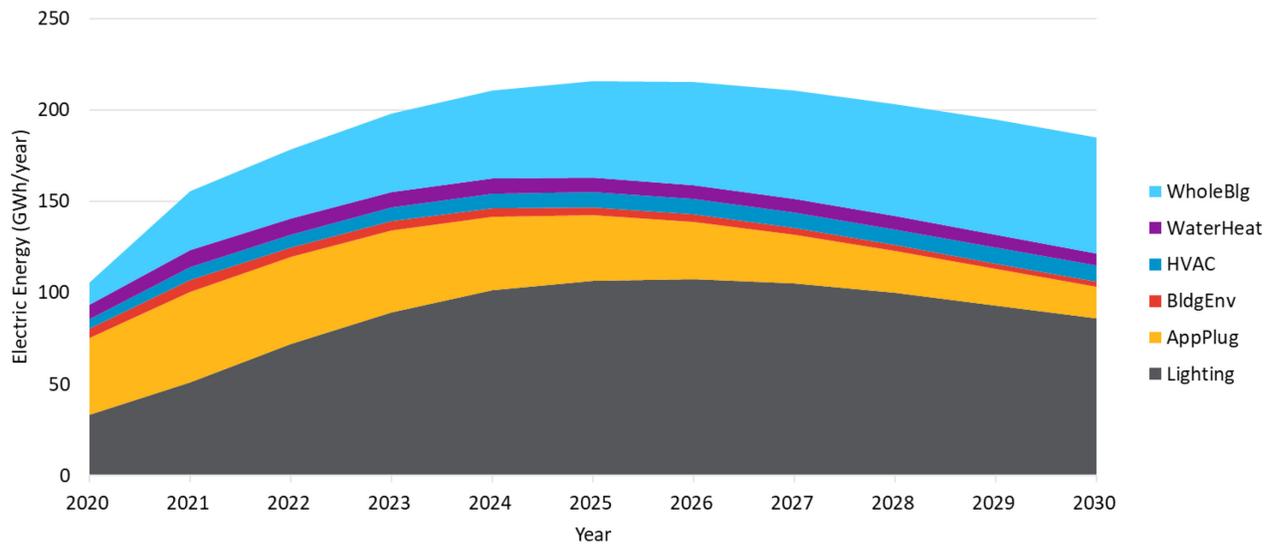


Figure 4-26 through Figure 4-30 show the breakdown of gas savings by end use in the residential sector. Key observations from these figures include the following:

- Negative gas savings due to interactive effects from lighting measures reduce the overall net gas potential in the residential sector across all scenarios.
- Among end-use categories that capture potential from discrete measures, appliances and building envelope regularly appear across all scenarios. Water heating is sensitive to the TRC threshold, so in some scenarios water heating dominates while in others it plays a small role.

- HVAC potential does not show up until 2022 in Alternative 1 and Alternative 4 because no measures screen the TRC test prior to that. It does not show up at any point during the forecast period for all other scenarios, indicating that no measures screen the TRC test for those scenarios.
- Residential whole building potential contributes significantly to overall potential. Like electric savings, whole building gas savings are driven by opportunities for new construction EE saving above and beyond 2019 Title 24 building codes. The model does not forecast any savings from residential whole building retrofit programs (like Energy Upgrade California) as they are found to not be cost-effective across any of the five scenarios.
- Unlike electric potential, overall potential does not taper off toward the end of the forecast period across all scenarios as most gas measures have long lifetimes and do not turn over as fast. As such, there continues to be opportunity for first-time adopters in the gas market, which does not saturate as fast.

Figure 4-26. Statewide Residential Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Reference)

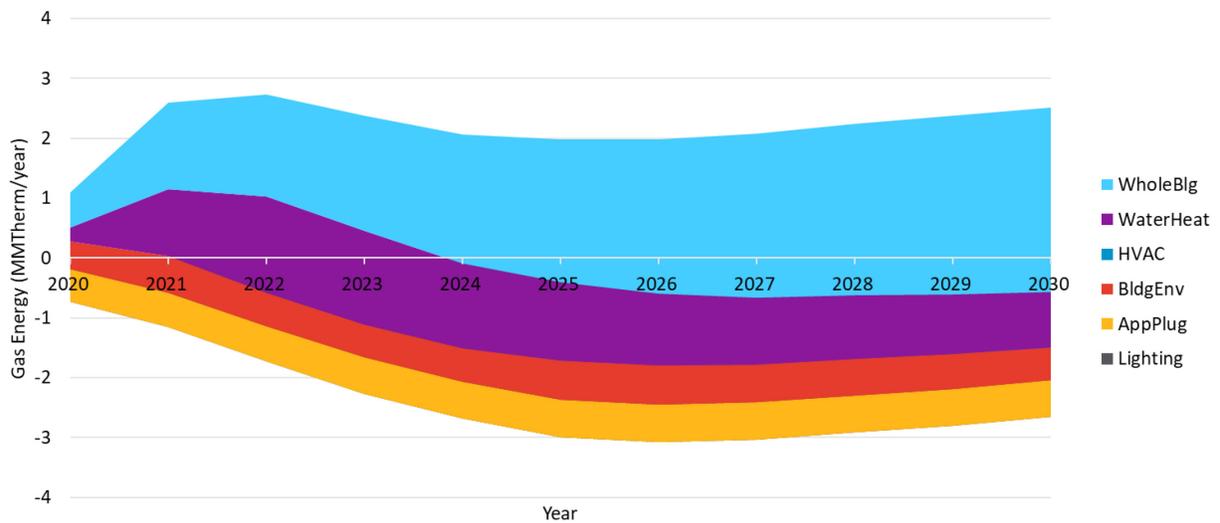


Figure 4-27. Statewide Residential Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 1)

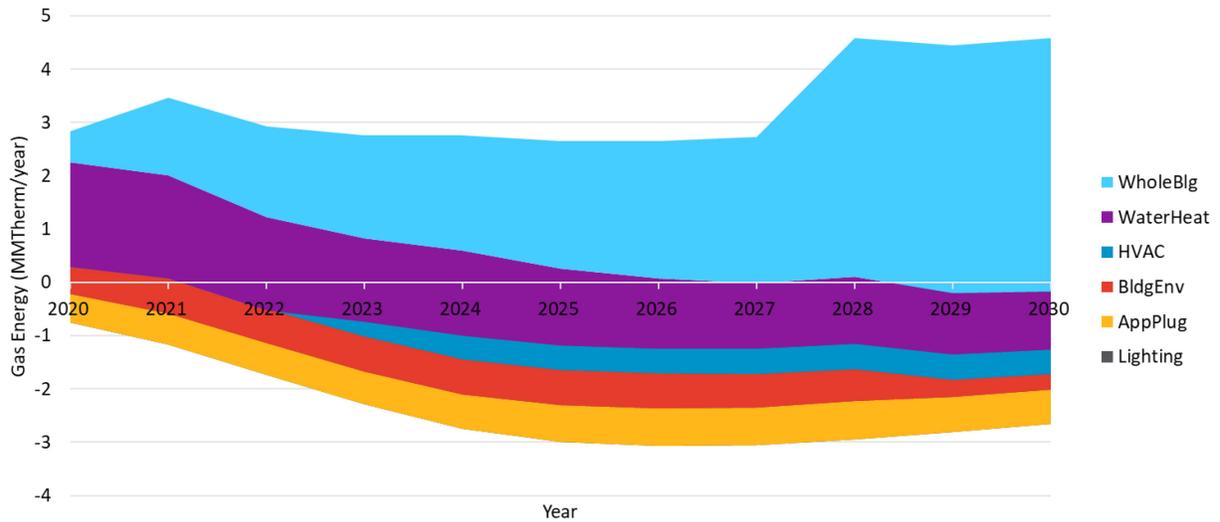


Figure 4-28. Statewide Residential Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 2)

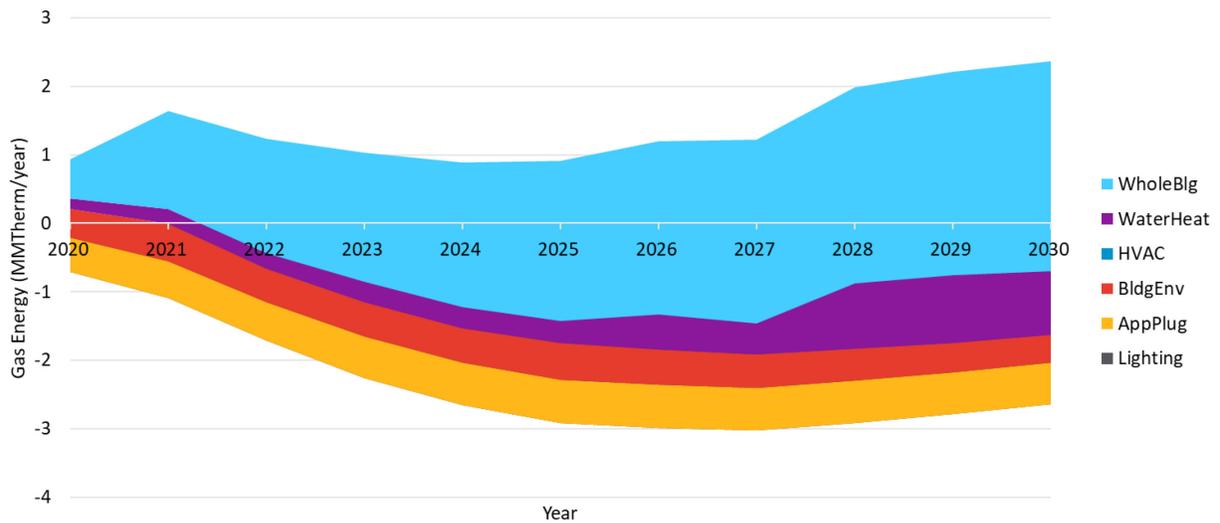


Figure 4-29. Statewide Residential Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 3)

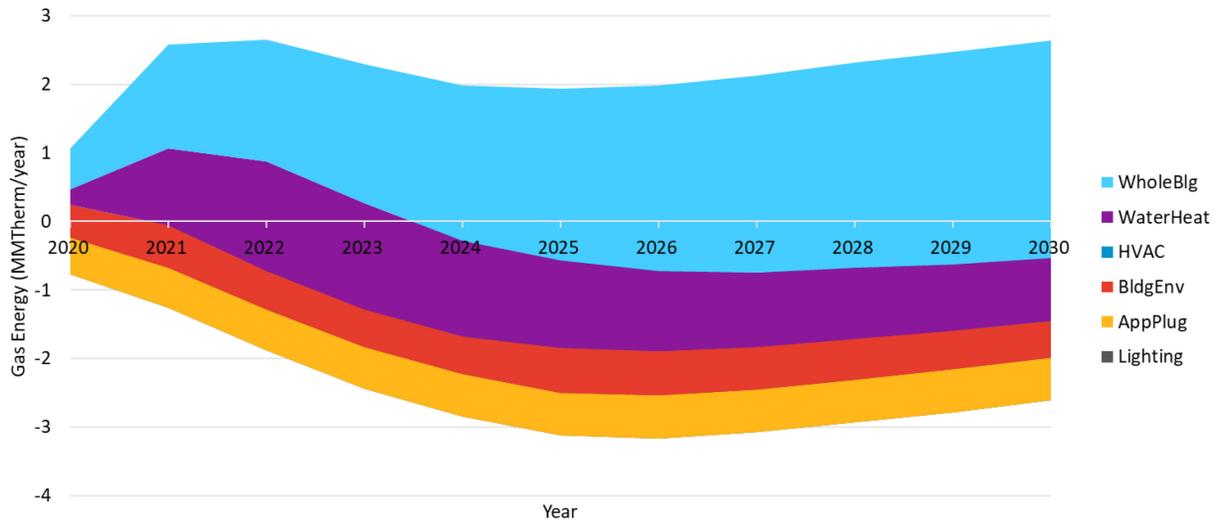
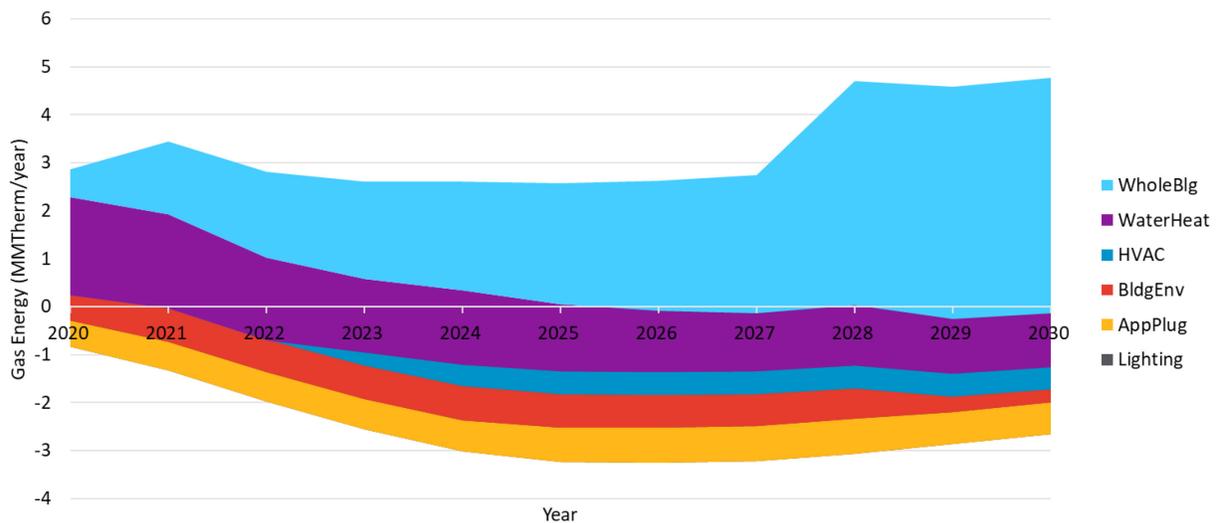


Figure 4-30. Statewide Residential Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 4)



4.1.3.2 Low Income Rebate Programs

Figure 4-31 through Figure 4-34 show the breakdown of electric savings by end use in the commercial sector for each scenario. The Reference, Alternative 1, and Alternative 2 scenarios have the same savings results, so they are grouped into one figure. The same applies for the Alternative 3 and Alternative 4 scenarios. Key observations from these figures include the following:

- The appliances and HVAC end uses account for most of the electric potential, with lighting playing a smaller role in electric potential. Meanwhile, the water heating end use dominates gas savings opportunities.
- Electric potential decreases over time as high efficiency appliances and HVAC measures begin to saturate in the low income market.
- These figures show the incremental first-year savings from new participants. It does not include savings from re-participants to remain consistent and comparable to other figures in this report. Savings from re-participants are captured in the cumulative savings calculation in the PG Model.

As noted earlier in Section 2.1.2, this study significantly updated the forecasting approach for the low income sector. The 2017 Study’s top-down approach relied significantly on data reported by the IOUs and the expectation that, starting in 2021, program participants would consist only of retreatments (i.e., homes that have participated in the program in previous years). The 2019 Study seeks to assess the true remaining potential in low income homes at the measure level regardless of if the residential customer is a first-time participant or a re-participant. As such, forecast potential in 2020 and beyond is agnostic of past program participation.

Figure 4-31. Statewide Low Income Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Reference, Alternative 1, and Alternative 2)

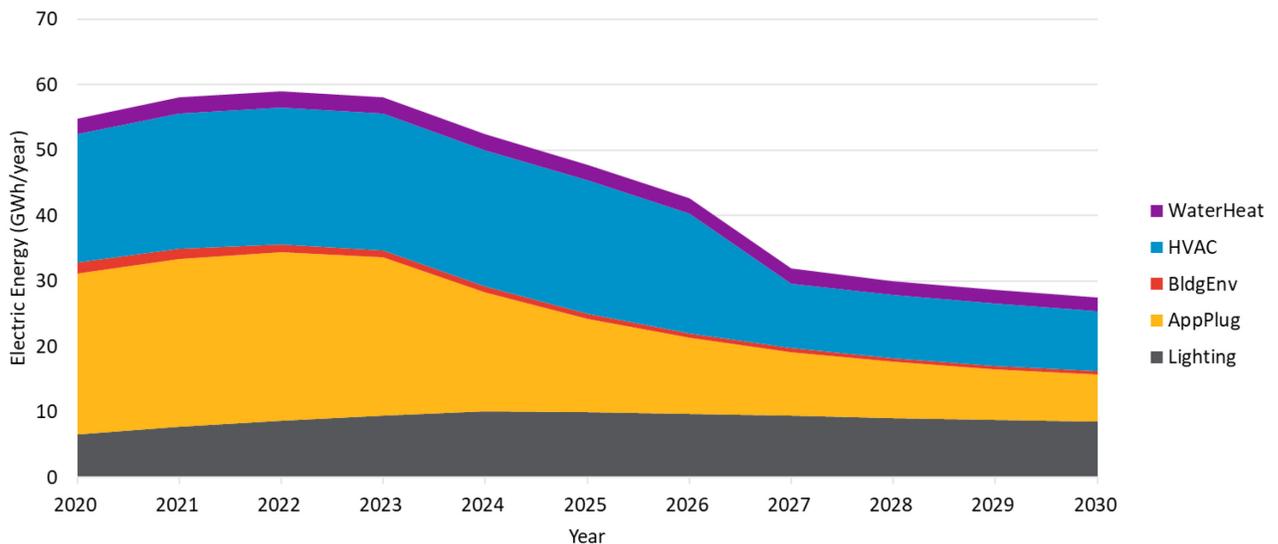


Figure 4-32. Statewide Low Income Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 3, Alternative 4)

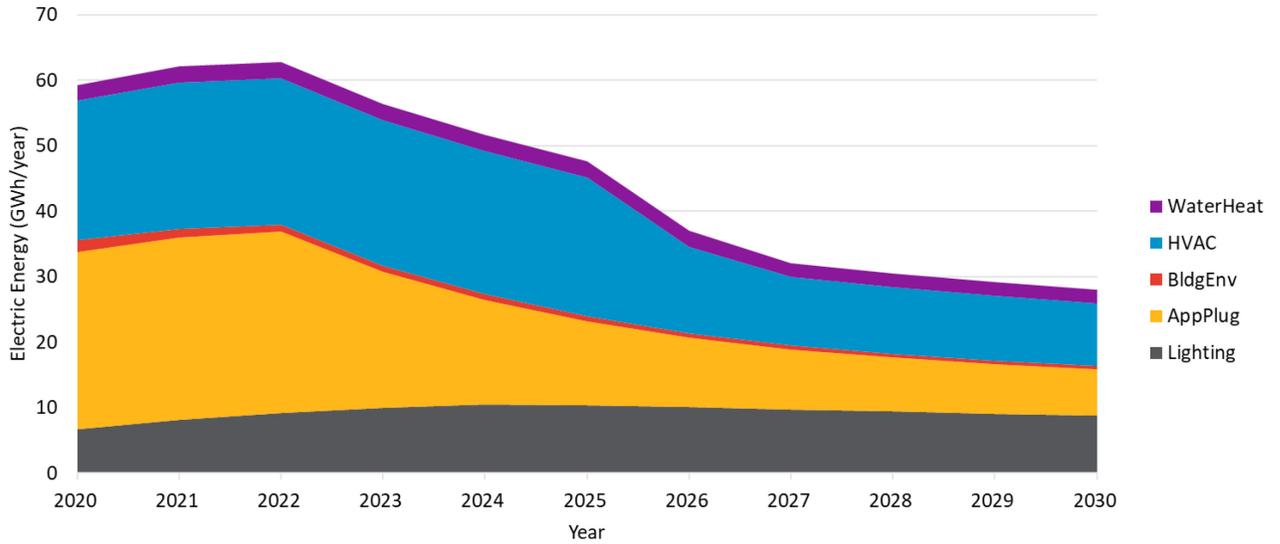


Figure 4-33. Statewide Low Income Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Reference, Alternative 1, and Alternative 2)

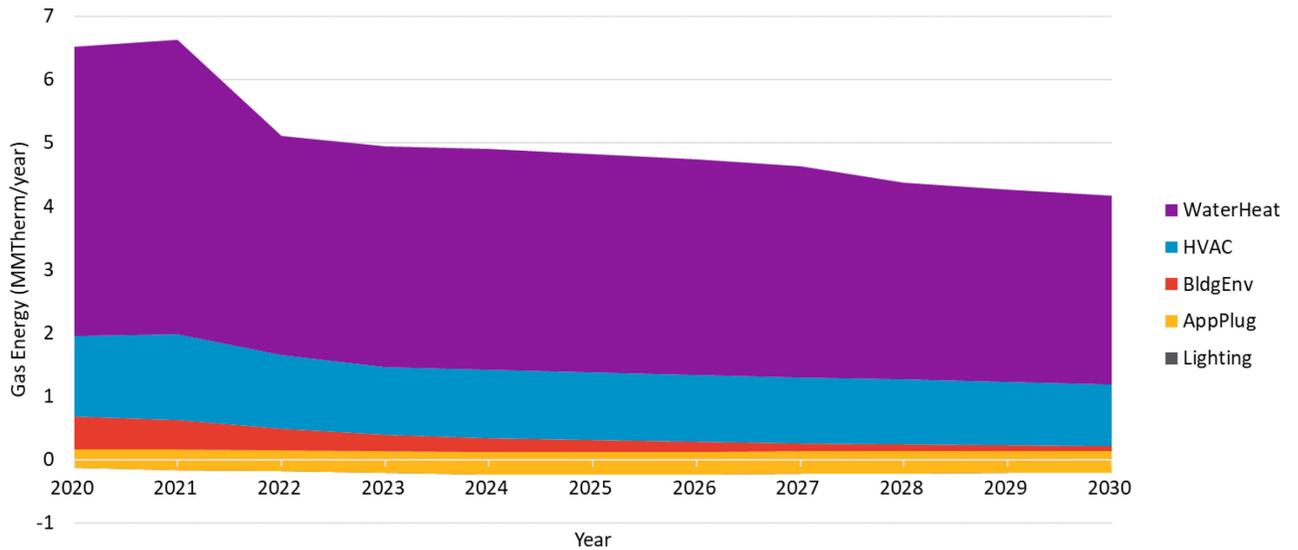
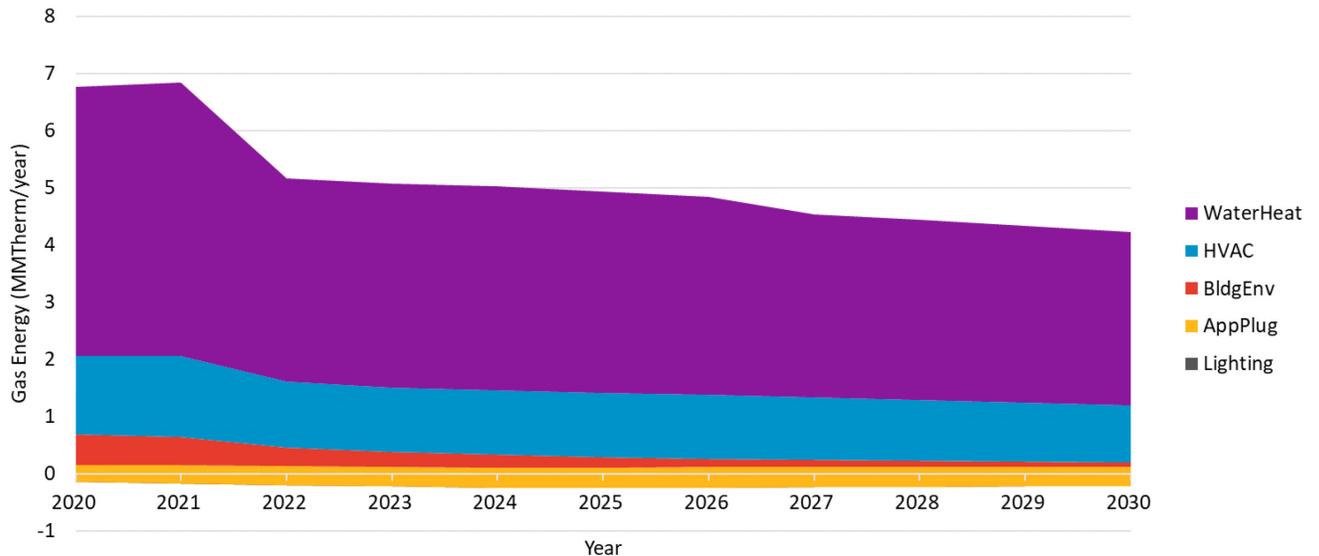


Figure 4-34. Statewide Low Income Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 3, Alternative 4)



4.1.3.3 Commercial Rebate Programs

Figure 4-35 through Figure 4-39 show the breakdown of electric savings by end use in the commercial sector for each scenario. Key observations from these figures include the following:

- Among end-use categories that capture potential from discrete measures, HVAC and commercial refrigeration measures dominate electric potential in the commercial sector across all scenarios.
- Lighting savings are a much smaller proportion of overall potential compared to the residential sector and compared to previous studies. Recent guidance from the CPUC indicates that LED lighting becomes the standard practice baseline in 2019.⁷⁰ Savings in the forecast period come from lighting controls measures and, for some building types (small commercial), AR programs. However, the market quickly becomes saturated, showing a decrease of savings in the future.
- Commercial whole building potential contributes significantly to overall potential across all scenarios. Savings for whole buildings account for savings from anticipated future iterations of building codes. Commercial whole building potential is lower than in past studies because the potential was reduced to account for LEDs becoming standard practice in commercial lighting.
- Overall potential decreases over the forecast period. This is due to the model simulating an increasingly saturated market over time as more customers begin adopting efficient equipment for the first time. This behavior is more pronounced in the commercial sector versus the residential sector because of the much smaller contribution of lighting savings.

⁷⁰ CPUC Resolution E-4952, October 11, 2018.
<http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF>

Figure 4-35. Statewide Commercial Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Reference)

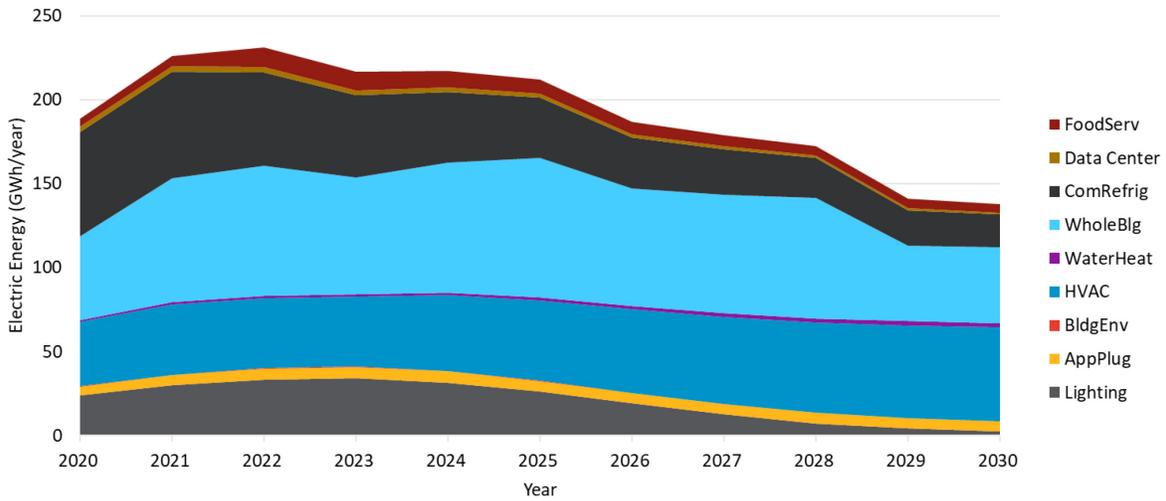


Figure 4-36. Statewide Commercial Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 1)

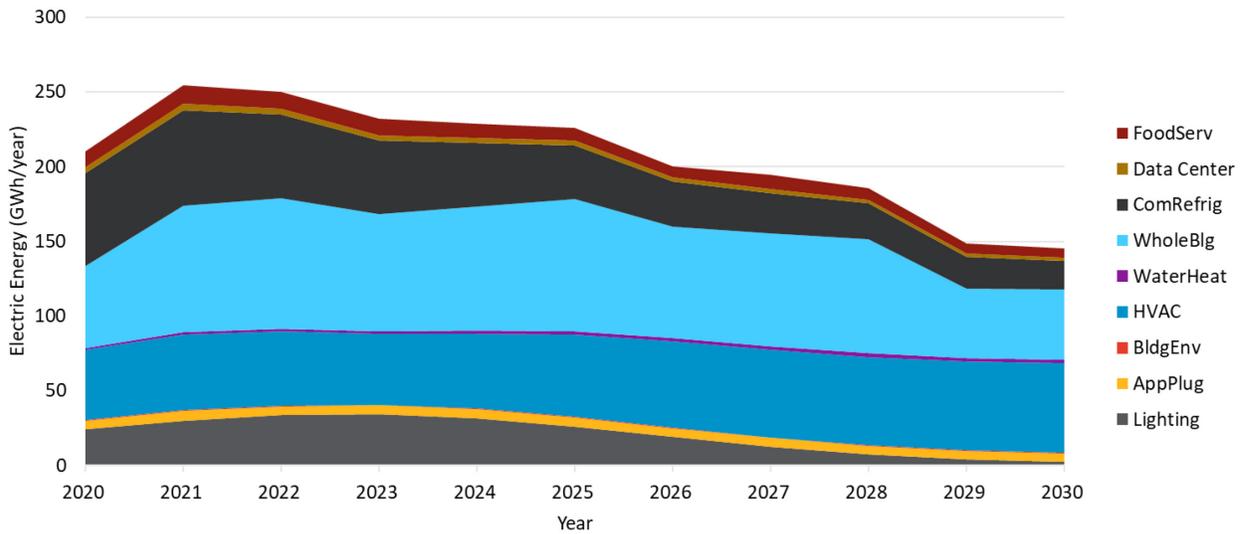


Figure 4-37. Statewide Commercial Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 2)

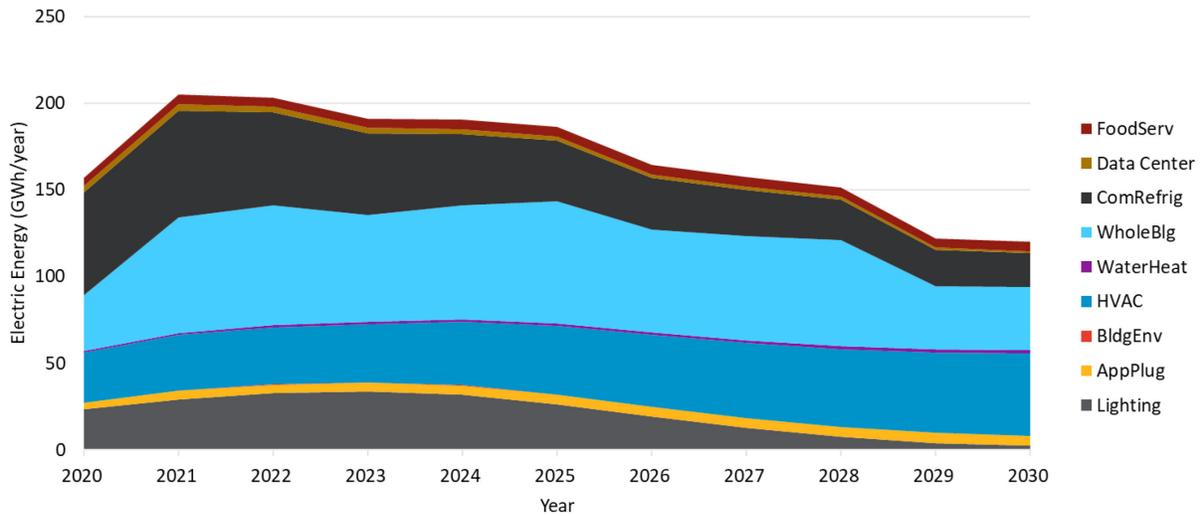


Figure 4-38. Statewide Commercial Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 3)

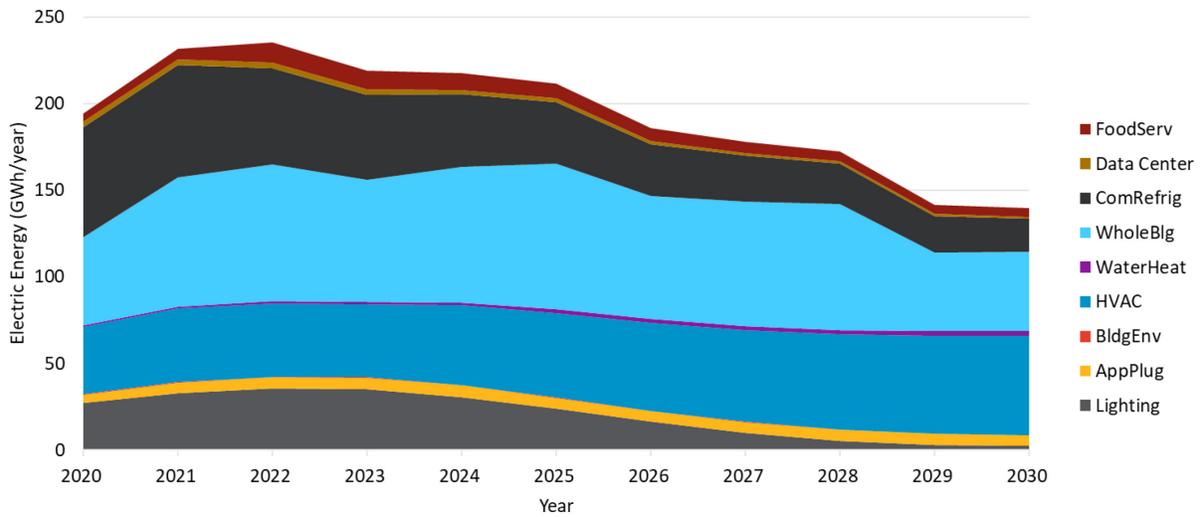


Figure 4-39. Statewide Commercial Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 4)

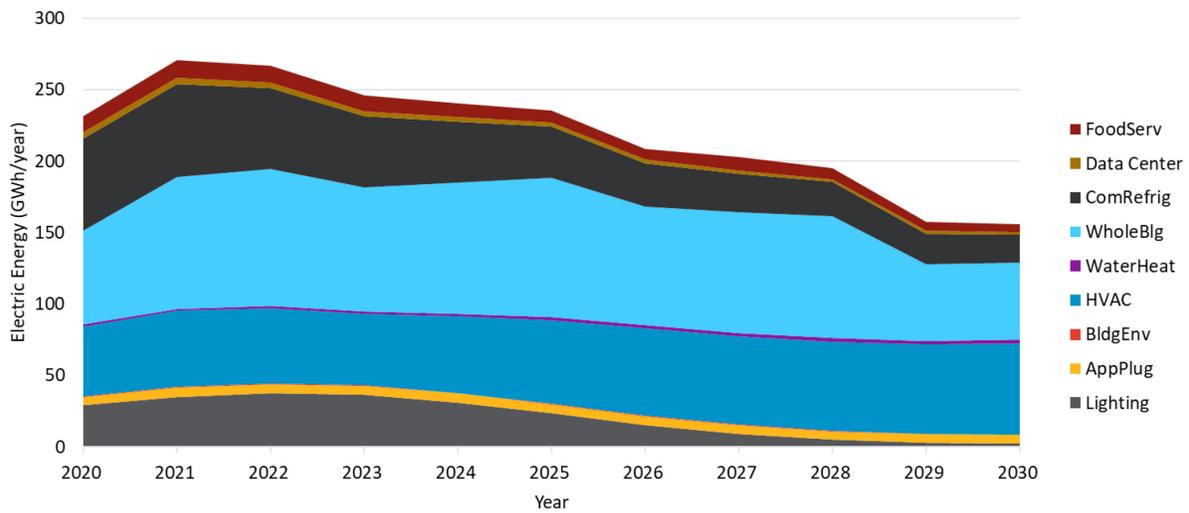


Figure 4-40 through Figure 4-44 show the breakdown of gas savings by end use in the commercial sector for each scenario. Key observations from these figures include the following:

- In contrast with the residential sector and past studies, there are no significant negative gas savings due to interactive effects from lighting measures because there is little electric potential from lighting measures.
- Among end-use categories that capture potential from discrete measures, food service and water heating dominate potential in the commercial sector, followed by HVAC measures across all scenarios. Unlike the residential sector, one or more HVAC measures is cost-effective under all scenarios throughout the forecast period.
- Commercial whole building potential also contributes to overall potential across all scenarios and is generally comparable to other end-use categories.
- Unlike electric potential, overall potential is relatively flat over the forecast period across all scenarios as most gas measures have long lifetimes and do not turn over as fast. As such, there continues to be opportunity for first-time adopters in the market, which does not saturate as fast.

Figure 4-40. Statewide Commercial Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Reference)

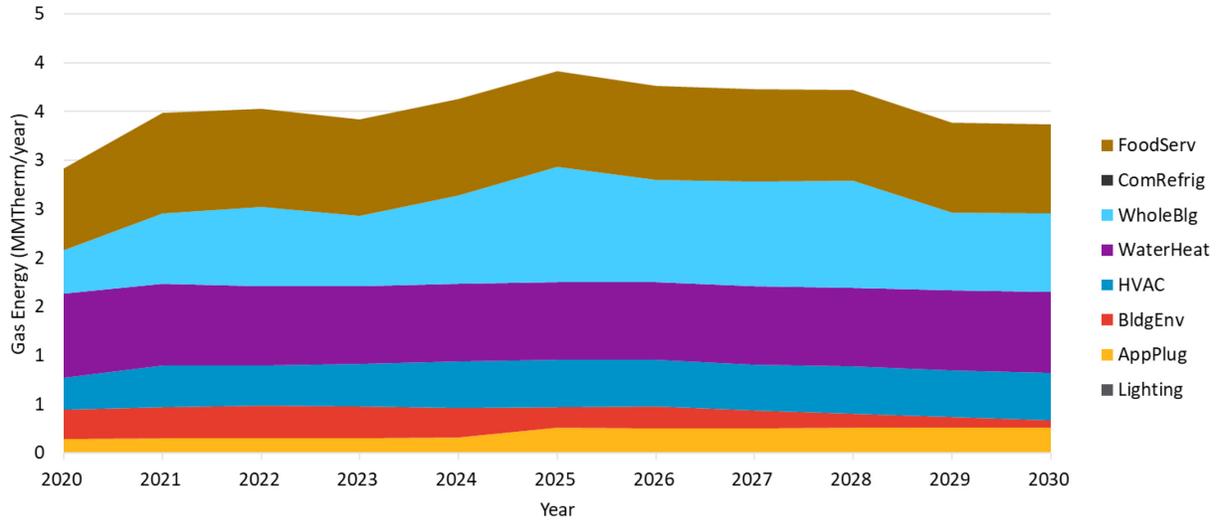


Figure 4-41. Statewide Commercial Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 1)

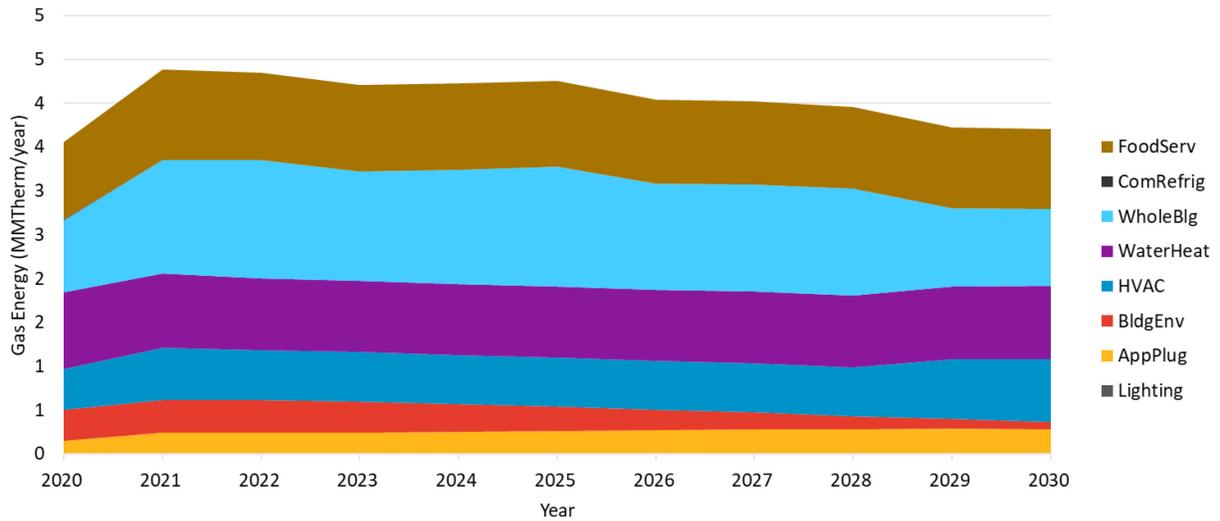


Figure 4-42. Statewide Commercial Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 2)

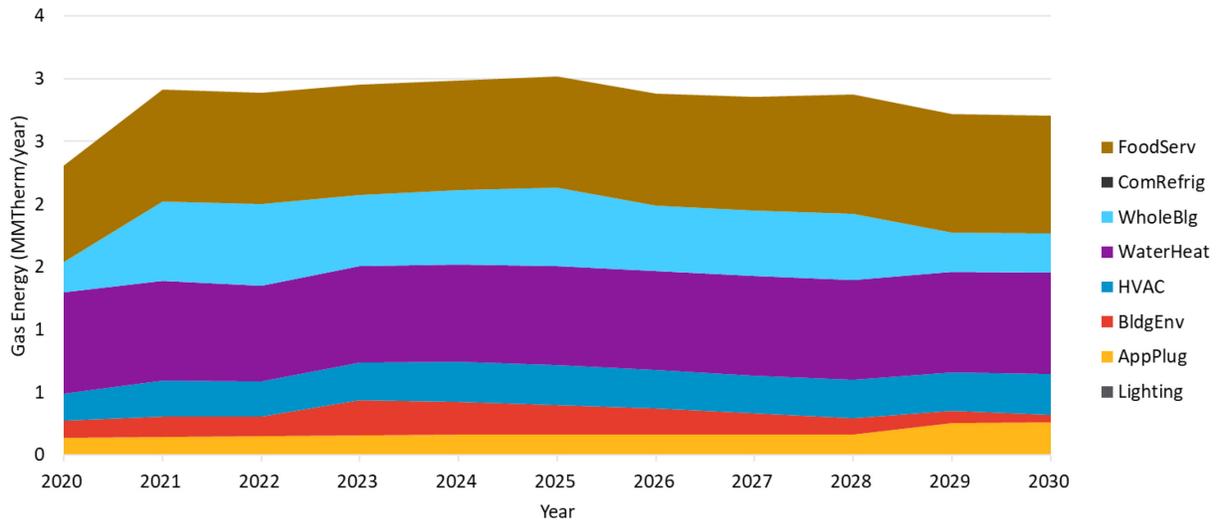


Figure 4-43. Statewide Commercial Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 3)

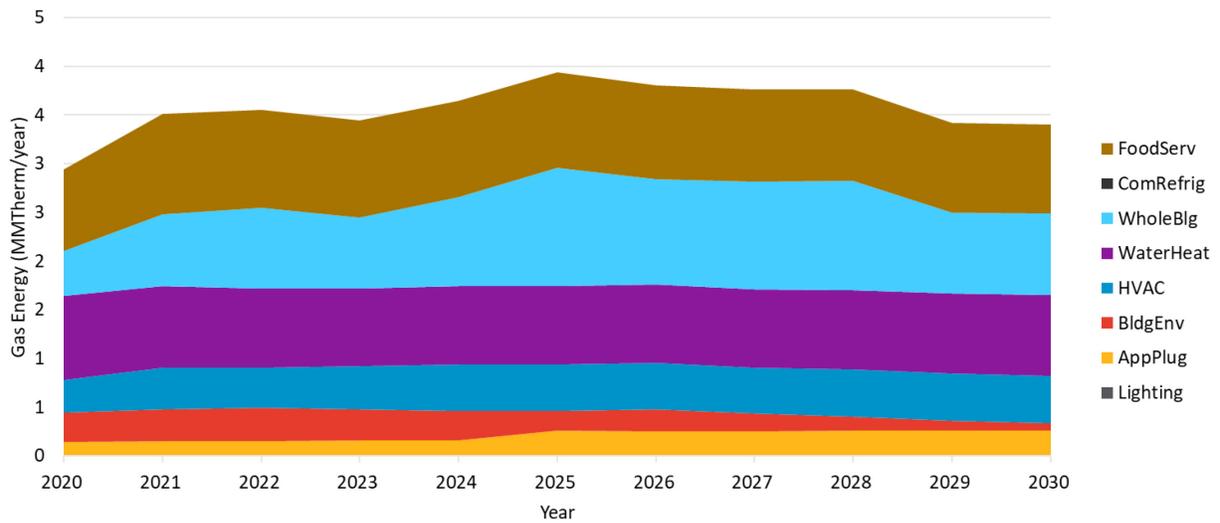
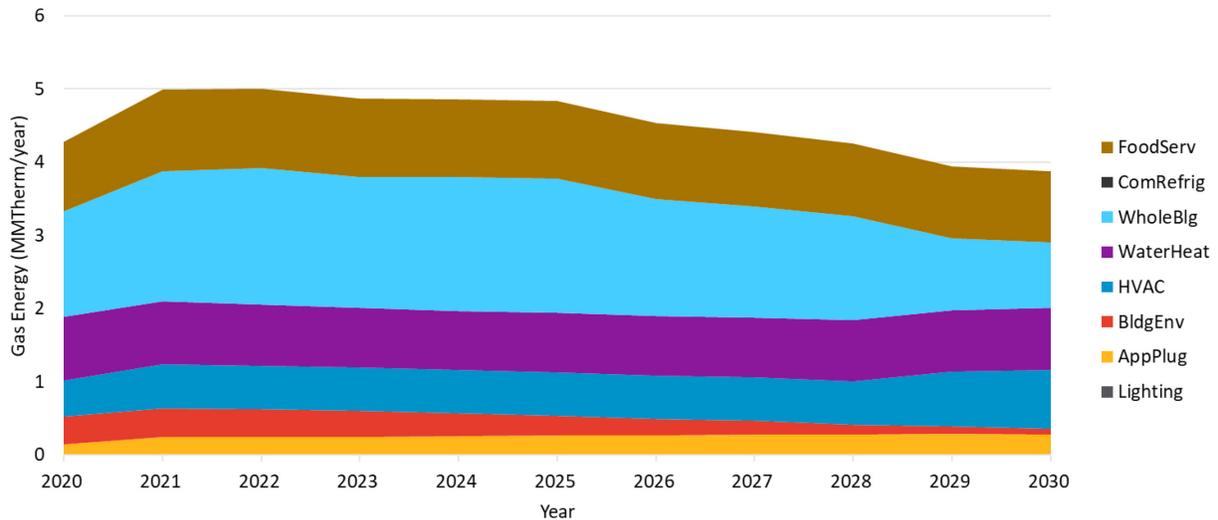


Figure 4-44. Statewide Commercial Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 4)



4.1.3.4 AIMS Rebate Programs

Figure 4-45 through Figure 4-49 show the breakdown of electric savings by end use in the AIMS sectors for each scenario. Key observations from these graphs are:

- Among end-use categories that capture potential from discrete measures that produce deemed savings, whole building dominates electric potential in the agriculture and industrial sectors, followed by machine drive and lighting measures across all scenarios.
- The whole building end-use category represents potential from generic custom measures and emerging technologies in the agriculture and industrial sectors. Potential from these measures contributes significantly to the agriculture and industrial sectors across all scenarios and is expected to increase over time. These measures are tagged into the whole building end use because it represents a broad array of opportunities across all end uses.
- The mining sector, which is made up of oil and gas extraction equipment, contributes minimally to overall potential across all scenarios.
- Only one street lighting measure, advanced lighting controls, contributes a steady amount of potential across the forecast period across all scenarios.
- Potential from individual technologies in the agriculture and industrial sectors ramps down over the forecast period across all scenarios. To align with historic program activity and the characteristics of the market, the calibration process saw a significant majority of the potential being realized between 2013 and 2018. Thus, the forecast years reflect less opportunity and an increasingly saturated market over time. This decrease in potential from deemed savings is somewhat made up for toward the end of the forecast period by increased potential from emerging technologies.

Figure 4-45. Statewide AIMS Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Reference)

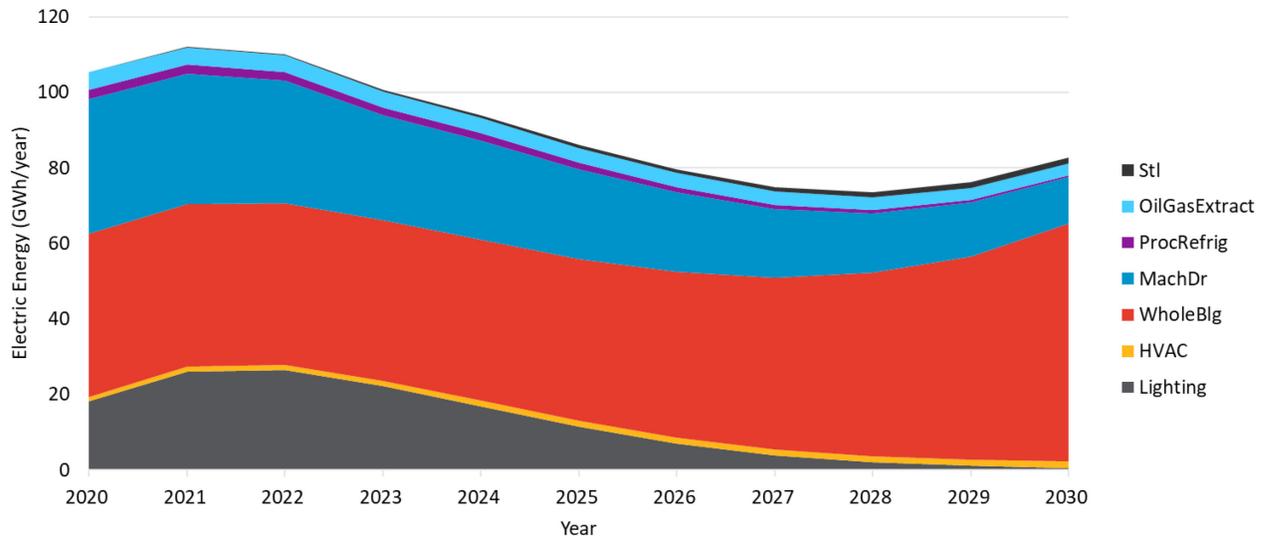


Figure 4-46. Statewide AIMS Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 1)

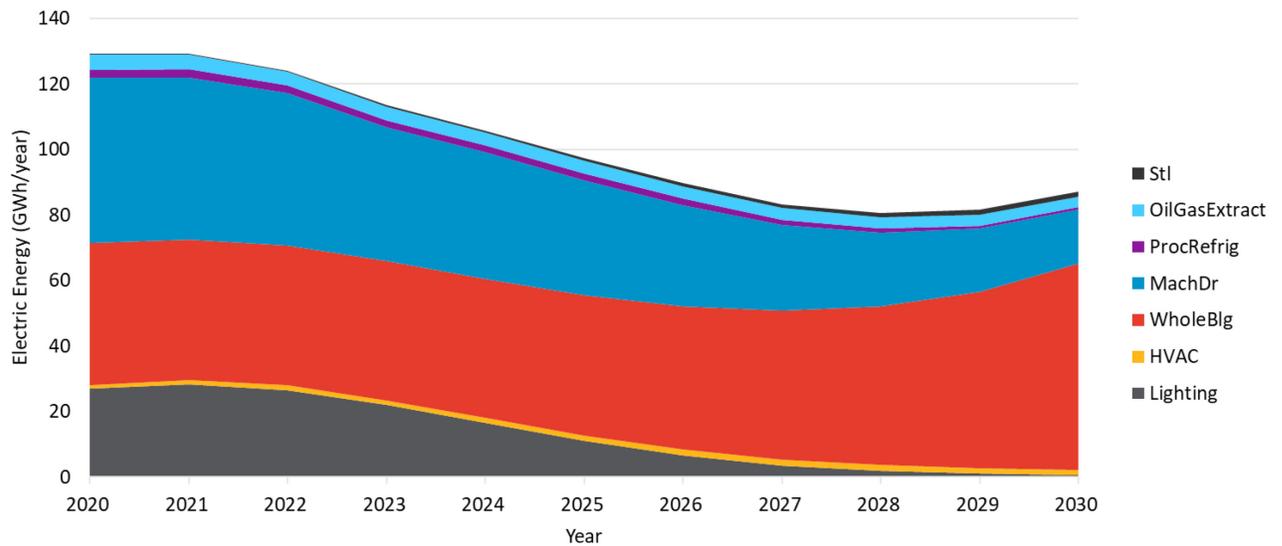


Figure 4-47. Statewide AIMS Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 2)

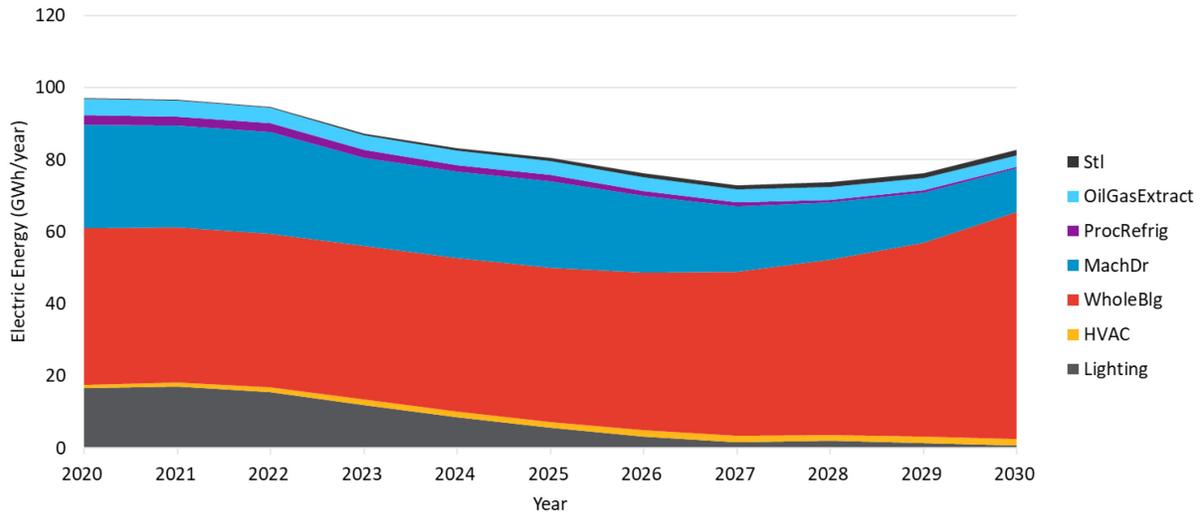


Figure 4-48. Statewide AIMS Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 3)

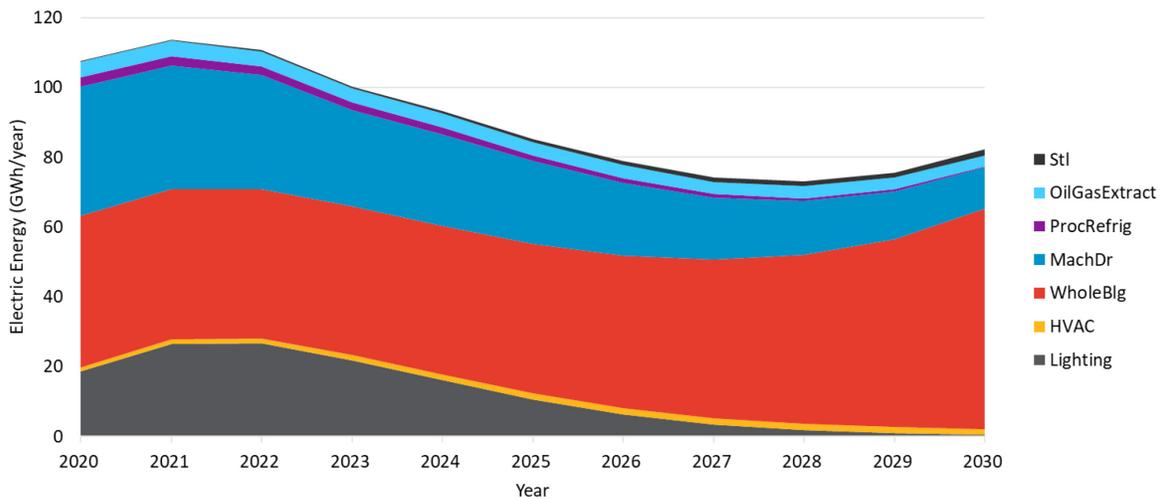


Figure 4-49. Statewide AIMS Incremental Electric Market Potential by End Use for Equipment Rebate Programs (Alternative 4)

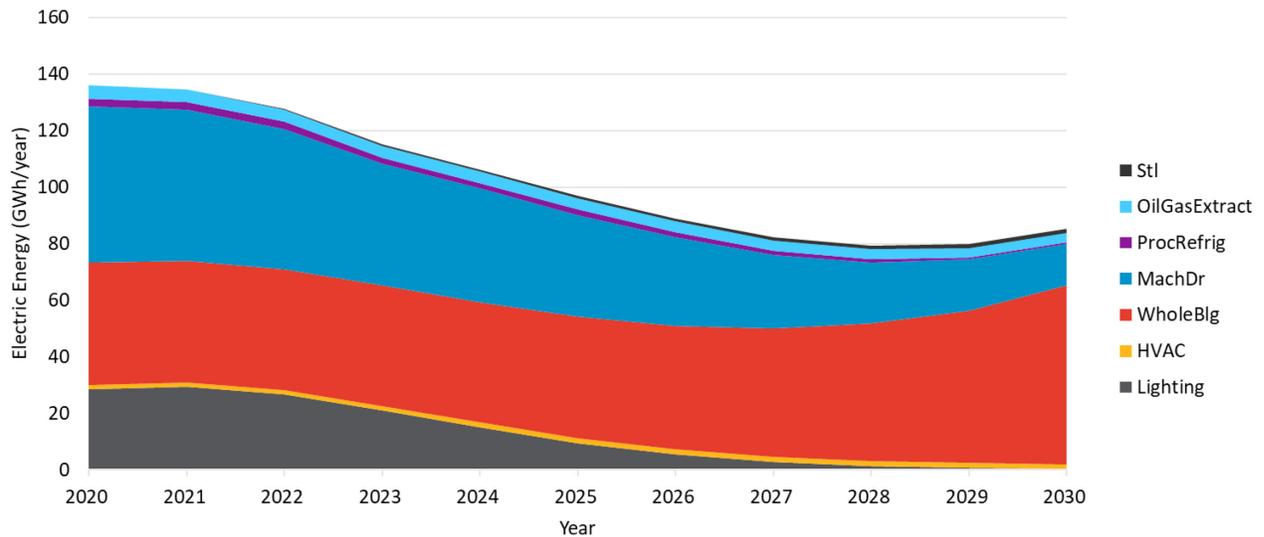


Figure 4-50 through Figure 4-54 show the breakdown of gas savings by end use in the AIMS sectors for each scenario. Key observations from these figures include the following:

- The whole building end-use category represents potential from generic custom measures and emerging technologies in the agriculture and industrial sectors. Potential from these measures contributes significantly to the agriculture and industrial sectors and is expected to increase over time across all scenarios.
- Among end-use categories that capture potential from discrete measures that produce deemed savings, process heat dominates gas potential in the agriculture and industrial sectors, followed by HVAC across all scenarios.
- The variation and spikes in potential for process heating is a result of different C-E threshold screens across the five scenarios. Process heating measures become cost-effective in different years of the forecast depending on the threshold used. For example, in Alternative 2, a TRC threshold of 1.25 is used, delaying the introduction of significant cost-effective potential until 2026, whereas Alternative 1 (using a threshold of 0.85) shows significant cost-effective potential starting in 2020.

Figure 4-50. Statewide AIMS Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Reference)

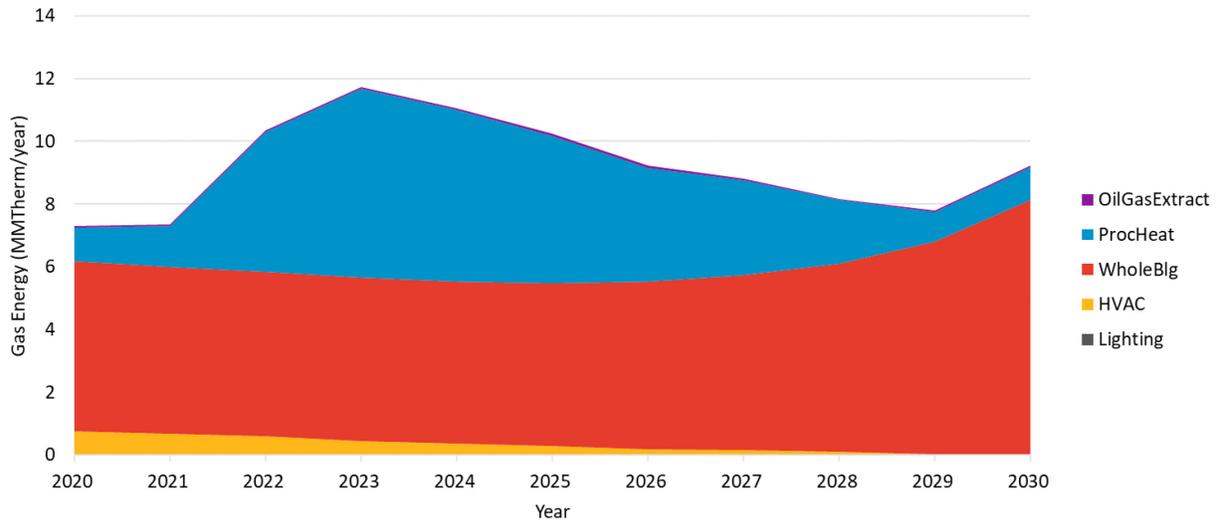


Figure 4-51. Statewide AIMS Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 1)

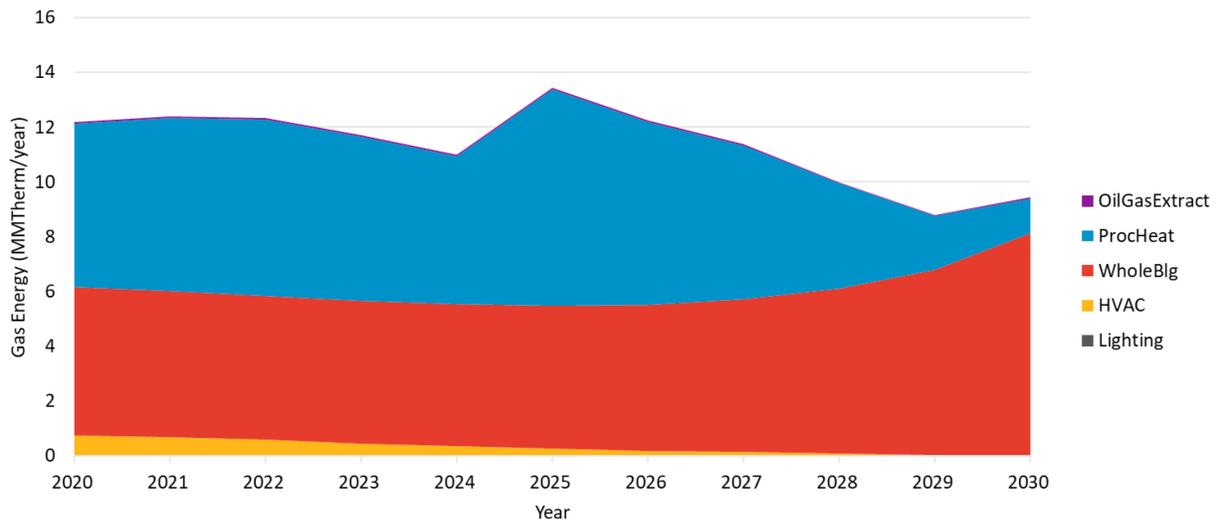


Figure 4-52. Statewide AIMS Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 2)

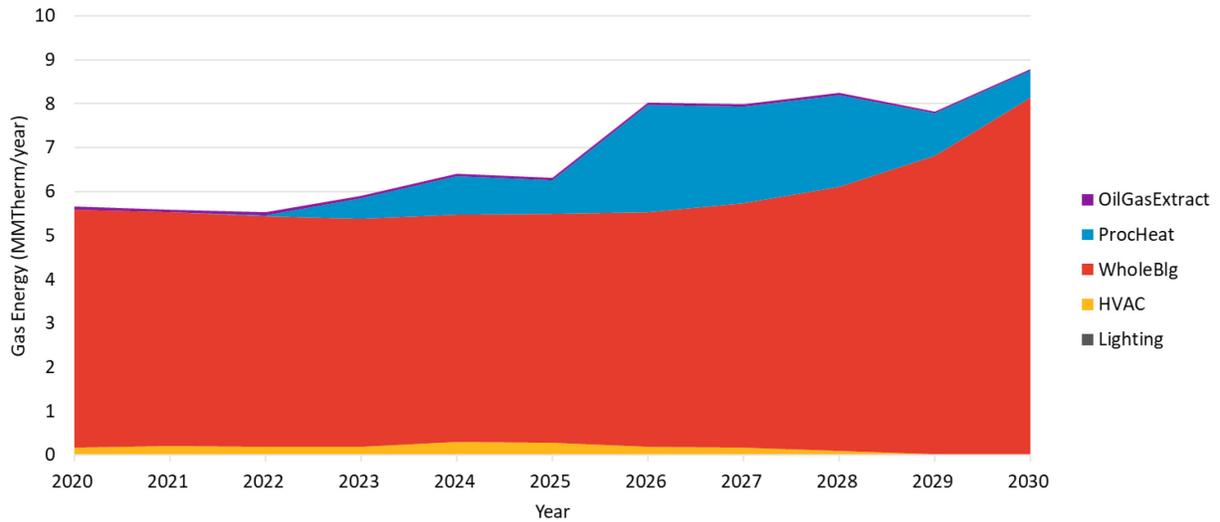


Figure 4-53. Statewide AIMS Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 3)

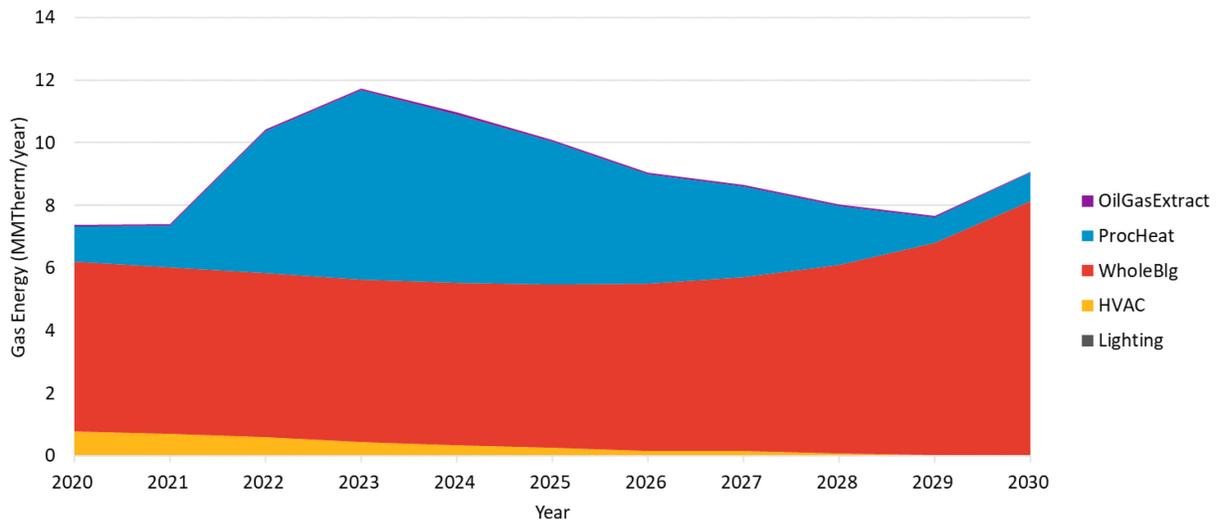
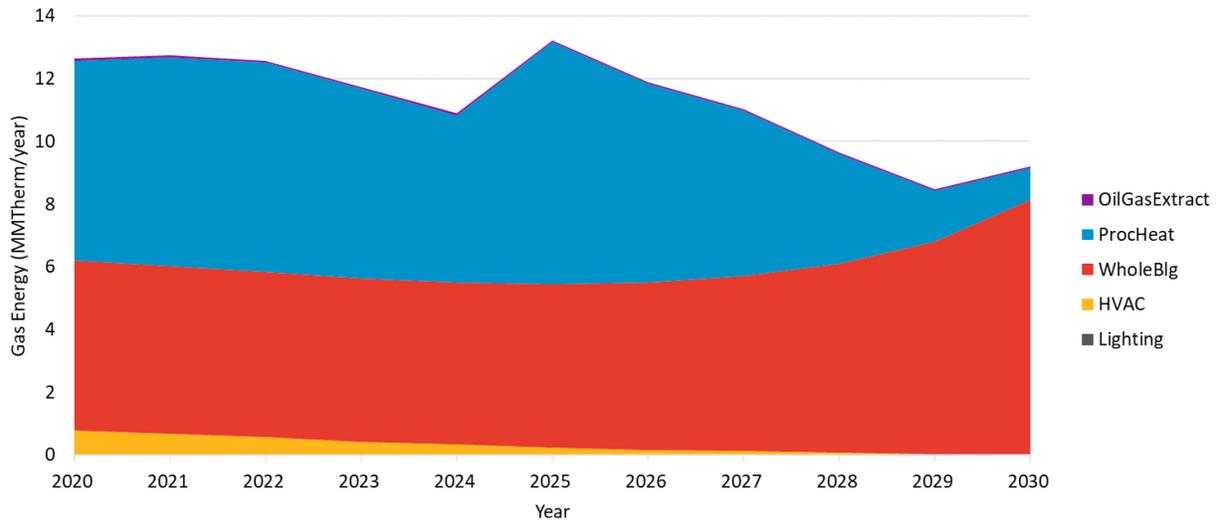


Figure 4-54. Statewide AIMS Incremental Gas Market Potential by End Use for Equipment Rebate Programs (Alternative 4)



4.1.3.5 Below Code Potential

Figure 4-55 through Figure 4-59 show the breakdown of electric below code potential by end use across all sectors for each scenario. These savings are captured through AR decisions in the model prompted by the availability of rebates for upgrading existing below code equipment. The Navigant team assumes that these rebates will be available starting in 2018 in the model. HVAC and water heating make up the majority of below code potential for both electric and gas fuel types.

Figure 4-55. Statewide Below Code Electric Potential by End Use for All Sectors (Reference)

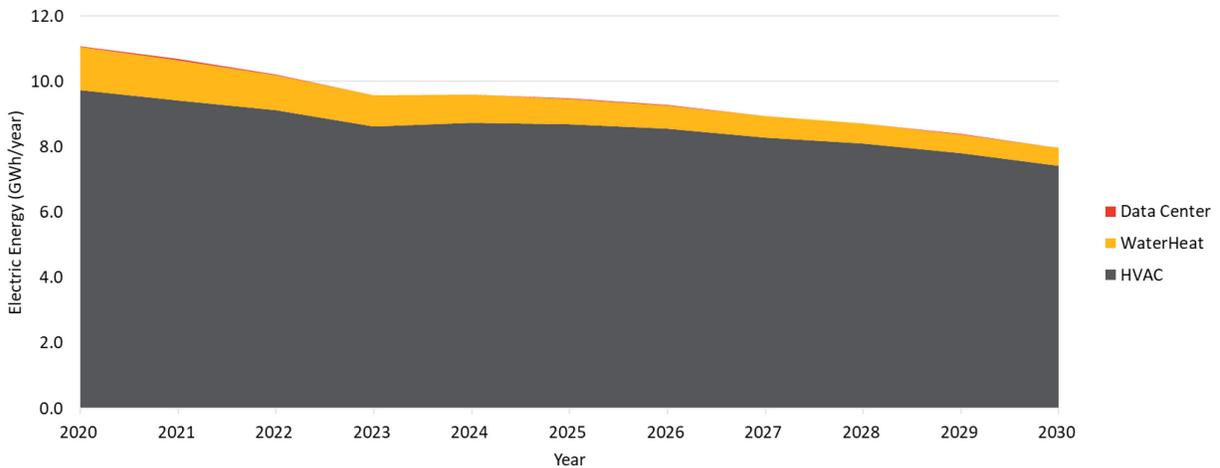


Figure 4-56. Statewide Below Code Electric Potential by End Use for All Sectors (Alternative 1)

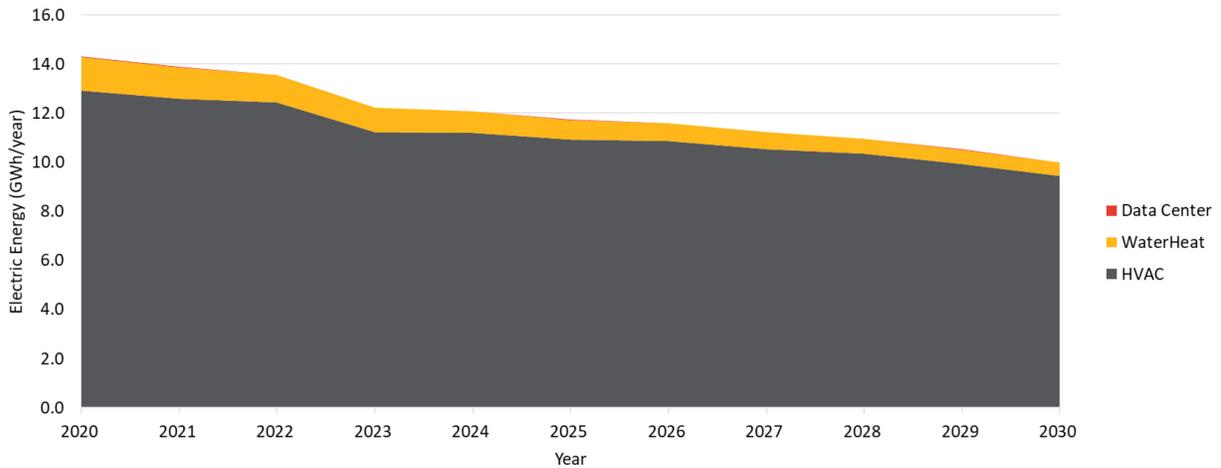


Figure 4-57. Statewide Below Code Electric Potential by End Use for All Sectors (Alternative 2)

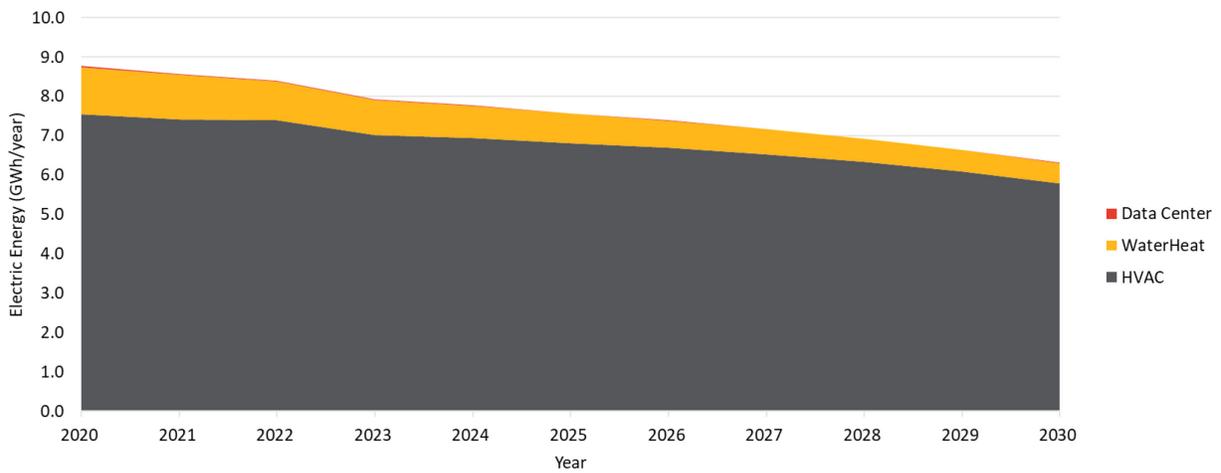


Figure 4-58. Statewide Below Code Electric Potential by End Use for All Sectors (Alternative 3)

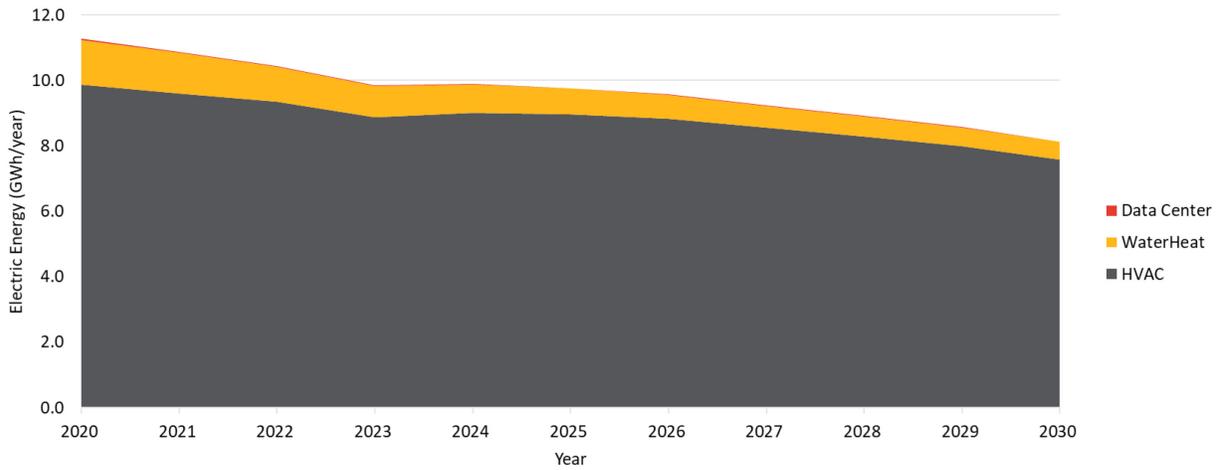


Figure 4-59. Statewide Below Code Electric Potential by End Use for All Sectors (Alternative 4)

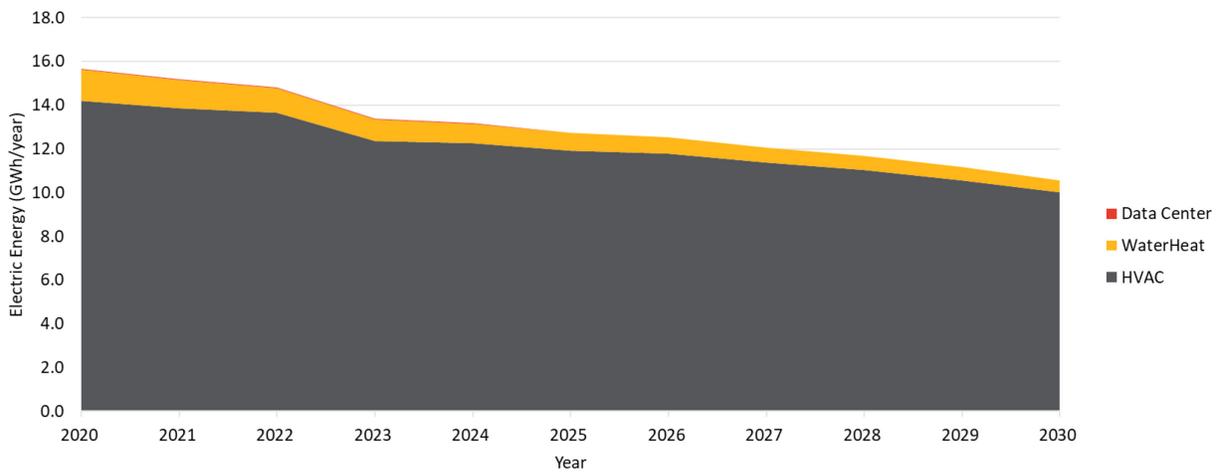


Figure 4-60 and Figure 4-64 show the breakdown of gas below code potential by end use across all sectors.

Figure 4-60. Statewide Below Code Gas Potential by End Use for All Sectors (Reference)

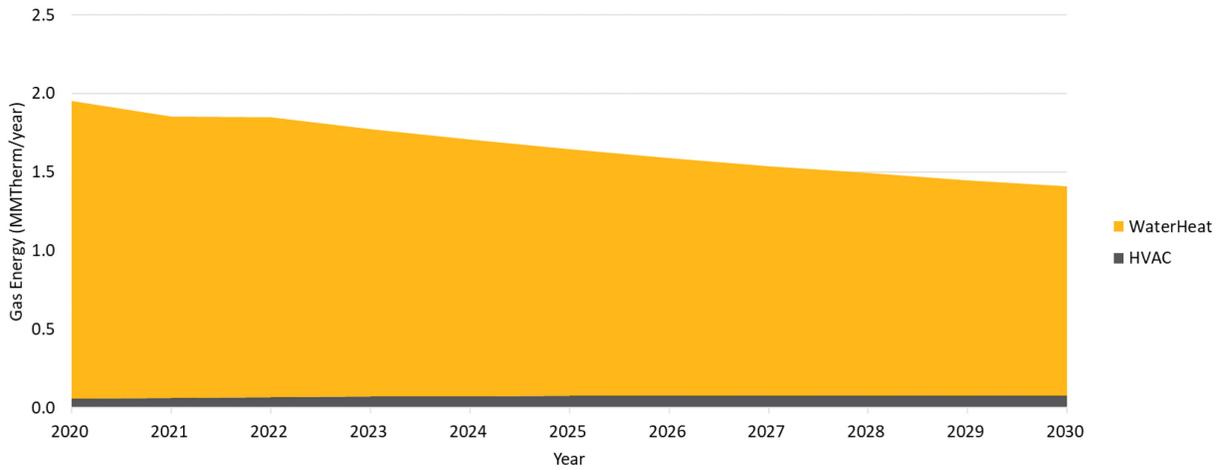


Figure 4-61. Statewide Below Code Gas Potential by End Use for All Sectors (Alternative 1)

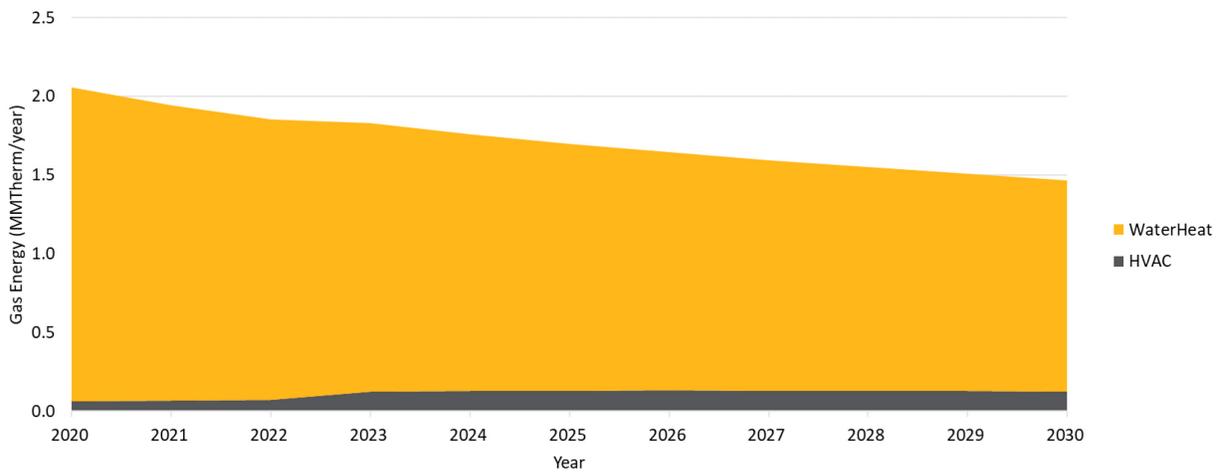


Figure 4-62. Statewide Below Code Gas Potential by End Use for All Sectors (Alternative 2)

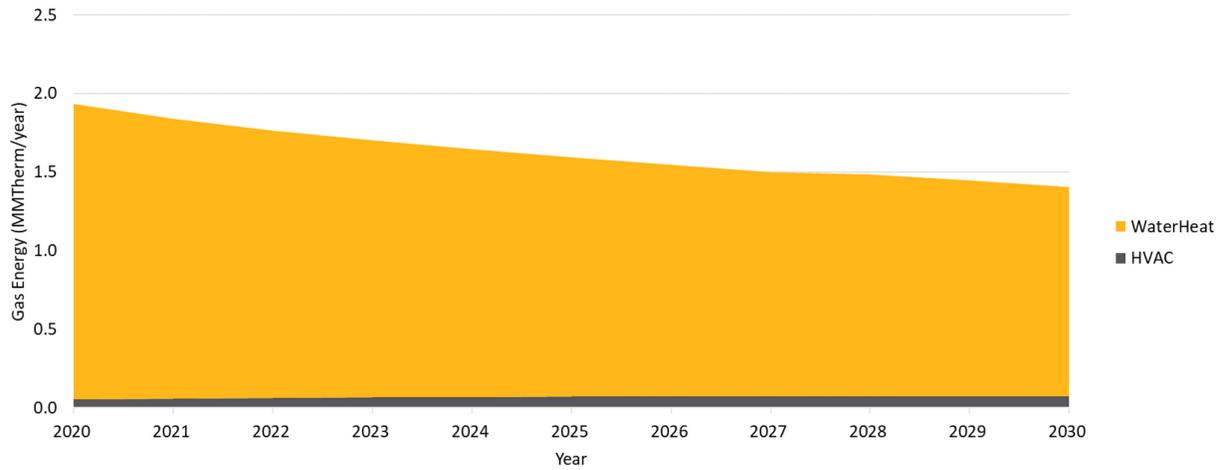


Figure 4-63. Statewide Below Code Gas Potential by End Use for All Sectors (Alternative 3)

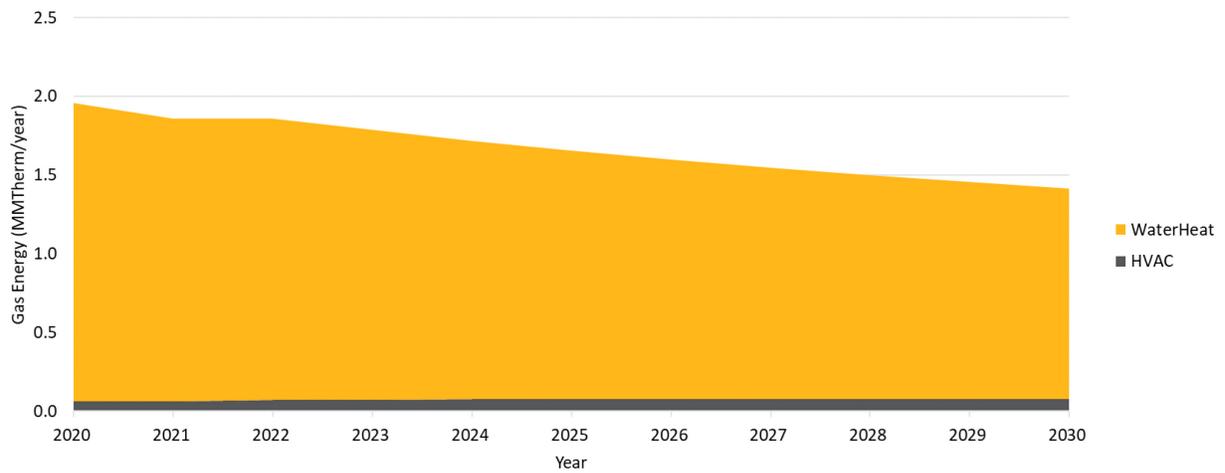
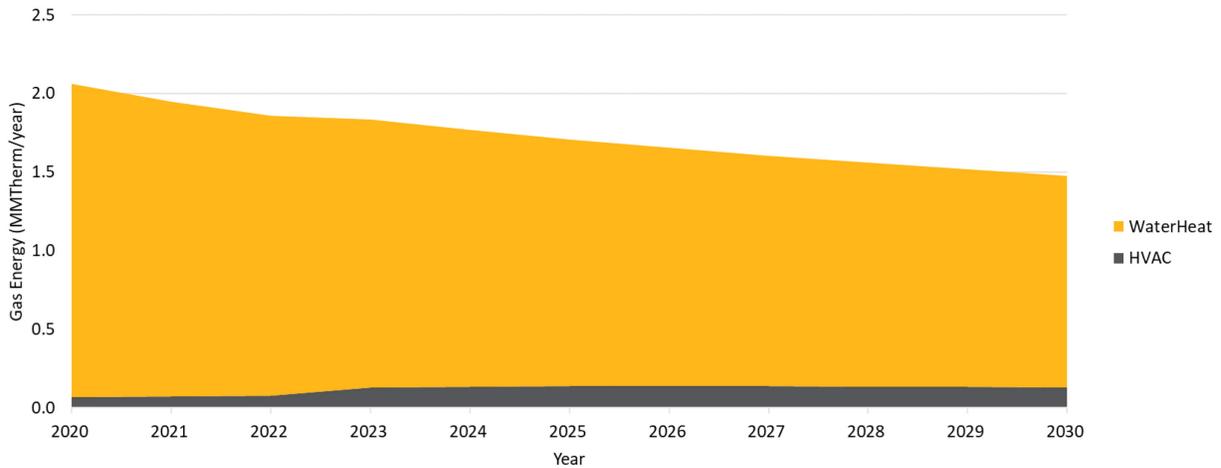


Figure 4-64. Statewide Below Code Gas Potential by End Use for All Sectors (Alternative 4)



4.1.3.6 Portfolio Cost-Effectiveness

The Navigant team calculated the cost-effectiveness (TRC, PAC, and RIM)⁷¹ for the portfolio of forecast measures under the equipment rebate programs for each IOU and each scenario. Several caveats are noted on these results:

- These results account for benefits and costs from rebated measures that contribute to equipment savings but exclude low income, C&S savings, BROs, and industrial/agricultural generic custom and emerging technologies.
- Results exclude several cost categories that would typically be accounted for in a portfolio-level C-E assessment (i.e., non-resource program costs).
- Program non-incentive costs are estimated based on past program years; these could vary in the future.

Figure 4-65 through Figure 4-68 show the TRC for each IOU across each scenario. Alternative 2 generally has the highest TRC given it uses the most restrictive TRC threshold for measures (1.25), while Alternatives 1 and 4 have the lowest TRC (use the least restrictive threshold). Overall, all scenarios for all utilities show a TRC greater than 1.0. All TRC values are above 1.25 except for Alternative 1 and Alternative 4 scenarios for PG&E in 2020.

⁷¹ TRC - Total Resource Cost. PAC - Program Administrator Cost. RIM - Ratepayer Impact Measure.

Figure 4-65. PG&E – TRC of Forecasted Rebate Program Scenarios

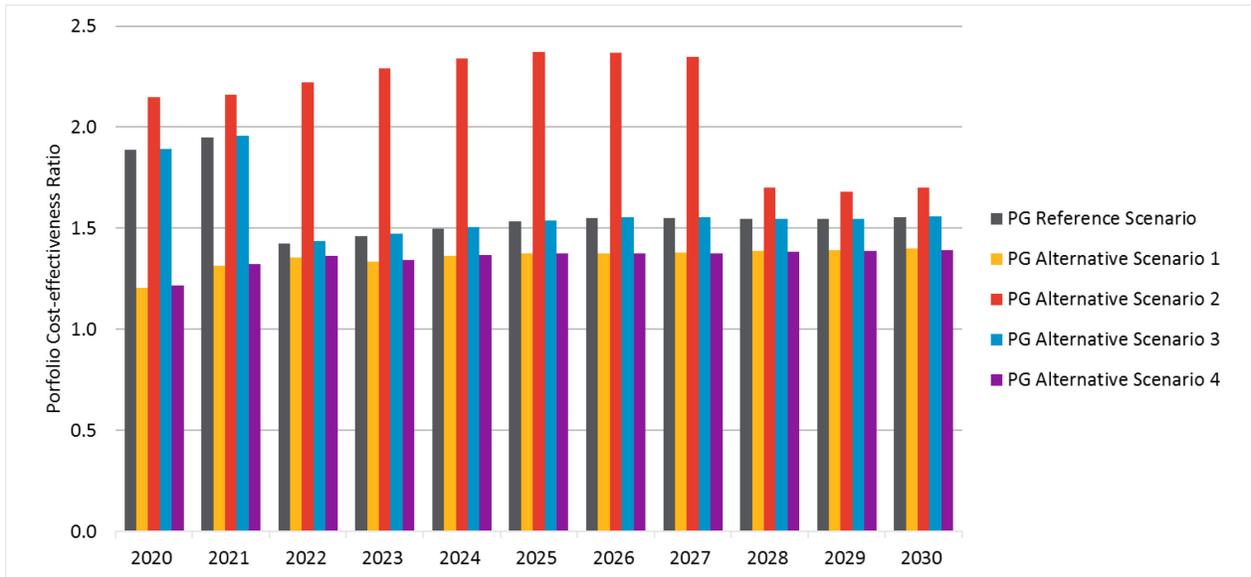


Figure 4-66. SCE – TRC of Forecasted Rebate Program Scenarios

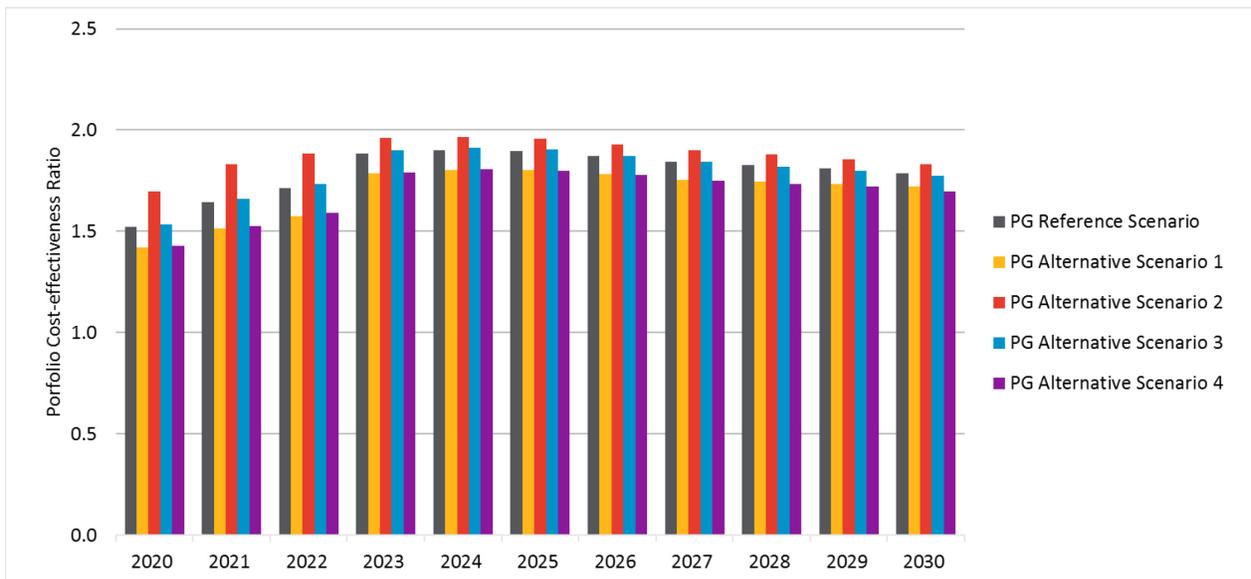


Figure 4-67. SCG – TRC of Forecasted Rebate Program Scenarios

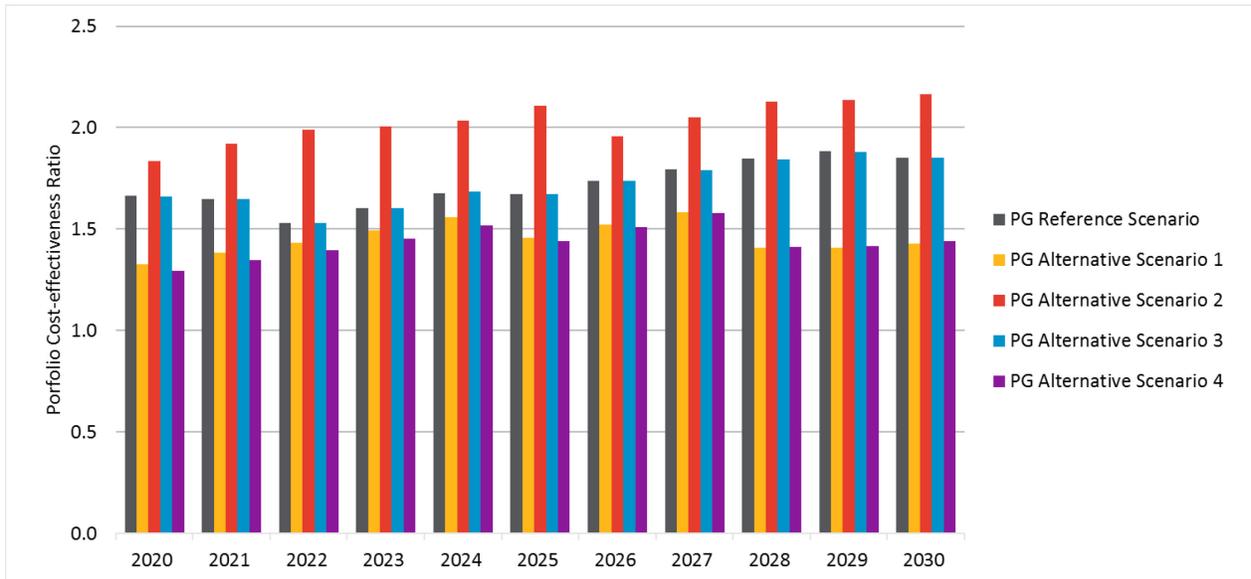
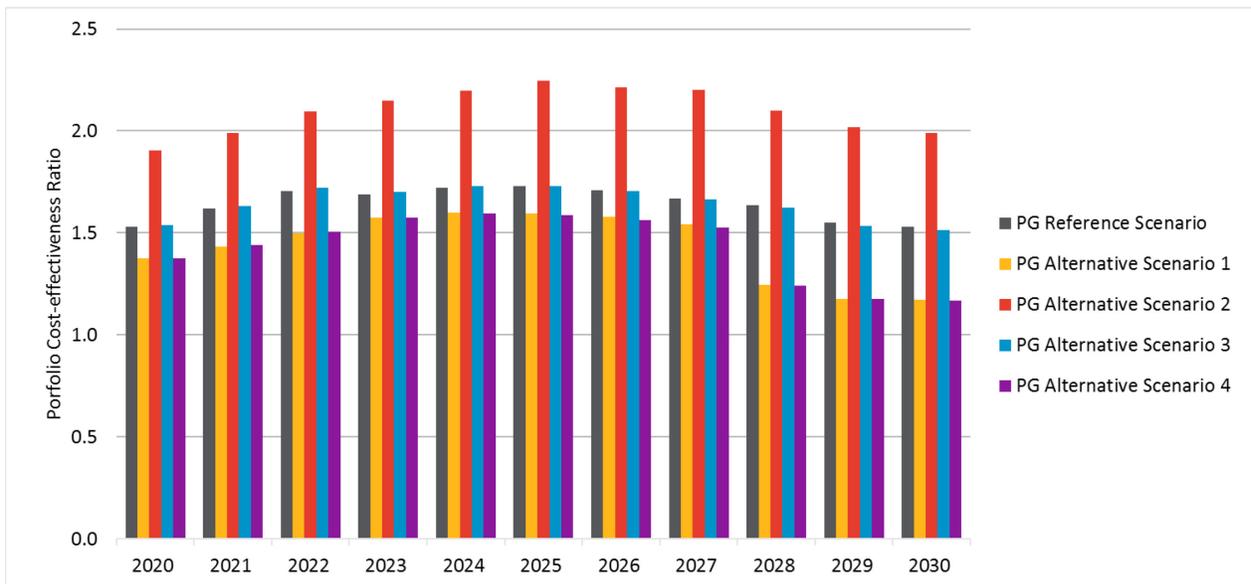


Figure 4-68. SDG&E – TRC of Forecasted Rebate Program Scenarios



4.1.4 BROs Scenario Results

This section presents incremental savings and program spending on BROs interventions under the reference and aggressive scenarios. The reference case includes only programs proven to be cost-effective through the TRC test screen, while the aggressive case includes all BROs programs characterized and assumes more aggressive adoption rates due to ramped up program delivery approaches relative to the reference case. Additional versions of figures appearing in this section for each IOU and including peak demand savings can be found in the results viewer.

Similar to 2017 Study results, the reference scenario is led by savings from HERs, as illustrated in Figure 4-69 and Figure 4-70. As such, program spending is also estimated to be led by HERs (Figure 4-71). HERs is one of the largest and most well studied existing interventions with reliable California data upon which to base a forecast.

Web-based, real-time feedback, BIEMS, building benchmarking, SEM, and the UAT also represent the highest impact interventions after HERs. Savings from all interventions increase over time as the Navigant team expects enrollment in programs to gradually increase. Additional details about penetration rates can be found in Appendix C.

Figure 4-69. BROs Electric Savings – Reference Scenario

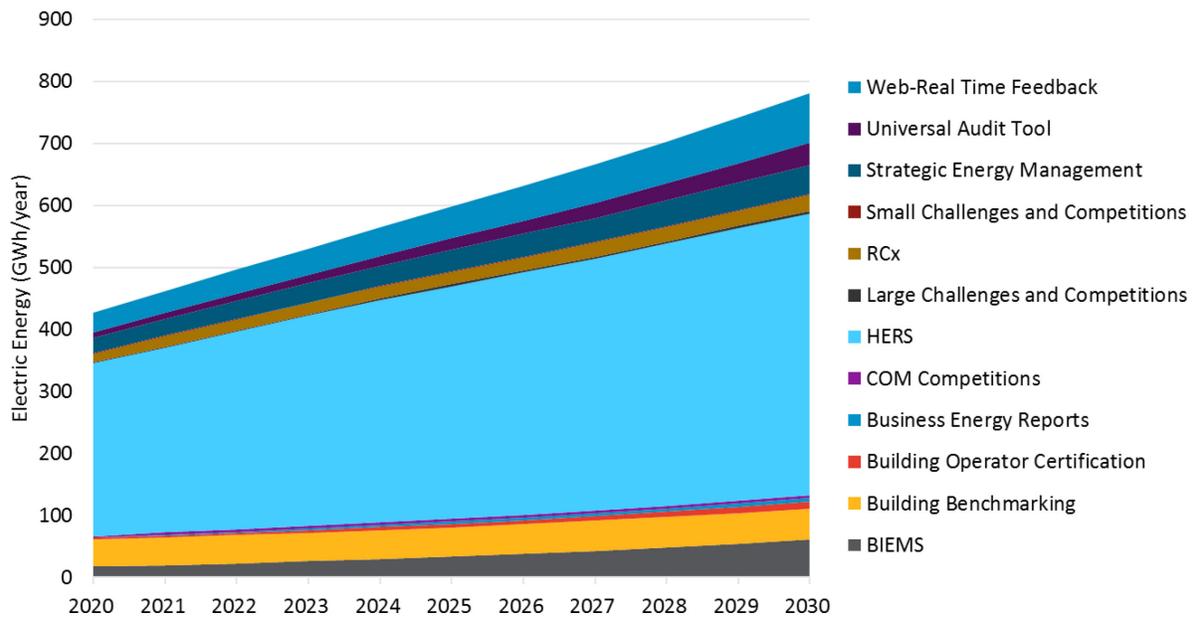


Figure 4-70. BROs Gas Savings – Reference Scenario

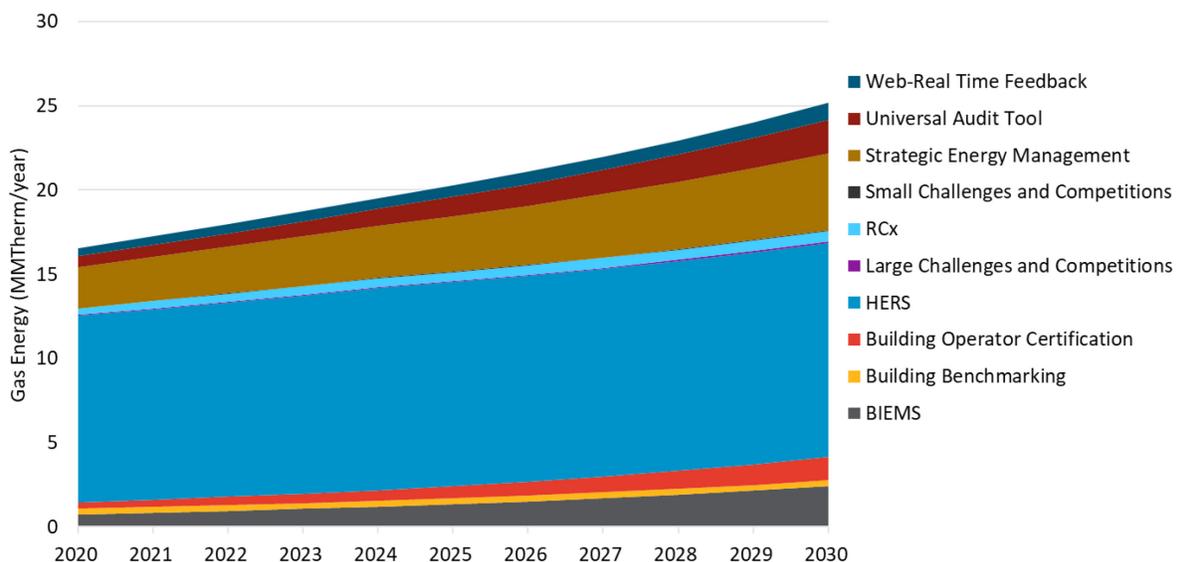
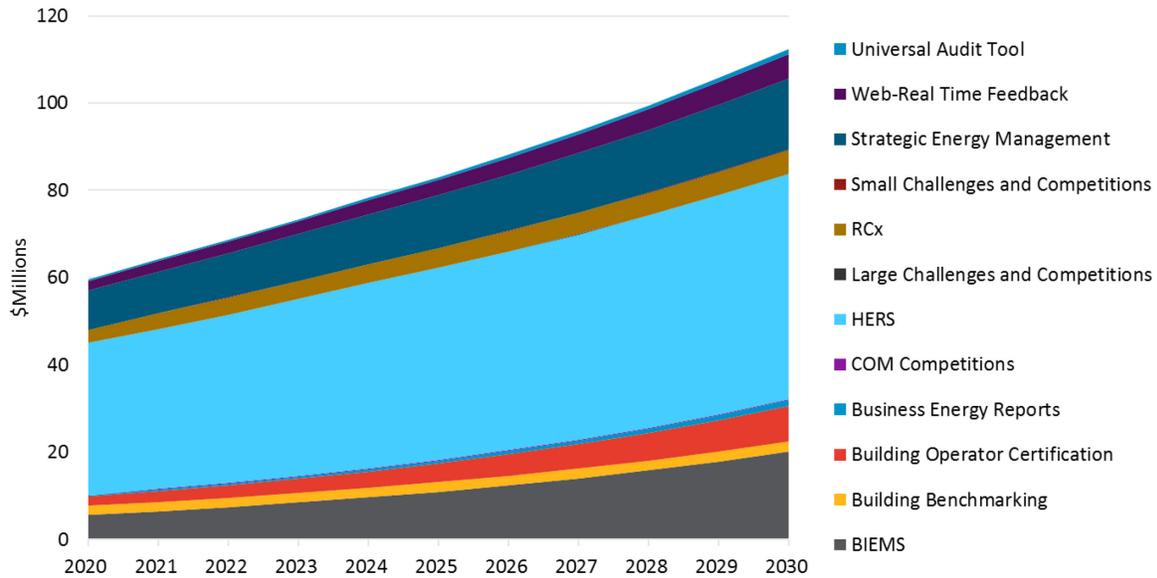


Figure 4-71. BROs Program Spending – Reference Scenario



The aggressive scenario still shows a large portion of savings originating from HERs through the forecast period (Figure 4-72 and Figure 4-73). The five highest impact interventions after HERs programs are BIEMS, web-based, real-time feedback, the UAT, building benchmarking, and SEM, which combine for 41% of overall BROs savings forecast in 2030. The aggressive scenario contains savings from in-home displays, while the reference scenario left this measure out due to its low cost-effectiveness. Savings and spending (Figure 4-74) in the aggressive scenario are just short of a doubling of the reference scenario.

Figure 4-72. BROs Electric Savings – Aggressive Scenario

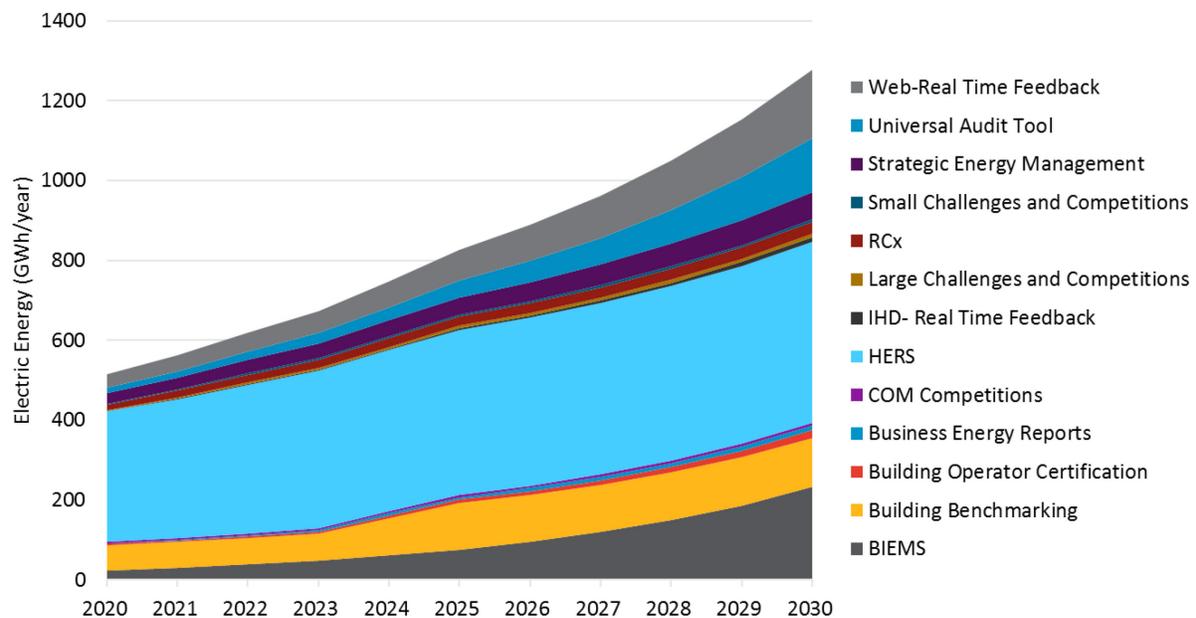


Figure 4-73. BROs Gas Savings – Aggressive Scenario

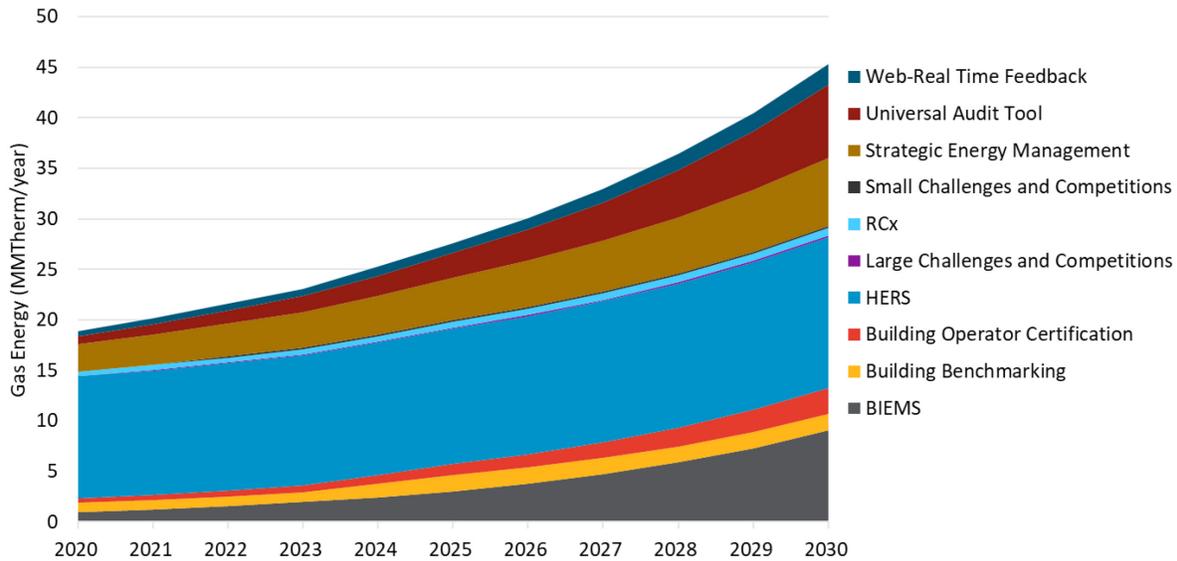
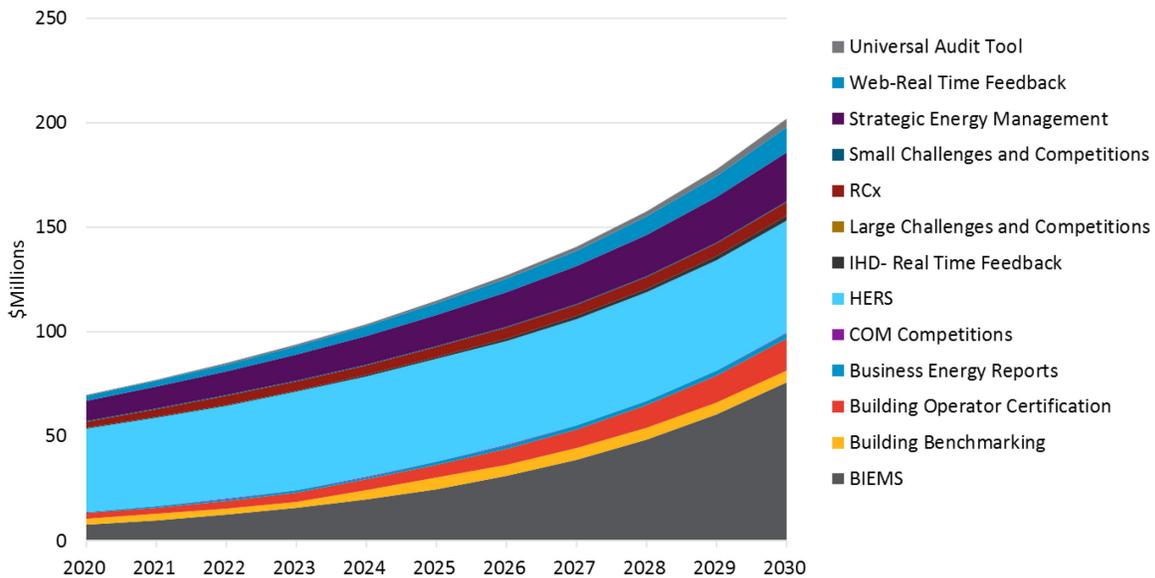


Figure 4-74. BROs Program Spending – Aggressive Scenario



4.2 C&S Savings

Incremental annual savings from C&S are illustrated in Figure 4-75 and Figure 4-76. Savings from C&S are similar to those estimated in the 2017 Study. Key changes of note are listed below:

- IOU claims for 2019 Title 24 are lower than those savings estimated in the 2017 Study.
- This study includes estimates for 2022 Title 24; these were not previously included in the mid-case of the 2017 Study.

- This study includes additional/updated standards claimed by the IOUs not included in the 2017 Study.

The team performed a high level review of the estimates the IOUs provided in their claims. Furthermore, the team notes that some C&S not on the books are inherently uncertain. C&S savings estimates represent the best estimate based on available data.

Incremental savings seems to decrease in the outer years as the market impacted by a code or standard has completely turned over and savings from the retrofit market are no longer counted.

Figure 4-75. C&S Electric Savings (Including Interactive Effects)

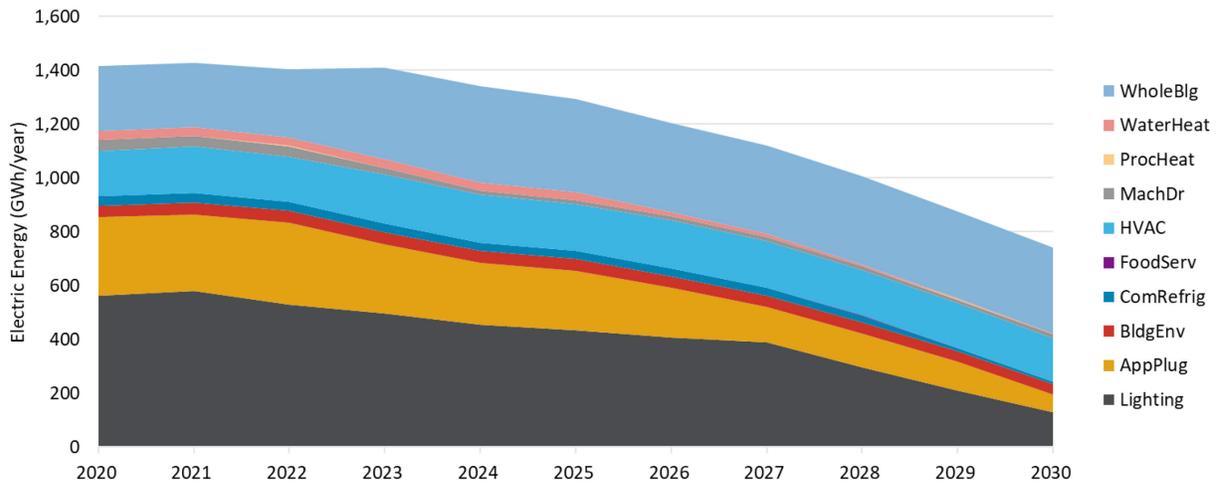
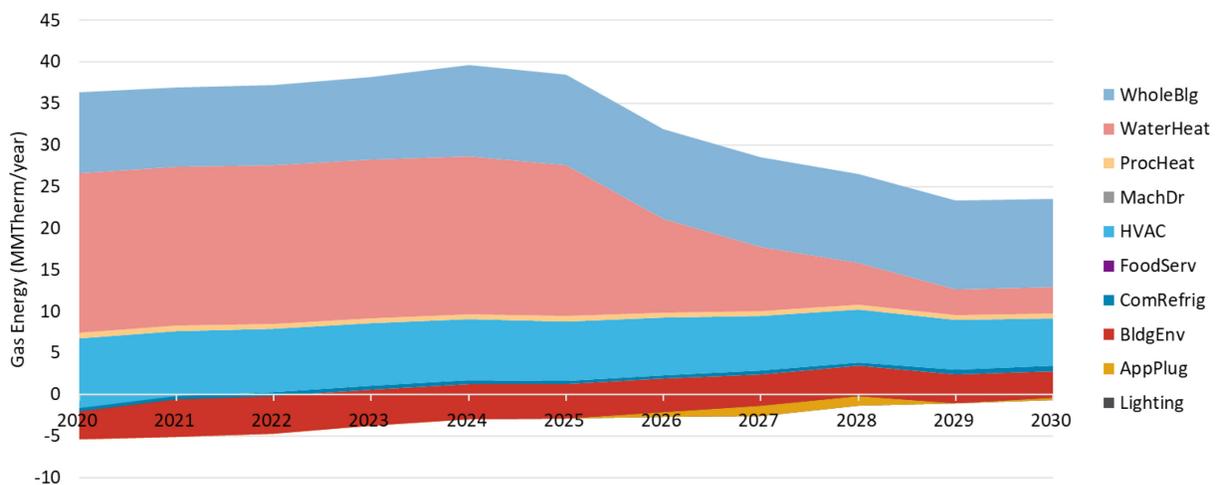


Figure 4-76. C&S Gas Savings (Including Interactive Effects)



Additional versions of Figure 4-75 and Figure 4-76 for each IOU and including peak demand savings can be found in the results viewer, under the Codes & Standards tab.

4.3 Detailed Study Results

Along with the model file and the summary results shown above, the Navigant team developed a web-based tool, the 2019 PG Results Explorer. The Results Explorer provides stakeholders the ability to manipulate and visualize model outputs. A separate database of measure-level results for rebate programs is also made available with this release.

The Results Explorer is a web-based tool that lets users explore the results of the five modeled scenarios in this study. Users can look at energy savings in terms of the total savings, incremental savings due to each program, cumulative savings over time, and the spending from the utility rebate programs; users can also see savings by the following:

- **Savings type:** Electrical energy, peak power demand, and natural gas
- **Service territory:** PG&E, SDG&E, SCE, and SCG
- **Scenario:** Five scenarios based on varying cost ratio thresholds and aggressiveness of program marketing by program administrators
- **Sector:** Covers residential, low income housing, commercial, industry, agriculture, mining, and street lighting
- **End-use category:** Includes appliances and plug loads, lighting, HVAC, data centers, process heat and refrigeration, oil and gas extraction, and food service

The full results viewer can be found at <https://bit.ly/2019-CA-Energy-Efficiency-PG-Study>.

4.3.1 Results Explorer Tabs

The Results Explorer consists of 12 tabs. The Welcome and Data Key tabs give a short overview of the project, viewing dimensionality, and key definitions used throughout the results tabs. The User Guide tab contains a detailed user's guide for the Results Explorer, including animated GIFs showing the process for changing graph dimensionality, drilling down into data, and exporting selected graphs to Excel and CSV formats. The remaining tabs allow users to view and slice data in a variety of ways, from high level statewide to granular utility and end-use-specific results. Results tabs include the following:

- **Market Potential:** Market potential is the EE savings that could be expected in response to specific levels of incentives and assumptions about market influences and barriers. Market potential is used to inform the utilities' EE goals, as determined by the CPUC. Data presented here includes all sources of savings examined in this study. Note that C&S savings includes interactive effects.
- **Program Spending:** Utility program spending includes incentives and non-incentive costs paid for equipment rebate programs (inclusive of low income) and BROs interventions. This data does not include costs associated with non-resource programs or C&S advocacy.
- **Savings Scenarios:** Detailed data on market potential across each of the five modeled scenarios. Dimensions include end use, building type, sector, and service territory. Market potential includes rebate programs, low income, and BROs. This tab does not include C&S savings.
- **Spending Scenarios:** Detailed data on program spending across each of the five modeled scenarios. Dimensions include sector, scenario, and service territory. Utility program spending includes incentives and non-incentive costs paid for equipment rebate programs and BROs

interventions. This data does not include costs associated with non-resource programs or C&S advocacy.

- Tech/Econ/Market Potential:** Detailed data on technical, economic, and cumulative market potential from IOU equipment rebate programs. These graphs do not show IOU claimable savings from behavior or C&S advocacy programs because the technical and economic potential for these sources are undefined. Technical potential is based on instantaneous potential, which is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve EE were taken. It does not account for equipment stock turnover. Economic potential is the subset of technical potential that is cost-effective under the relevant screening test in each scenario.
- Rebate Prog. Savings by End Use:** Detailed data on market potential from rebate programs (inclusive of low income programs) by end use, sector, building type, and service territory.
- Cost-Effectiveness:** C-E ratio compares total program benefits to total program costs for the portfolio of forecast measures under the equipment rebate programs for each IOU and each scenario. Tests define costs and benefits differently, and all are defined by the California Standard Practice Manual. The three cost tests shown are the TRC, PAC, and RIM tests.
- Behavior Programs:** Detailed data only for behavior, retrocommissioning, and operational efficiency (BROs) programs. Dimensions include building type, sector, and service territory. Results are viewed at the BROs measure level.
- Codes and Standards:** Detailed results only for C&S. Dimensions include end use, sector, and service territory. Results are shown in two forms: with and without interactive effects.

Each results tab includes a description of the viewable data, dynamic chart, drop down filters for available chart configuration dimensions, and instructions for frequently performed tasks. The viewer is illustrated in

Figure 4-77 and Figure 4-78.

Figure 4-77. Results Explorer Tab Configuration (Illustrative)

California Energy Efficiency Program Goals: Results Explorer

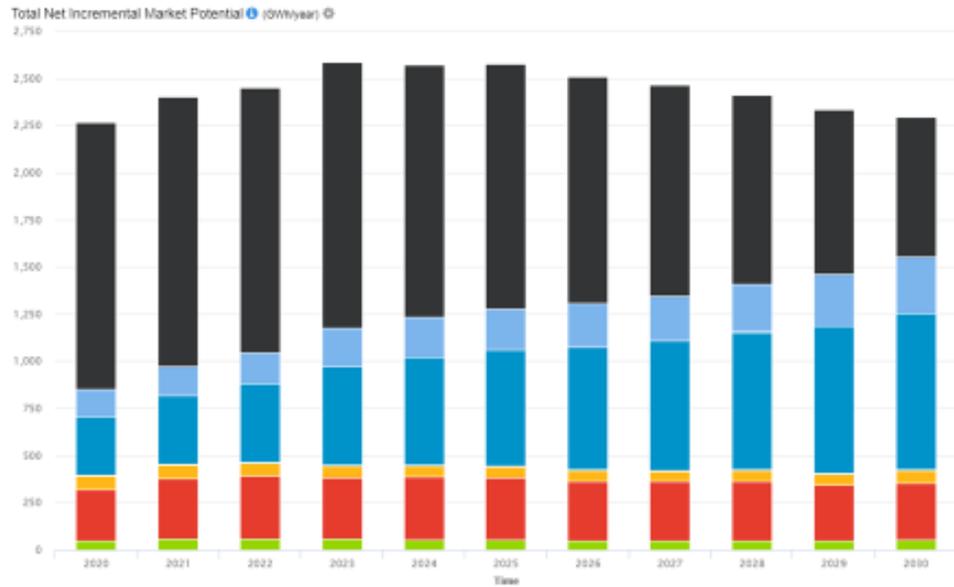
Market potential is the energy efficiency savings that could be expected in response to specific levels of incentives and assumptions about market influences and barriers. Market potential is used to inform the utilities' energy efficiency goals, as determined by the California Public Utilities Commission (CPUC). Data presented here includes all sources of savings examined in this study. Note that C&S savings includes interactive effects.

Description of Tab Data

Dynamic Chart

Adjustable Key Indexes

NAVIGANT



Sector:(all) Time:(all) Service Territory:(all)

Drag and drop any of the indexes listed below the graph to change the key index. Note that changing the x-axis from "Time" will not provide sensible results.

Click on any data series segment or marker point to access the list of drill down indexes.

Hover over the chart, then click the Gear icon to export data underlying the chart.

Instructions for Frequently Performed Tasks

Drop Down Filters for Chart Dimensionality

Market Potential Quantity

Incremental, Net

Definition

Net potential represents the difference in consumption with and without the program or measure having been implemented. Incremental potential considers only the first year the program or measure is implemented.

Scenario

PG Reference Scenario

Definition

"Business as usual" and the continuation of current policies. Cost effectiveness threshold of 1.

Savings Type

Electric Energy (GWh/year)

Service Territory

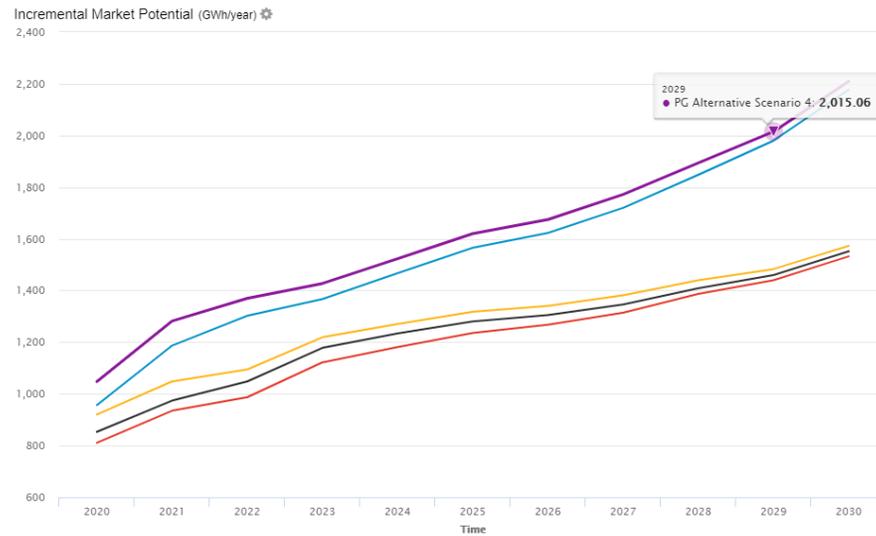
All

Figure 4-78. Results Explorer Scenario Comparison (Illustrative)

California Energy Efficiency Program Goals: Results Explorer

Detailed data on market potential across each of the 5 modeled scenarios. Dimensions include End Use, Building Type, Sector and Service Territory.

Market potential includes rebate programs, low income, and BROs.



Incentive Program Quantity
Incremental Market Potential

Definition
First year net savings from new program participants

Scenario
 PG Reference Scenario
 PG Alternative Scenario 1
 PG Alternative Scenario 2
 PG Alternative Scenario 3
 PG Alternative Scenario 4

Savings Type
Electric Energy (GWh/year)

Scenario:(all) Time:(all) End Use:(all) Building Type:(all) Sector:(all) Service Territory:(all)

- Drag and drop any of the indexes listed below the graph to change the key index. Note that changing the x-axis from "Time" will not provide sensible results.
- Click on any data series segment or marker point to access the list of drill down indexes.
- Hover over the chart, then click the Gear icon to export data underlying the chart.

APPENDIX A. CALIBRATION

A.1 Overview

Forecasting is the inherently uncertain process of estimating future outcomes by applying a model to historic and current observations. As with all forecasts, the PG Model results cannot be empirically validated a priori, as there is no future basis against which one can compare simulated versus actual results. Despite that all future estimates are untestable at the time they are made, forecasts can still warrant confidence when historic observations can be shown to reliably correspond with generally accepted theory and models.

Calibration provides both the forecaster and stakeholders with a degree of confidence that simulated results are reasonable and reliable. Calibration is intended to achieve three main purposes:

- Anchors the model in actual market conditions and ensures that the bottom-up approach to calculating potential can replicate previous market conditions.
- Ensures a realistic starting point from which future projections are made.
- Accounts for varying levels of market barriers and influences across different types of technologies. The model applies general market and consumer parameters to forecast technology adoption. There are often reasons why markets for certain end uses or technologies behave differently than the norm—both higher and lower. Calibration offers a mechanism for using historic observations to account for these differences.

The calibration process is not a regression of savings or spending (not drawing a future trend line of savings based on past program accomplishments). Rather, calibration develops parameters that describe the customer decision-making process and the velocity of the market based on recent history. Once these parameters are set, the model uses them as a starting point for the forecast period

The PG Model was calibrated in two steps. First, a draft calibration was conducted based on historic data from 2013 through 2016. Second, the draft calibrated results were reviewed with stakeholders to incorporate effects post-2017 and the collective insights of stakeholders on how the future may differ from the past.

Step 1 calibrated by reviewing portfolio data from 2013 through 2016⁷² to assess how the market has reacted to program offerings in the past. The calibration starts in 2013 because a key input to the model (equipment saturation data) was based on data collected in the 2012-2013 timeframe. Thus, the model must begin in the same year that its equipment stock data begins.

Step 2 allows for calibration to account for more recent changes to programs. The Navigant team held a workshop on March 21, 2019 to present preliminary draft results of the residential, commercial and industrial sectors to stakeholders. Following the presentation was a discussion of the following:

⁷² Calibration extends through 2016 rather than 2017 or 2018 due to the timeline constraints placed on this study. The 2017 model and study was set up to extract and process calibration data from the CPUC's EEstats website. EEstats provides data up through 2016. Program data (including program plans) for 2017 and beyond are housed on the CPUC's CEDARS website. Mining data from CEDARS under the short timeline of this project was not possible.

- Stakeholder impressions/reactions to the magnitude of the savings and breakdown across different end uses
- Stakeholder input on future trends not captured during the historical calibration
- Stakeholder insights regarding specific sectors/end uses will be significantly impacted by program changes (positive or negative)
- Defensible reasoning to support any suggested changes

A.2 Necessity of Calibration

Senate Bill 350 directs the following: *“In assessing the feasibility and cost-effectiveness of energy efficiency savings ... the Public Utilities Commission shall consider the results of energy efficiency potential studies that are not restricted by previous levels of utility energy efficiency savings.”* This does not imply that a potential study should not be calibrated.

Calibration refers to the standard process of adjusting model parameters such that model results align with observed data. In evaluative statistical models, calibration is called regression, and goodness of fit is typically the main focus since the models are usually simple. In situations of complex dynamics and non-linearity (as in this study), model sophistication and adequacy can become the main focus. But grounding the model in observation remains equally necessary. The ability of a forecast to reasonably simulate observed data affords credibility and confidence to forecast estimates.

Although there are data supporting all underlying parameters in the PG Model, much of the data are at an aggregate level that can be inadequate to forecast differences across the various classes of technologies and end uses. The customer willingness-to-adopt factor is a good example of this effect. Customers may exhibit certain average purchase tendencies in adopting measures based on their financial characteristics. Nevertheless, there may be features of certain end use technologies that cause customer behavior to vary from the average. Residential building envelope is an end use where adoption of measures like insulation is consistently lower than would be predicted compared with other end uses. Residential lighting adoption, on the other hand, performs better than the average predicted customer purchase tendencies, even after adjusting for differences in financial attractiveness. We often think of these differences as the influence of non-financial product attributes or of market barriers.

Calibration is not an optional exercise in modeling. One might suggest that the average customer data should be sufficient to make a reliable aggregated forecast. Nevertheless, there are two important non-linearities that compel us toward a more granular parameterization:

- Program portfolios are not evenly composed across end-uses. This leads to an uneven weighting issue whereby average customer willingness and awareness may not lead to the correct calculation of total savings and costs.
- The dynamics in the model regarding the timing of adoption can become incompatible with the remaining potential indicated by program achievements. For example, if the forecast results were not calibrated for LED lighting in the residential sector, the saturation may remain inaccurately low in early years and indicate a larger remaining potential in future years. Thus calibrating upward may increase potential in the early years but decrease potential in later years. This implies that in the absence of IOU program intervention, residential LED would have historically had much lower adoption. Calibration therefore allows us to capture these program influences to more accurately reflect remaining potential.

The team treats the calibrated results as the most basic set of interpretable results from which alternate scenarios are developed.

A.3 Interpreting Calibration

Calibration can constrain market potential for certain end uses when aligning model results with past IOU energy efficiency (EE) portfolio accomplishments. Although calibration provides a reasonable historic basis for estimating future market potential, past program achievements may not capture the potential due to structural changes in future programs or changes in consumer values. Calibration can be viewed as holding constant certain factors that might otherwise change future program potential, such as:

- Consumer values and attitudes toward energy efficient measures;
- Market barriers associated with different end uses;
- Program efficacy in delivering measures; and
- Program spending constraints and priorities.

Changing values and shifting program characteristics would likely cause deviations from market potential estimates calibrated to past program achievements.

Does calibrating to historic data constrain the future forecast? In a strictly numeric sense, yes. If a certain end use is calibrated downward or upward, then future adoption and its timing are affected. Nevertheless, this should not be interpreted as “calibration constrains the level of adoption that we think is possible.” Rather calibration provides a more accurate estimate of the rate of technology turnover in the market, current state of customer willingness, market barriers, program characteristics and remaining adoption potential

One interpretation is that the calibration process creates a floor for the remaining potential. Market barriers, customer attitudes, and program efficacy generally move in the direction of improvement.

A.4 Implementing Calibration

The PG study calibration process primarily seeks to develop a set of consumer decision and market parameters that best represent recent history. Once these parameters are developed they are used as the start point of the PG Model’s stock turnover algorithms and consumer decision algorithms.

The process of developing these parameters requires historic market data. The PG Model uses 2013-2016 program data (net savings, gross savings, program spending data)⁷³ and performs a “back cast” to fit model parameters such that historic achievements are generally matched. Frequently asked questions about this process and their answers include:

- **Why start in 2013?** This the year where we have holistic saturation data for the entire market of EE technologies, it is a reasonable market starting point.

⁷³ See <http://eestats.cpuc.ca.gov>

- **Why end in 2016?** Our model was set up to extract data from EEStats (this data source goes through 2016).
- **Can we calibrate using 2017-2018 data?** We would still need to use 2013-2016 data and append it with additional years.

The calibration process was conducted in two steps.

In Step 1, the Navigant team adjusted model parameters and compared the “back-cast” of the model against historic program data for 2013-2016. Individual adjustments to three key levers (listed in the table below) were made at the IOU, sector, and end use level until a reasonable match with historic data was achieved.

Table A-1. Calibration Levers

Lever	Drivers and Impact on Model Results
Awareness	<ul style="list-style-type: none"> • Increasing initial awareness shortens the time required for a measure to reach 100% consumer awareness and accelerates adoption. • Increasing marketing strength increases adoption rate of technologies in the nascent stage (i.e., having low initial consumer awareness).
Willingness	<ul style="list-style-type: none"> • Adjustments to incentive levels increase adoption, increase budget, and increase savings. • Consumer implied discount rate can be adjusted to account for non-cost related market barriers that may be higher or lower than normal.
Stock Turnover	<ul style="list-style-type: none"> • The model assumes technologies turn over based on EUL. However, the real velocity of the market and turnover dynamics are not this perfect/exact. Adjusting turnover rates allows the model to better reflect real world market dynamics.

Step 1 was a process relying on historic data. However, the Navigant team readily recognizes the future of consumer decisions processes and market momentum may not look like the past. For example:

- **Future Customer Decision Process:** The past decision parameters may not be representative of the future paradigm:
 - **Programs are shifting to third party:** The way programs market and influence customer decisions may change
 - **Customer have more access to their own data:** Will they be a more informed customer, or be overburdened in their own analysis paralysis?
- **Future Program Focus:** Our “Crystal Ball” is hazy when it comes to:
 - How programs will redesign to accommodate LED “standard practice baseline”
 - Recent EM&V studies/pilots provide new data that may influence the future of program offerings
 - Greater role for third party implementation

- BROs programs that are beyond the status quo of HERs

- **Other Unknowns**

Given these uncertainties, Step 2 of the calibration process sought feedback from stakeholders on the reasonableness of the forecast resulting from Step 1 and what adjustments (if any) should be made. On March 21, 2019 the Navigant team presented preliminary draft results for the residential, commercial, and industrial sectors (which historically accounted for 85% of rebate program savings) and asked stakeholder to provide feedback and information such as:

- Impressions/reactions to the magnitude of the savings and breakdown across different end uses
- Thoughts on trends in key end uses
- Insights regarding specific sectors/end uses will be significantly impacted by program changes (positive or negative)
- Defensible reasoning to support changes

The Navigant team collected informal comments and made adjustment to the forecast period as necessary.

APPENDIX B. TECHNICAL, ECONOMIC AND CUMULATIVE MARKET POTENTIAL FOR EQUIPMENT REBATE PROGRAMS

Figure B-1 through Figure B-10 illustrate the statewide technical, economic, and cumulative market potential from IOU equipment rebates for electric (GWh) and gas (MMtherms), respectively, for each scenario. These figures do not show IOU-claimable savings from behavior or C&S advocacy programs as the technical and economic potential for these sources are undefined. The cumulative market potential line is based on an accumulation start year of 2020 to assist in tracking additional achievable energy efficiency (AAEE) for the CEC's demand forecast and to support utility Integrated Resource Planning efforts.

The technical potential is based on instantaneous potential, which is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve energy efficiency (EE) were taken. It does not account for equipment stock turnover. The economic potential shown in the graph is a subset of technical potential that is cost-effective under the relevant screening test in each scenario. Both the technical and economic potential lines grow steadily over time to reflect stock growth across all scenarios.

The gap between the economic and technical potential on the graphs reflects that a significant number of measures are not cost-effective. A key driver for this is the 2016 and 2018 avoided cost updates. The 2016 avoided cost updates which produced avoided costs that were significantly lower than previous iterations. Further updates in 2018 codified a GHG adder that was slightly lower than what was used in the previous PG study. This gap becomes smaller as the TRC threshold to screen measures becomes less stringent. This gap is smallest in Alternative 1 where the TRC threshold is 0.85 (compared to 1.25 in Alternative 2).

Figure B-1. Statewide Technical, Economic, and Cumulative Electric Market Potential for Equipment Rebate Programs (Reference)

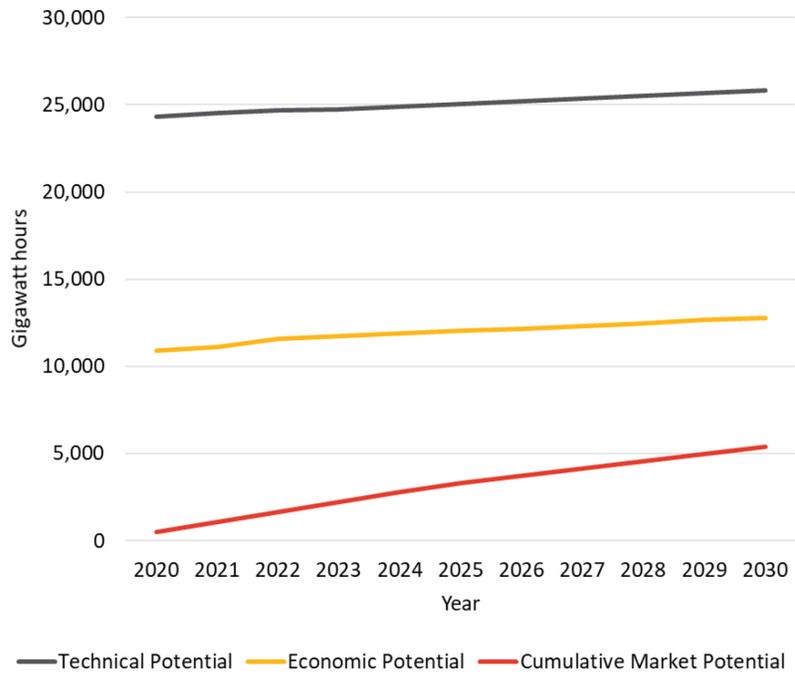


Figure B-2. Statewide Technical, Economic, and Cumulative Electric Market Potential for Equipment Rebate Programs (Alternative 1)

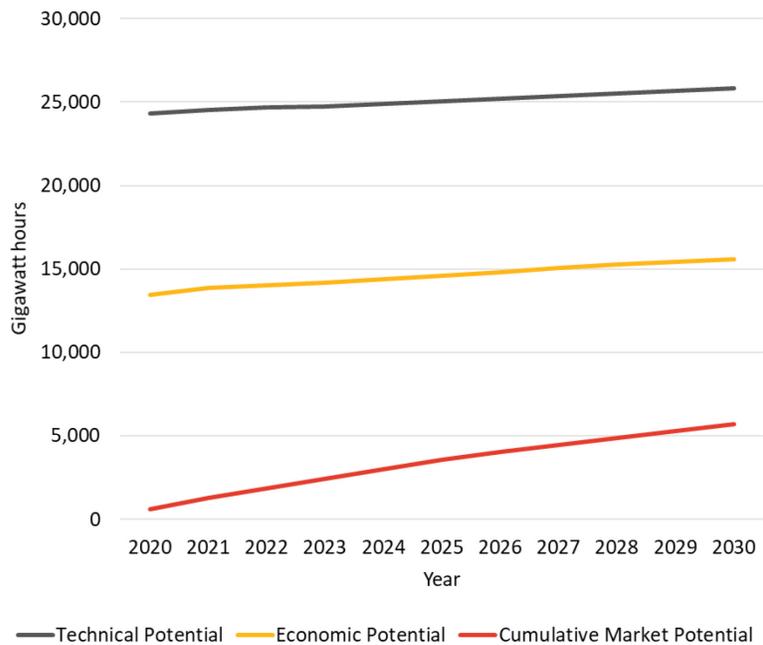


Figure B-3. Statewide Technical, Economic, and Cumulative Electric Market Potential for Equipment Rebate Programs (Alternative 2)

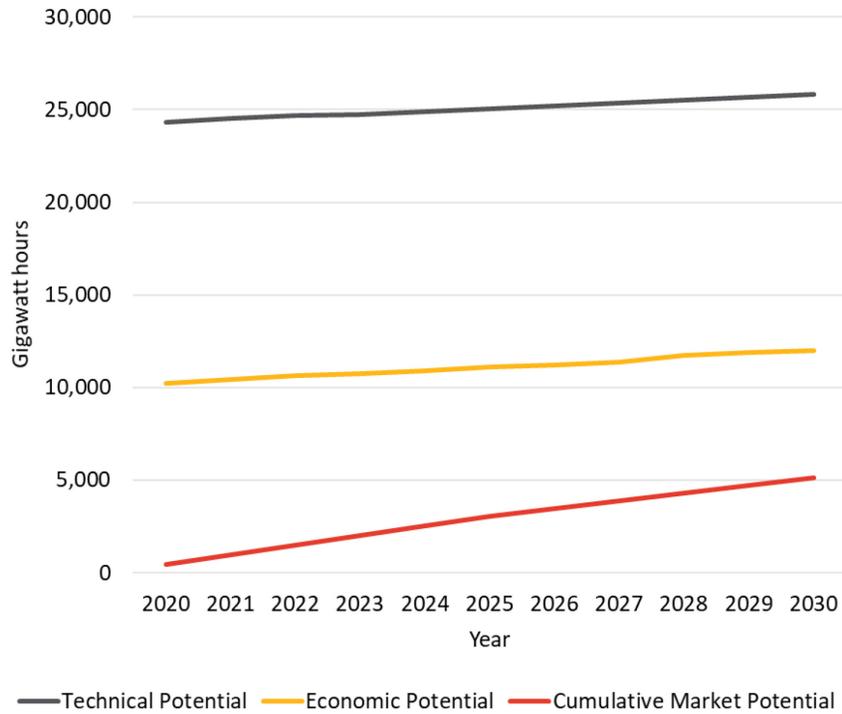


Figure B-4. Statewide Technical, Economic, and Cumulative Electric Market Potential for Equipment Rebate Programs (Alternative 3)

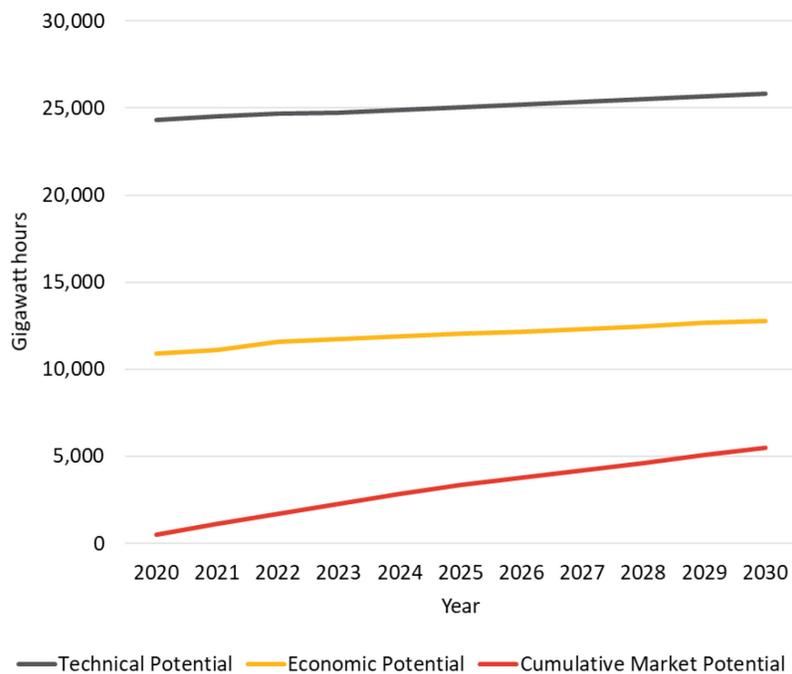


Figure B-5. Statewide Technical, Economic, and Cumulative Electric Market Potential for Equipment Rebate Programs (Alternative 4)

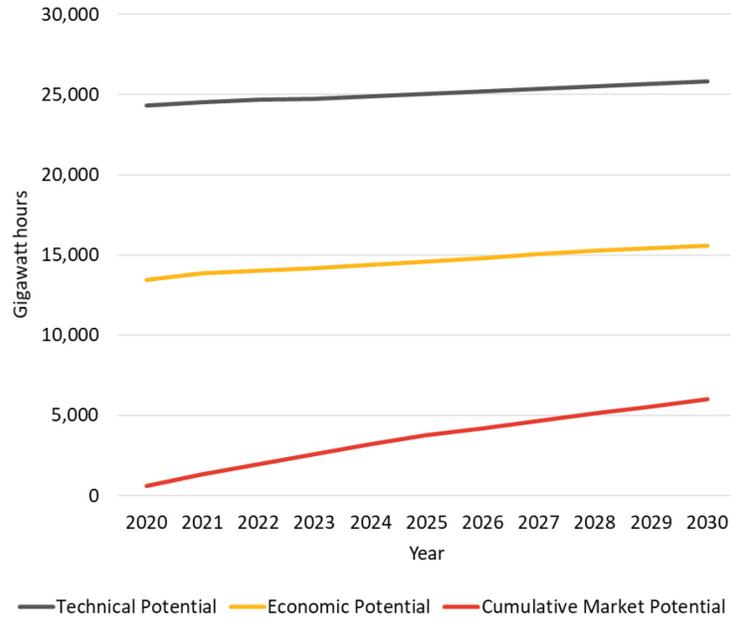


Figure B-6. Statewide Technical, Economic, and Cumulative Gas Market Potential for Equipment Rebate Programs (Reference)

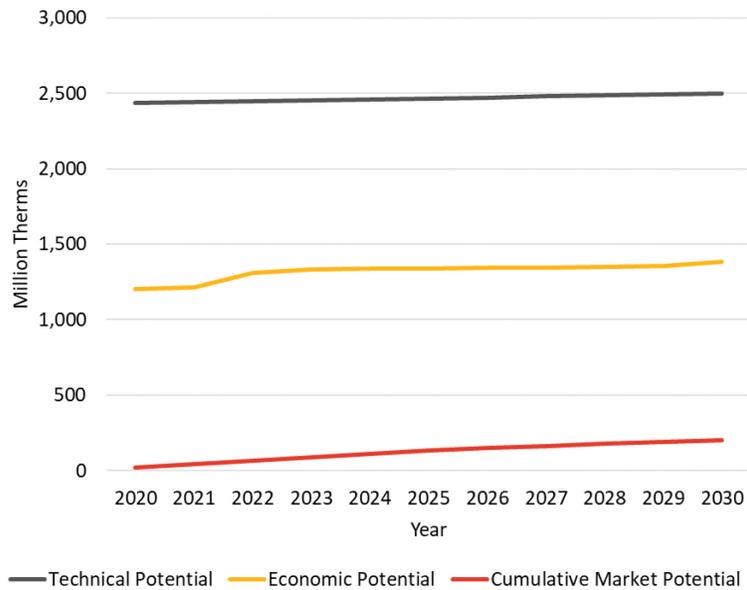


Figure B-7. Statewide Technical, Economic, and Cumulative Gas Market Potential for Equipment Rebate Programs (Alternative 1)

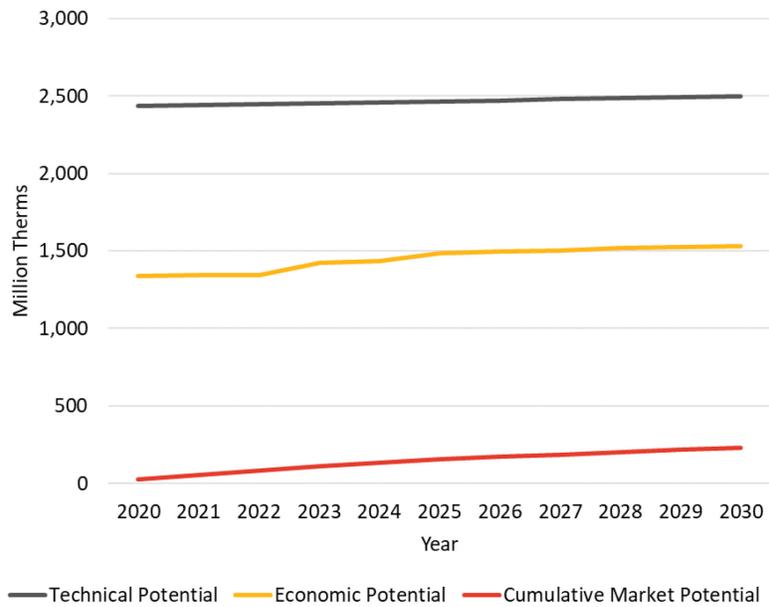


Figure B-8. Statewide Technical, Economic, and Cumulative Gas Market Potential for Equipment Rebate Programs (Alternative 2)

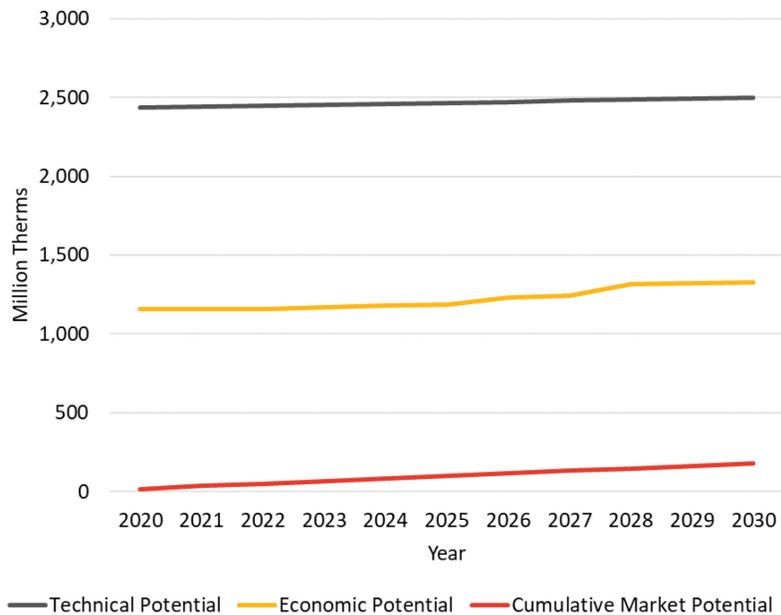


Figure B-9. Statewide Technical, Economic, and Cumulative Gas Market Potential for Equipment Rebate Programs (Alternative 3)

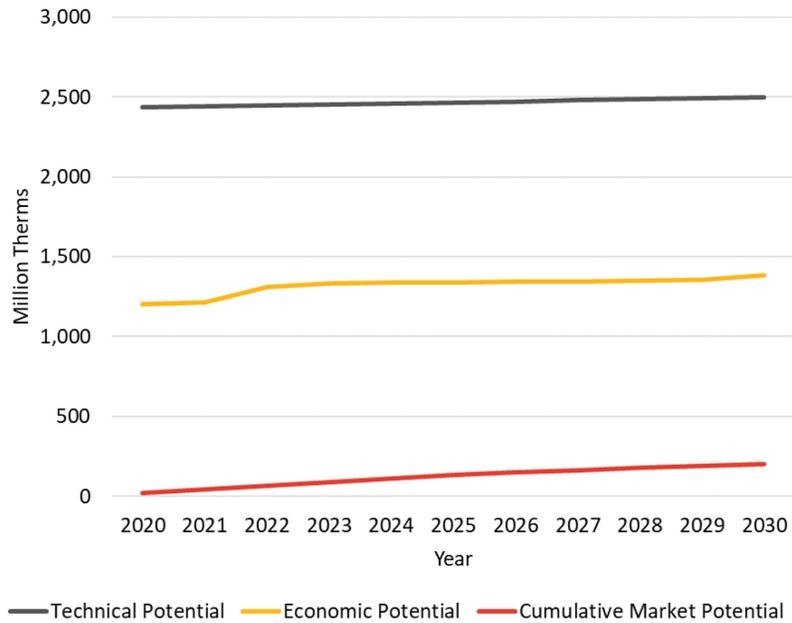
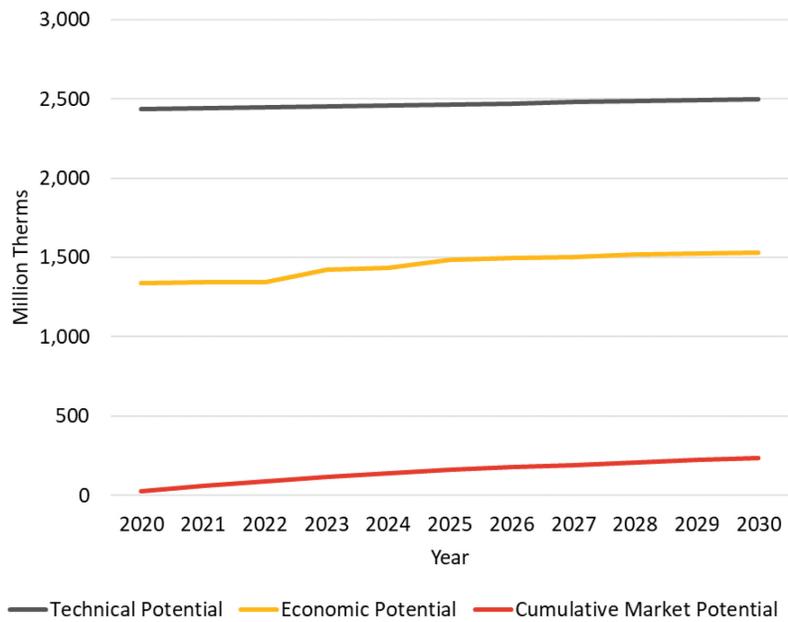


Figure B-10. Statewide Technical, Economic, and Cumulative Gas Market Potential for Equipment Rebate Programs (Alternative 4)



APPENDIX C. BROS

This appendix discusses the BROs interventions that are included 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 to each utility and building type.

C.1 Residential – HERs

C.1.1 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 (EE), and occasionally messaging about rewards or incentives. HER 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 1.3% to 1.4%, while gas savings are 0.7% to 1.4%. Costs are set at \$0.06-\$0.10 per kWh and \$0.92-\$1.88 per therm.⁷⁴

Table C-1. HERs – Key Assumptions

Sector	Type	EUL Years	Savings		Cost		kW/kWh Savings Ratio
			kWh	therm	kWh	therm	
RES	HERs	1	1.3% – 1.4%	0.7% – 1.4%	\$0.06 – \$0.10	\$0.92 – \$1.88	0.000096 – 0.000266

C.1.2 Assumptions and Methodology

Eligibility and Participation

Although all targeted residential households may receive HERs as participants in an opt-out program, in practice, PG&E found that 0.5% of customers elect to opt out. For this reason, the Navigant team reduced applicability to 99.5% for single-family homes. Applicability for multifamily homes is further reduced to 89.5%, dropping another 10% to account for multifamily homes that do not have individual meters.⁷⁵ SCE

⁷⁴ Cost for PG&E and SDG&E are split across electric and gas fuel types.

⁷⁵ 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

provided data indicating that only 0.17% of its multifamily customers are master-metered, so the applicability in its territory remains higher, at 99.33%.

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.⁷⁶ For this reason, the team reviewed all formal California IOU evaluations of HER 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.^{77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91} Additionally, SCG indicated that they would not deploy a HER program until

⁷⁶ PG&E, Application of Pacific Gas and Electric Company for Approval of 2018-2025 Rolling Portfolio Energy Efficiency Business Plan and Budget, Public Utilities Commission of the State of California, January 17, 2017

SCE, Southern California Edison Company's Energy Efficiency Rolling Portfolio Business Plan Application, Statewide Administration Approach, Public Utilities Commission of the State of California, January 17, 2017

SDG&E, Application of San Diego Gas & Electric Company (U 902-M) to adopt Energy Efficiency Rolling Portfolio Business Plan Pursuant to Decision 16-08-019, Public Utilities Commission of the State of California, January 17, 2017

SCG, Energy Efficiency Business Plan for Southern California Gas Company, Public Utilities Commission of the State of California, January 17, 2017

⁷⁷ 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

⁷⁸ 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

⁷⁹ DNV KEMA, Review of PG&E Home Energy Reports Initiative Evaluation, 5-31-2013, CPUC Energy Division

⁸⁰ 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

⁸¹ 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

⁸² 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

⁸³ 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

⁸⁴ 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

⁸⁵ DNV GL, SDG&E Home Energy Reports Program 2013 Impact Evaluation ED Res 3.3, October 17, 2014, California Public Utility Commission

⁸⁶ 2. DNV GL. May 5, 2017. Review and Validation of 2015 Southern California Edison Home Energy Reports Program Impacts (Final Report). California Public Utilities Commission, May 5, 2017. CALMAC Study ID: CPU0156.01.

⁸⁷ 1. DNV GL. May 5, 2017. Review and Validation of the Pacific Gas & Electric Home Energy Reports Program Impacts (Final Report). California Public Utilities Commission, May 5, 2017. CALMAC Study ID: CPU0155.01.

⁸⁸ 3. DNV GL. May 5, 2017. Impact Evaluation of 2015 San Diego Gas and Electric Home Energy Reports and Manage Act Safe Programs (Final Report). California Public Utilities Commission, May 5, 2017. CALMAC Study ID: CPU0157.01.

⁸⁹ 4. PG&E. 2017. RTR for the Review and Validation of 2015 Pacific Gas and Electric Home Energy Reports Program Impacts (Final Report) (DNV GL, Calmac ID #CPU0155.01, ED WO #ED_D_Res_3). California Public Utilities Commission, 2017. Calmac ID: CPU0155.01.

⁹⁰ 5. SCE. 2017. RTR for the Review and Validation of 2015 Southern California Edison Home Energy Reports Program Impacts (Final Report) (DNV GL, Calmac ID #CPU0156.01). California Public Utilities Commission, 2017. Calmac ID: CPU0156.01.

⁹¹ 6. SDG&E. 2017. RTR for the Impact Evaluation of 2015 San Diego Gas & Electric Home Energy Reports and Manage-Act-Save Programs (Final Report) (DNV GL, Calmac ID #CPU0157.01). California Public Utilities Commission, 2017. Calmac ID: CPU0157.01.

2018,⁹² and that it would ramp up over 3 years.⁹³ Finally, a cap was placed on the penetration of HERs based on feedback from PG&E that the bottom quartile of energy consumers will not be targeted and an equal number of customers need to be reserved as a comparison group for evaluation purposes. The behavioral model then applies these projected penetration rates to the number of forecast IOU households, which increases over time from 2016 to 2030, resulting in an increase in the absolute number of actual HER participants over time.

Savings

The Navigant 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 to 2015, depending upon each utility's first year of operation.^{94,95} The team 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 1 year for HER program participants. That is, while customers may participate in a utility HER program for more than 1 year, their average adjusted savings are 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 1 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 1 year is assumed, as is standard with traditional persistence calculations for HER programs.

The ratio of kW to kWh savings was developed using a weighted average of adjusted kW and kWh savings as reported in the above-mentioned DNV GL 2017 evaluation findings for PG&E, SDG&E and SCE. This ratio was then updated based on California hourly load profiles to align with the 2019 DEER peak period definition.⁹⁶

Cost

Costs per unit of kWh and therm savings were based on California Energy Data and Reporting System (CEDARS).⁹⁷ These costs were distributed to the kWh and therm savings (weighted by savings) as reported in the CEDARS database. The Energy Adviser costs sourced from the CEDARS database are an aggregate of home energy report and online audit tool costs.

C.2 Residential – Universal Audit Tool

C.2.1 Summary

⁹² Informal comments on the webinar presented on April 20, 2017.

⁹³ Comments of Southern California Gas Company on Proposed Decision Adopting Energy Efficiency Goals for 2018 – 2030.

⁹⁴ KEMA, SDG&E Home Energy Reports Program Savings Results, August 23, 2013, San Diego Gas and Electric

⁹⁵ 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>

⁹⁶ California Public Utilities Commission (CPUC). Resolution E-4952, October 11, 2018.

<http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF>

⁹⁷ "Energy Adviser" programs savings and costs, California Energy Data and Reporting System (CEDARS)

The Universal Audit Tool (UAT) is an opt-in online tool that asks residential customers questions about their homes, their use of household appliances, and occupancy patterns and then it offers EE advice regarding ways they can save money and energy. The UAT is provided by all four of California’s investor owned utilities. While each utility has its own branding, and some utilities require customers to log in while others do not, on the whole their features and functionality are similar. All four tools enable customers to develop plans to save energy based on estimates of the annual savings they are likely to see if the enact the recommended energy-saving advice.

Estimated electric savings range from 1.2-1.8%, while gas savings are 1.5-2.6%. Costs are set at \$0.06 - \$0.14 per kWh and \$1.15 -\$4.02 per therm. For low income customers costs range from \$0.11 -\$0.47 per kWh and \$3.73 -\$7.78 per therm.

Table C-2. UATs – Key Assumptions

Sector	Type	EUL Years	Savings		Cost		kWh/kWh Savings Ratio
			kWh	therm	kWh	therm	
RES	UAT	1	1.2 - 1.8%	1.5 - 2.6%	\$0.01 - \$0.02	\$0.18 - \$0.38	0.000096 – 0.000266
RES – Low Income	UAT	1	1.2 - 1.8%	1.5 - 2.6%	\$0.01 - \$0.02	\$0.18 - \$0.38	0.000096 – 0.000266

C.2.2 Assumptions and Methodology

Eligibility and Participation

All residential customers of the four IOUs are eligible to use the UAT. Customers can access the tool after sign up for online services through their utility’s My Energy or Energy Advisor web portals. Moreover, as with the HERs forecast, the Navigant team reduced the applicability for multifamily homes by 10% to account for multifamily homes that do not have individual meters.

According to a 2017 evaluation of the UAT by DNV GL,⁹⁸ over the years the tools have been active the number of customers has grown. Customer engagement and online survey completion vary by IOU, as does the associated level of marketing effort to drive customers to participate or re-participate for deeper savings. To forecast participation levels for the 2020 model the team relied on the participation numbers reported in the DNV GL evaluation to establish cumulative treatment sizes and then determined saturation levels based on the number of households per utility. (Because evaluated participation rates were not available for SCE in reviewed sources, this value was calculated using an average percentage of saturation from the other California electric utilities.) Starting saturation rates for early model years range from 0.5% to 0.8% and grow at compound growth rate of 12% per year, topping out at between 2.5% and 3.9% participation by 2030.

Savings

⁹⁸ 7. DNV GL. March 31, 2017. Universal Audit Tool Impact Evaluation-Residential: California Public Utilities Commission, March 31, 2017. CALMAC ID: CPU0160.01.

The team relied on the above-mentioned 2017 DNV GL evaluation of the UAT to set per-household adjusted kWh and therm savings values for participating customers at each utility. Because evaluated kWh savings were not available for SCE, a rate of 1.2% kWh savings was applied since it was equivalent to the evaluated savings for PG&E, which was more conservative than the higher percentage of evaluated savings for SDG&E.

The model uses an EUL of 1 year for UAT participants. That is, while customers may participate in a utility UAT for more than 1 year, their average adjusted savings are assumed to be the same as for all other participants in that year. For this model, an EUL of 1 year is assumed, as is standard with traditional persistence calculations for residential behavior programs.

Because evaluated demand savings data was unavailable for UAT participants the team applied the figure used for HERs for all three electric utilities.

Cost

Costs per unit of kWh and therm savings were based on CEDARS.⁹⁹ These costs were distributed to the kWh and therm savings (weighted by savings) as reported in the CEDARS database. The Energy Adviser costs sourced from the CEDARS database are an aggregate of home energy report and online audit tool costs. The majority of the Energy Adviser costs are assumed to be associated with HERs; 20% of the Energy Adviser costs are attributed to the UAT costs.

C.3 Residential – Real-Time Feedback: In Home Displays and Online Portals

C.3.1 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 smartphone 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, the Navigant team has separated its 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 IHDs, 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 (DR) programs, our analysis focused on programs designed to drive EE. In all, the Navigant team reviewed a total of 38 programs, including 20 providing IHDs and 18 offering

⁹⁹ "Energy Adviser" programs savings and costs, California Energy Data and Reporting System (CEDARS)

online portals. Several programs offered both types of feedback. In those cases, the team categorized them in the IHD category since they had associated costs for the hardware.

Table C-3. 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%	--	\$0.19	--	0.000224
RES	Real-Time Feedback – Online Portal	1	2.2%	1.3%	\$0.07	--	0.000224

C.3.2 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, the team assumes 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 California homes use natural gas for water heating.¹⁰⁰

IHDs did not pass the C-E screen, and so are not included in the reference case. SCE indicated they would not deploy these programs until 2019, and they would still only be pilots at that time.¹⁰¹ This assumption was used for all utilities. The team assumes penetration rates for programs that use online portals to display customer information will be higher than those that rely on IHDs. For online portals, our reference case assumes an 8% increase in penetration per year, while the aggressive case assumes a 15% annual increase, based on professional judgement. PG&E provided penetration rate data for IHDs.¹⁰²

Savings

Savings forecasts differ for online portals and IHDs. For online portals, the Navigant team estimates 1.3% savings for both kWh and therms. For IHDs, the team estimates 2.3% savings for kWh and no gas

¹⁰⁰ 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>

¹⁰¹ Informal comments on the webinar presented on April 20, 2017.

¹⁰² Ibid.

savings. These estimates were developed based on numerous data points for kWh savings.^{103,104,105,106,107,108}

The model uses an EUL of 1 year, the same as the team applies for HER program participants. Because insufficient demand savings data was available for real time feedback for non-DR programs, for ratio of kW to kWh for HERs is used 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, the team assumed that the utilities will provide the hardware and that IHDs cost \$100, annualized over 5 years – similar to the life of other consumer electronics.¹⁰⁹

To calculate the cost, the Navigant team 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 \$0.07 per kWh saved not including the hardware.¹¹⁰ For IHDs, the team adds in the annualized \$100 hardware acquisition and installation costs, resulting in \$0.19 per kwh of savings (assuming 7,000 kwh per household).

C.4 Residential – Competitions: Large and Small

C.4.1 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. 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,

¹⁰³ Kira Ashby, 2016 Behavior Program Summary, 2016, Consortium for Energy Efficiency, from <https://library.cee1.org/content/2016-behavior-program-summary-public>

¹⁰⁴ 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>

¹⁰⁵ 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

¹⁰⁶ Ben Foster and Susan Mazur-Stommen. 2012. "Results from Real-Time Feedback Studies." American Council for an Energy Efficient Economy. Report Number B122

¹⁰⁷ Reuven Sussman and Maxine Chikumbo. 2016. "Behavior Change Programs: Status and Impact." American Council for an Energy Efficient Economy. Report Number B1601

¹⁰⁸ 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.

¹⁰⁹ PG&E provided this reference in response to the webinar on April 20: <https://www.amazon.com/Rainforest-Energy-Monitor-ZigBee-Gateway/dp/B00AII248U>

¹¹⁰ Alberta Energy Efficiency Alliance, Energy Savings through Consumer Feedback Programs, Feb 2014, City of Calgary

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 targeted 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, the team separates its modeling calculations to estimate the savings for the two types of competitions separately.

The Navigant team defines 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, the team reviewed 18 small competitions and five large competitions. Data availability varied across programs.

Table C-4. 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	0.000224
RES	Large Competitions (>10,000 ppl)	1	14%	5.2%	\$0.002	\$0.101	0.000224

C.4.2 Assumptions and Methodology

Eligibility and Participation

All residential customers are considered eligible to participate in competitions. The estimated participation rate of 6.5% for small competitions was determined by averaging available reported participation rates. 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.¹¹¹ CoolChallenge California¹¹² provided a participation rate of 0.1% for large competitions.

¹¹¹ Grossberg, Frederick; Wolfson, Mariel; Mazur-Stommen, Susan; Farley, Kate; and Steven Nadel. 2015.(February) “Gamified Energy Efficiency Programs.” ACEEE Report B1501.

¹¹² PG&E provided the following reference: Jones, Christopher M. and Kammen, Daniel M. 2014 “The CoolCalifornia Challenge: A Pilot Inter-City Household Carbon Footprint Reduction Competition.” Contract Number: 10-325, California Air Resources Board. <https://www.arb.ca.gov/research/apr/past/10-325.pdf>

This information was supplemented with findings from program reviews conducted by the Consortium for Energy Efficiency,¹¹³ American Council for an Energy-Efficient Economy,¹¹⁴ and Illume Advising.¹¹⁵

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 2019-2021 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 the participation rate and a targeted 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

The team averaged the percentage of kWh savings reported to arrive at 8.1% for small competitions and CoolCalifornia Challenge reported 14% for large competitions.¹¹⁶ 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%.¹¹⁷

Because competitions can be run for different lengths of time, lasting from a few months to multiple years, the team standardized the model on an EUL of 1 year. (This is the same EUL that we apply for other residential interventions.) Because insufficient demand savings data was available for residential competitions, the team applied the ratio used for HERs for all three electric utilities.

Cost

Costs associated with competitions are largely associated with program administration and game-related prizes. Navigant used data gathered from the 2015 ACEEE's report on EE and gamification and information from the CEE database of behavioral programs to create cost estimates for both small and large behavior-based competitions. The team approached the calculations for both small and large

¹¹³ Kira Ashby, 2016 Behavior Program Summary, 2016, Consortium for Energy Efficiency, from <https://library.cee1.org/content/2016-behavior-program-summary-public>

¹¹⁴ 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>

¹¹⁵ 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.

¹¹⁶ PG&E provided the following reference: Jones, Christopher M. and Kammen, Daniel M. 2014 "The CoolCalifornia Challenge: A Pilot Inter-City Household Carbon Footprint Reduction Competition." Contract Number: 10-325, California Air Resources Board. <https://www.arb.ca.gov/research/apr/past/10-325.pdf>

¹¹⁷ Grossberg, Frederick; Wolfson, Mariel; Mazur-Stommen, Susan; Farley, Kate; and Steven Nadel. 2015.(February) "Gamified Energy Efficiency Programs." ACEEE Report B1501.

competitions in the same way. The Navigant team 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. The team estimated total program savings by multiplying the average number of participants per competition by the cost per participant. The team estimated total program savings by multiplying average household electricity consumption by the average number of participants and the average savings rate per participant.

The Navigant team assumes that prizes account for 50% of program costs. The team 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. The team 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.¹¹⁸

C.5 Commercial – Strategic Energy Management

C.5.1 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

¹¹⁸ Grossberg, Frederick; Wolfson, Mariel; Mazur-Stommen, Susan; Farley, Kate; and Steven Nadel. 2015.(February) "Gamified Energy Efficiency Programs." ACEEE Report B1501.

- 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.

The model inputs for electric and natural gas shown in the table below 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 \$0.27 per kWh and \$3.65 per therm, and are also applied consistently by building type across utilities.

Table C-5. Commercial SEM – 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%	\$0.27	\$3.65	0.000102

C.5.2 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 2019 Study 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,¹¹⁹ 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 2019 Study applies an applicability factor of between 45% and 90%. A compound annual growth rate (CAGR) was used to forecast growth in participation over time, starting in 2020.¹²⁰ A 2% CAGR was used

¹¹⁹ 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.

¹²⁰ Informal comments in response to the webinar held April 20, 2017.

in the reference case, while the aggressive case used a 4% CAGR. Because current SEM penetration in the market segments studied is low, it is expected that these CAGRs will achieve segment penetrations by 2030 of approximately 1.2% for the reference case and 1.5% for the aggressive case.

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 operational savings. Based on a literature review of 16 institutional SEM plans, such as the LW Hospitals Alliance 2014 plan,¹²¹ and market studies such as the Northwest Energy Efficiency Alliance (NEEA) Market Progress Evaluation Report,¹²² 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 5 years.¹²³ A ratio of 0.000102 kW to kWh 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. This ratio was then updated based on California hourly load profiles to align with the 2019 DEER peak period definition.¹²⁴ The EUL and kW to kWh ratio before peak period modification are consistent with the 2017 Study.

Cost

Consistent with the 2017 Study, costs for electricity and natural gas savings in the 2019 Study are estimated at \$0.27 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

C.6 Commercial – Building Operator Certification

C.6.1 Summary

Building operator certification (BOC) offers EE training and certification courses to commercial building operators in the commercial sector. BOC has been modeled 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:¹²⁵

¹²¹ Joint Strategic Energy Management Plan for Listowel Wingham Hospitals Alliance, 2014

¹²² Hospitals and Healthcare Initiative Market Progress Evaluation Report 7, Northwest Energy Efficiency Alliance. March 26, 2015. REPORT #E15-310

¹²³ Personal communication with Kay Hardy, CPUC. May 9, 2017.

¹²⁴ California Public Utilities Commission (CPUC). Resolution E-4952, October 11, 2018. <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF>

¹²⁵ Analysis to Update Potential Goals and Targets for 2013 and Beyond, literature search results provided in Appendix C. Navigant Consulting Inc., March 19, 2012

- 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 the table below 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 segment¹²⁶ and IOU from 153 kWh to 14 kwh for electricity, and as defined in the 2009 CEUS. EUL is set to 3 years per CPUC Decision 16-08-019, 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 C-6. 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	BOC	3	14-153	0.3-35.7	\$0.29	\$3.65	0.000092

C.6.2 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 5% to 100%, depending on the market segment. This model assumes that BOC program interventions in the commercial market have been ongoing (though SoCalGas does not claim savings until 2018) 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 penetrations 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 forecast indicate that the risk of double counting savings is minimal and was therefore was not considered in this model.

¹²⁶ As defined in the 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/>.

Savings

The method of calculating unit energy savings has changed over time and the 2019 Study uses the same approach and values used in the 2017 Study. For context, the 2015 Study used the same average electric and natural gas savings of 58 kWh and 5.6 therms per 1,000 sq. ft. of participating building space for all market segments.¹²⁷ The 2017 Study refined this approach and applied a market segment-specific UES value that accounted for differences in building energy density. For example, a grocery store with much higher energy densities than 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.

Consistent with the 2017 Study, the 2019 model uses an EUL of 3 years, per CPUC Decision 16-08-019, and a ratio of 0.000092 kW to kWh was applied to all three electric utilities. This value is based on an analysis of several third-party programs operating in California during the 2014-2015 portfolio cycle. This ratio was then updated based on California hourly load profiles to align with the 2019 DEER peak period definition.¹²⁸

Cost

Costs for electricity and natural gas savings are estimated at \$0.29 per kWh and \$3.65 per therm, applied consistently by building type across utilities. These cost values did not change between the 2018 and 2020 studies.

C.7 Commercial – Building Energy and Information Management Systems

C.7.1 Summary

The potential for building energy management and information systems (BEIMS) were first modeled by Navigant as part of the AB 802 Technical Analysis.¹²⁹ 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 the 2019 model.

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

¹²⁷ Energy Efficiency Potential and Goals Study for 2015 and Beyond Stage 1. Final Report Section 3.7.1 Non-Residential Behavior Model Updates. Navigant Consulting Inc., September 25, 2015

¹²⁸ California Public Utilities Commission (CPUC). Resolution E-4952, October 11, 2018. <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF>

¹²⁹ AB802 Technical Analysis, Potential Savings Analysis. Navigant Consulting, Inc., Reference No.: 174655. March 31, 2016

- 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 the table below 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 are due to differences in segments’ energy densities and differences in climate across utilities. Costs for electricity and natural gas savings also varied by utility between \$0.20 and \$0.46 per kWh and between \$0.18 and \$0.49 per therm.

Table C-7. 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	3	1.1% - 4.2%	0.2% - 9.3%	\$0.20 - \$0.44	\$0.18 – \$0.49	0.000112

C.7.2 Assumptions and Methodology

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%.¹³⁰ 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. Penetration reflects that SoCalGas does not claim savings until 2018, and 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 market saturations as of 2017, these growth rates result in BEIMS forecast penetrations of 5.6% and 20.9% for the reference and aggressive cases, respectively by the end of the forecast horizon in 2030.

¹³⁰ AB802 Technical Analysis, Potential Savings Analysis. Navigant Consulting, Inc. Reference No.: 174655, March 31, 2016

Savings

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

$$\text{Unit Energy Savings, BEIMS} = \text{Starting Saturation of EMS by Building Type} \times \text{Total Annual Consumption} \times \% \text{ End Use Consumption for HVAC} \times \% \text{ End Use Savings by Building Type.}$$

This equation resulted in a range of 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 forecast indicate that the risk of double counting savings is minimal and was therefore 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. This UES, defined through work on the AB 802 Technical Analysis, is then used in the potential model to calculate annual segment level savings for each fuel type and IOU using the following equation:

$$\text{Segment Savings, BEIMS} = \text{Segment UES} \times \text{Penetration Rate} \times \text{Total Annual Segment Consumption} \times \text{Segment Applicability Factor.}$$

Consistent with the 2017 Study, the model uses an EUL of 3 years per CPUC Decision 16-08-019 and a ratio of kW to kWh of 0.000112 was applied to all three electric utilities as defined in the AB802 Technical Analysis.¹³¹ This ratio was then updated based on California hourly load profiles to align with the 2019 DEER peak period definition.¹³²

Cost

Costs for electricity and natural gas savings are estimated based on research referenced in the AB 802 Technical Analysis.¹³³ The costs per unit of fuel savings were calculated for each utility and fuel type as shown in Table C-8.

Table C-8. Building Energy and Information Management Systems Cost per Unit Energy Savings

Fuel	Utility	Cost
kWh	PG&E	\$0.435
kWh	SCE	\$0.204
kWh	SDG&E	\$0.323
kWh	SCG	NA
therms	PG&E	\$0.340
therms	SCE	NA
therms	SDG&E	\$0.489
therms	SCG	\$0.180

¹³¹ Ibid.

¹³² California Public Utilities Commission (CPUC). Resolution E-4952, October 11, 2018. <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K049/225049353.PDF>

¹³³ Ibid.

C.8 Commercial – Business Energy Reports

C.8.1 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 EE, 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 new addition in the emerging field of behavior change programs and are now in pilot testing at PG&E and other non-California utilities.

Navigant’s modeling estimates are primarily based on three sources: 1) PG&E’s response to the webinar on April 20, 2017, 2) 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 3) 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.¹³⁴ In the Commonwealth Edison pilot the utility engaged 6,009 medium sized (100-1,000 kW) commercial customers in Illinois.¹³⁵ While the Commonwealth Edison customers represented numerous sectors, only those businesses in the “lodging” and “other” categories showed significant savings.

Table C-9. Business Energy Reports - Key Assumptions

Sector	Type	EUL Years	Savings		Cost		kW/kWh Savings Ratio
			kWh	therm	kWh	therm	
COM	BERs	2	0.32%	-	\$0.20	\$6.12	0.000102

C.8.2 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, the team assumes that utilities

¹³⁴ Jim Stewart, Energy Savings from Business Energy Feedback [for Xcel Energy], Cadmus, October 21, 2015, Behavior, Energy, and Climate Change Conference 2015

¹³⁵ 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>

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 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 square feet.¹³⁶ 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 (<1 m 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 no penetration. Under the aggressive scenario, penetration begins at 2% in 2019 and ramps up at 2% per year, reaching 24% by 2030.

Savings

The model uses electricity savings of 0.32%, no gas savings,¹³⁷ and an EUL of 2 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 SEM. This yielded 0.000102, 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

¹³⁶ U.S. Energy Information Administration, Commercial Building Energy Consumption Survey, <http://www.eia.gov/consumption/commercial/data/2012/index.php?view=consumption#c13-c22>

¹³⁷ Informal comments on the webinar presented on April 20, 2017 from PG&E cite results of a trial that ran January to October in 2014.

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.

C.9 Commercial – Benchmarking

C.9.1 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 across utilities, but vary by building type. Costs were estimated to be \$0.05 per kWh and \$0.24 per therm and are not utility specific.

Table C-10. 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%	\$0.05	\$0.24	0.000102

C.9.2 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.¹³⁸ 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.¹³⁹ 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.

There is uncertainty as to whether the utilities will be able to claim savings from these initiatives if benchmarking is mandated by some level of government. However, this study still identifies potential in the reference and aggressive scenarios as guidance for what potential is available in the case that

¹³⁸ U.S. EIA. Commercial Building Energy Consumption Survey (CBECS) “Table B6. Building size, number of buildings, 2012.” (May 2016).

¹³⁹ U.S. EIA. Commercial Building Energy Consumption Survey (CBECS) “Table C1. Total energy consumption by major fuel, 2012.” (May 2016).

savings are eligible. For the reference scenario, a penetration of 7.6% is applied for all electric utilities through the forecast period. For the aggressive scenario, PG&E begins with 7.6% penetration, but then climbs to 15.1% in 2020 and 22.7% in 2025. The aggressive scenario for the other three utilities are 7.6% in 2019 and 15.1% starting in 2024.

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.^{140, 141, 142, 143, 144} We divided reported savings in half because we assume 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 2 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 SEM. This yielded 0.000102, 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.¹⁴⁵ 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.

C.10 Commercial – Competitions

C.10.1 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

¹⁴⁰ SF Environment and ULI Greenprint Center for Building Performance. "San Francisco Existing Commercial Buildings Performance Report: 2010-2014." (2015)

¹⁴¹ Katherine Tweed. "Benchmarking Drives 7 Percent Cut in Building Energy. (October 2012) Greentech Media

¹⁴² City of Chicago. "City of Chicago Energy Benchmarking Report 2016."

¹⁴³ 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.

¹⁴⁴ 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.

¹⁴⁵ CPUC, Statewide Benchmarking Process Evaluation, Volume 1, CPU0055.01, Submitted by NMR Group and Optimal Energy, April 2012.

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.

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 addition to overall summary data available through the ACEEE¹⁴⁶ and the CEE,¹⁴⁷ 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.^{148,149} 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.¹⁵⁰

Table C-11. Commercial Competitions - Key Assumptions

Sector	Type	EUL Years	Savings		Cost		kW/kWh Savings Ratio
			kWh	therm	kWh	therm	
COM	Competitions	2	1.9%	--	\$ 0.04	--	0.000102

C.10.2 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

¹⁴⁶ Kira Ashby, 2016 Behavior Program Summary, 2016, Consortium for Energy Efficiency, from <https://library.cee1.org/content/2016-behavior-program-summary-public>

¹⁴⁷ 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>

¹⁴⁸ 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>

¹⁴⁹ 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*.

¹⁵⁰ TecMarket Works, Impact Evaluation of the Smart Energy Now Program (NC) (Pilot) for Duke Energy, February 21, 2014.

effort is focused on the following five building types: large offices, small offices, retail, restaurants, and lodging.^{151,152} 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 8% for large offices and lodging and a lower applicability factor of 4% for small to medium businesses - small offices, restaurants, and retail.¹⁵³

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 one city and hold steady through 2030. SCE and SDG&E 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 in 2024, they add a second city-size competition.

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 PG&E's study of Step Up and Power Down (1.9% kWh). No gas savings are modeled.

The model uses an EUL of 2 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 0.000102, which is the figure used for all three electric utilities.

Cost

Costs of \$0.04 per kWh are drawn from Smart Energy Now.¹⁵⁴

C.11 Commercial – Retrocommissioning

C.11.1 Summary

The potential for retrocommissioning (RCx) was modeled as a component of behavioral savings in the 2013, 2015, and 2018 studies and this update refines several of the underlying assumptions and inputs

¹⁵¹ 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.

¹⁵² 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.

¹⁵³ Informal comments received in response to the webinar on April 20, 2017 from PG&E indicate a limited willingness to participate in commercial competitions.

¹⁵⁴ TecMarket Works, Impact Evaluation of the Smart Energy Now Program (NC) (Pilot) for Duke Energy, February 21, 2014.

used. RCx is defined as commissioning performed on buildings that have not been previously commissioned. This model also includes the allowed recommissioning of buildings that have undergone commissioning after 5 years have passed. The model focuses on RCx activities that impact HVAC system operations and includes, for example, measures such as the following:¹⁵⁵

- 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 the table below, are based on customer segment consumption (kWh or therms per year). Electricity and natural gas savings range from 2.3% to 12.7%, and are applied consistently 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. Industry literature indicates that demand savings associated with RCx are minimal and the 2019 Study does not forecast demand savings for RCx, as such the kW/kWh savings ratio is 0.

Table C-12. Commercial Retrocommissioning - Key Assumptions

Sector	Type	EUL Years	Savings		Cost		kW/kWh Savings Ratio
			kWh	therm	kWh	therm	
COM	RCx	5	2.3% - 5.17%	2.3% - 5.17%	\$0.21	\$0.38	0.000112

C.11.2 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 91%. Consistent with the 2017 Study, the 2019 Study also

¹⁵⁵ 2016 Statewide Retrocommissioning Policy & Procedures Manual, Version 1.0. Effective Date: July 19, 2016

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 (though SoCalGas does not claim savings until 2018), and a CAGR was used to forecast growth in participation through the model forecast horizon. In the reference case, a 3.1% CAGR was used to forecast growth in RCx, while the aggressive case used a 4.5% CAGR. Recommissioning is anticipated in 25% of RCx participants after 5 years, and re-participation is additionally discounted by 25% to avoid double counting of savings influenced by other programs, such as BOC and SEM. Low initial penetration of RCx results in forecast penetrations of 2.3% and 2.8% for the reference and aggressive cases, respectively, over the forecast horizon.

Savings

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

$$\text{Energy Savings, RCx} = \text{Penetration of RCx by Building Type} \times \text{Total Annual Consumption} \times \% \text{ End Use Consumption for HVAC} \times \% \text{ End Use Savings by Building Type}$$

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 and 2018 Studies.^{156, 157, 158} Savings for offices, colleges, and schools were capped at 5% to reflect feedback from SCE on their experience.¹⁵⁹ The model uses an EUL of 3 years per CPUC Decision 16-08-019. A ratio of kW to kWh of 0.000112 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 2017 Study.

C.12 Industrial/Agriculture – Strategic Energy Management

C.12.1 Summary

SEM in the industrial and agricultural sectors is a ‘holistic’ approach to managing energy use that continuously improves energy performance based on various initiatives. SEM, per CPUC and California

¹⁵⁶ 2014 Retro-Commissioning (RCx) Program Extreme Makeover, CenterPoint Energy at <http://www.centerpointenergy.com/en-us/Documents/2014%20RCx%20Kickoff%20Slides.pdf>

¹⁵⁷ EPA. http://www.epa.gov/statelocalclimate/documents/pdf/table_rules_of_thumb.pdf

¹⁵⁸ DEER ExAnte2013 - RTU-Retro, Rooftop Unit retrocommissioning COM IOU Workpaper

¹⁵⁹ Informal comment received in response to webinar held April 20, 2017.

IOU design, is a continuous improvement approach that focuses on changing business practices to enable companies to save money by reducing energy consumption and waste. The industrial sector SEM pilot program currently being administered by California IOUs served as the basis for this forecast. As defined in the California Industrial SEM Design Guide,¹⁶⁰ leading SEM programs are designed to support industrial companies by focusing on several high-level objectives:

- Implementing EE projects and saving energy, primarily from savings in operations and maintenance (O&M).
- Establishing the energy management system (EMS) or business practices that help a facility to manage and continuously improve energy performance.
- Normalizing, quantifying, and reporting facility-wide energy performance.
- Getting peers to talk to one another.

The model inputs for electric and natural gas shown in the table below represent savings associated with SEM operational and behavioral changes. Savings are estimated based on building type consumption (kWh or therms per year) for each market segment and are applied consistently across utilities. Costs for electricity and natural gas are \$0.20/kWh and \$1.35/therm, and those are also applied consistently by building and fuel type across utilities.

Table C-13. Industrial/Agriculture SEM - Key Assumptions

Sector	Type	EUL Years	Savings		Cost		kW/kWh Savings Ratio
			kWh	therm	kWh	therm	
Industrial	SEM	4.3	1.9% - 4.4%	1.9% - 3.9%	\$0.20	\$1.35	0.000195
Agriculture	SEM	4.3	3.1% - 3.9%	3.0	\$0.20	\$1.35	0.000195

C.12.2 Assumptions and Methodology

Eligibility and Participation

Eligibility and participation estimates in the 2019 Study are consistent with the 2017 Study that defined eligibility and participation based on guidance provided by the CPUC regarding the IOUs and as part of the 2017 SEM Pilot Program development effort.¹⁶¹ Per the design of the CPUC SEM pilot and the market considerations expressed in the IOU business plans, savings in the industrial sector are initially forecast to begin in 2019 for high use market segments, including the petroleum, food, electronics, and chemicals segments, while more widespread implementation for all other industrial segments begins in 2021. Although in theory SEM applies to all customer sizes, in practice applicability of SEM is constrained to large customers. In general, this guidance does not mean that any industrial or agricultural market

¹⁶⁰ Version 1.0, February 8, 2017. Prepared by Sergio Dias Consulting LLC

¹⁶¹ Strategic Energy Management -- Comments and Responses on Design and EMV Guides, <http://www.energydataweb.com/cpuc/search.aspx>

segment will be excluded from participating in SEM but does restrict the applicability of SEM to larger participants in each market segment. Consequently, an applicability factor for SEM was defined for all industrial and agricultural market sectors and ranged between 39% and 93% for electricity and 48% to 99% for natural gas for the industrial sector, as shown in Table C-14, and between 40% and 65% for both electricity and natural gas for the agricultural sector as shown in Table C-15.

Table C-14. Industrial SEM Applicability

Segment	Fuel	Applicability
Ind - Petroleum	kWh	93%
Ind - Food	kWh	77%
Ind - Electronics	kWh	45%
Ind - Stone-Glass-Clay	kWh	85%
Ind - Chemicals	kWh	74%
Ind - Plastics	kWh	75%
Ind - Fabricated Metals	kWh	72%
Ind - Primary Metals	kWh	59%
Ind - Industrial Machinery	kWh	48%
Ind - Transportation Equipment	kWh	56%
Ind - Paper	kWh	82%
Ind - Printing & Publishing	kWh	61%
Ind - Textiles	kWh	39%
Ind - Lumber & Furniture	kWh	48%
Ind - All Other Industrial	kWh	48%
Ind - Petroleum	therms	99%
Ind - Food	therms	95%
Ind - Electronics	therms	64%
Ind - Stone-Glass-Clay	therms	97%
Ind - Chemicals	therms	98%
Ind - Plastics	therms	81%
Ind - Fabricated Metals	therms	85%
Ind - Primary Metals	therms	94%
Ind - Industrial Machinery	therms	48%
Ind - Transportation Equipment	therms	66%
Ind - Paper	therms	97%
Ind - Printing & Publishing	therms	82%
Ind - Textiles	therms	50%
Ind - Lumber & Furniture	therms	52%
Ind - All Other Industrial	therms	48%

Table C-15. Agricultural SEM Applicability

Segment	Fuel	Applicability
Ag - 110 - CEC custom NAICS code	kWh	65%

Ag - 111 - Crop Production	kWh	65%
Ag - 112 - Animal Production and Aquaculture	kWh	65%
Ag - 113 - Forestry and Logging	kWh	65%
Ag - 114 - Fishing, Hunting and Trapping	kWh	65%
Ag - 221 - CEC custom NAICS code - Water Pump	kWh	40%
Ag - 110 - CEC custom NAICS code	therms	65%
Ag - 111 - Crop Production	therms	65%
Ag - 112 - Animal Production and Aquaculture	therms	65%
Ag - 113 - Forestry and Logging	therms	65%
Ag - 114 - Fishing, Hunting and Trapping	therms	65%
Ag - 221 - CEC custom NAICS code - Water Pump	therms	40%

The starting saturation for all segments is estimated at 1.5% with a compound annual growth rate (CAGR) of 6.7% for the reference case and 10.0% for the aggressive case. By 2030 this yields a market saturation of 3.5% and 5.2% for the reference and aggressive cases, respectively.

Savings

The savings forecast for SEM is an estimate of O&M savings based on a literature review indicating that an average UES for O&M savings of 3.0% of annual sector level consumption is appropriate for the industrial and agricultural sectors. Savings at the segment level will vary, however, because SEM in the industrial and agricultural sectors applies primarily to usage associated machine drive, process heating, and process refrigeration. As such, segment specific UES values were calculated based on how much energy is consumed for these three uses.

the table below shows how usage varies by sector for the industrial segment where, for example, 93% of petroleum segment consumption is accounted for by the end uses impacted by SEM, versus the textile segment where only 39% of energy is consumed by these same end-use categories. On average, these end uses account for 64% on total industrial sector usage. An SEM segment savings adjustment factor was calculated by dividing the SEM applicable segment consumption by the market average consumption, for example for petroleum sector the SEM applicable segment consumption of 93% was divided by the industrial sector average consumption of 64% to yield an SEM segment UES adjustment factor of 1.5 for the petroleum segment. An SEM UES multiplier was then calculated by multiplying the average SEM industrial sector savings of 3.0% by the SEM segment savings adjustment factor. In this example, the average SEM industrial sector savings of 3.0% was multiplied by the UES adjustment factor of 1.5 for the petroleum segment, yielding a multiplier of 4.4%. The table below provides the UES multipliers used to forecast natural gas savings.

Table C-16. Industrial SEM Electricity UES Multipliers

Segment	SEM Target End Uses			SEM Applicable Segment Consumption	SEM Segment Savings Adjustment Factor	SEM UES Multiplier
	Machine Drives	Process Heat	Process Refrigeration			
Petroleum	88%	0%	6%	93%	1.5	4.4%
Stone-Glass-Clay	61%	24%	1%	85%	1.3	4.0%
Paper	77%	4%	2%	82%	1.3	3.9%

Food	42%	7%	29%	77%	1.2	3.7%
Plastics	51%	15%	9%	75%	1.2	3.6%
Chemicals	61%	5%	9%	74%	1.2	3.5%
Fabricated Metals	49%	20%	3%	72%	1.1	3.4%
Printing & Publishing	52%	2%	7%	61%	1.0	2.9%
Primary Metals	29%	29%	1%	59%	0.9	2.8%
Transportation Equipment	37%	13%	6%	56%	0.9	2.7%
All Other Industrial	33%	9%	6%	48%	0.8	2.3%
Industrial Machinery	33%	9%	6%	48%	0.8	2.3%
Lumber & Furniture	36%	8%	4%	48%	0.7	2.3%
Electronics	21%	12%	12%	45%	0.7	2.2%
Textiles	31%	5%	3%	39%	0.6	1.9%

Source: Navigant analysis

Table C-17. Industrial SEM Natural Gas UES Multipliers

Segment	SEM Target End Uses			SEM Segment Savings Adjustment Factor	SEM UES Multiplier
	Service Hot Water	Process Heat	Other		
Petroleum	14%	59%	26%	1.3	3.861%
Stone-Glass-Clay	1%	90%	6%	1.3	3.765%
Paper	25%	26%	46%	1.3	3.783%
Food	59%	28%	9%	1.2	3.713%
Plastics	46%	24%	11%	1.1	3.162%
Chemicals	28%	28%	43%	1.3	3.834%
Fabricated Metals	15%	65%	6%	1.1	3.330%
Printing & Publishing	13%	64%	5%	1.1	3.199%
Primary Metals	5%	78%	10%	1.2	3.645%
Transportation Equipment	15%	30%	21%	0.9	2.569%
All Other Industrial	16%	20%	12%	0.6	1.873%
Industrial Machinery	16%	20%	12%	0.6	1.873%
Lumber & Furniture	12%	28%	12%	0.7	2.023%
Electronics	42%	10%	12%	0.8	2.496%
Textiles	18%	19%	13%	0.6	1.947%

The 2019 Study uses this same process to develop savings multipliers for the agricultural sector, however because NAICS codes associated with the agricultural sector were changed to align with the IEPR definition of the agricultural sector, the same level of data used in the industrial sector forecast was not available. As such, the average UES for O&M savings of 3.0% of annual sector level consumption was used for most agricultural market segments with adjustments for segments that are primarily large motor loads, such as municipal and irrigation water pumping, as shown in Table C-18.

Table C-18. Agricultural SEM Electricity and Natural Gas UES Multipliers

Segment	Fuel	SEM UES Multiplier
Ag - 111 - Crop Production	kWh	3.1%
Ag - 112 - Animal Production and Aquaculture	kWh	3.1%
Ag - 113 - Forestry and Logging	kWh	3.1%
Ag - 114 - Fishing, Hunting and Trapping	kWh	3.1%
Ag - 221 - CEC custom NAICS code - Water Pump	kWh	3.9%
Ag - 111 - Crop Production	therms	3.0%
Ag - 112 - Animal Production and Aquaculture	therms	3.0%
Ag - 113 - Forestry and Logging	therms	3.0%
Ag - 114 - Fishing, Hunting and Trapping	therms	3.0%
Ag - 221 – Municipal and Irrigation Water Pumping	therms	3.0%

Source: Navigant analysis

The 2019 Study uses the SEM UES multiplier to forecast segment level potential net savings using the following equation:

$$\text{SEM segment level EE net savings potential} = \text{SEM UES Multiplier} \times \text{Annual Segment Consumption}^{162}$$

The model holds the industrial and agricultural segment UES multiplier constant throughout the forecast horizon.

Cost

Costs for electricity and natural gas savings are estimated at \$0.20/kWh and \$1.35/therm and are applied consistently by building and fuel type across utilities. Costs are based on an analysis of third-party industrial sector programs operating in California during the 2014-2015 portfolio. These costs are lower than those for emerging technology and generic custom type measures, reflecting that SEM savings are O&M based and do not include rebate measures for large capital investments.

¹⁶² Electric (GWh) and natural gas (therm) from the 2017 IEPR Forecast

APPENDIX D. AIMS SECTORS

This appendix provides additional detail and data for the industrial and agriculture sectors. Industrial and Agricultural building types are classified by grouping buildings in NAICS codes. The table below references the building types used in this study with their associated NAICS codes.

Sector	Subsector (Building Type)	NAICS
Industrial	Chemicals	325
	Electronics	334x, 335
	Fabricated Metals	332
	Food	311x, 312
	Industrial Machinery	333
	Lumber & Furniture	337, 321, 1133
	Paper	322x
	Petroleum	324
	Plastics	326
	Primary Metals	331
	Printing & Publishing	323, 511, 516
	Stone-Glass-Clay	327x
	Textiles	313, 314, 315, 316
	Transportation Equipment	336
All Other Industrial	339	
Agriculture	Dairies, fishing, and hunting	112, 114
	Irrigated Agriculture, vineyards, forestry, and greenhouses	111, 113
	Water pumping	221

D.1 Industrial

The following table displays the industrial measure list used in the diffusion model.

Measure Name	End-Use Category	Description
HVAC Equipment Upgrade (Electric and Gas)	HVAC	Upgrades to electric and gas HVAC equipment (using better than code energy-efficiency rating [EER] or coefficient of performance [COP]), and heat recovery
EE Lighting	Lighting	Lighting controls and early retirement potential to LED fixtures

Measure Name	End-Use Category	Description
Compressed Air	Machine Drive	Air compressor adjustments such as pressure reduction, staging, system controls, and leak identification and repair. VFD controls on air compressors to allow for loading/unloading of the compressed air system, and to replace any inefficient throttling devices
Fan VFD	Machine Drive	Variable frequency drive (VFD) controls on fans (not including HVAC fans) to take advantage of partial load conditions
Pump Upgrades	Machine Drive	Proper sizing and operation of pumps to increase pump efficiency
Energy Efficient Aerator	Machine Drive	Replacing existing inefficient aerators on wastewater systems with higher efficiency aerator technologies
Motor VFD	Machine Drive	Installation of higher efficient or premium motors across all industry processes
Pump VFD	Machine Drive	VFD controls on pumps to take advantage of partial load conditions
Boiler Controls and Optimization	Process Heating	Pressure reduction, leak reduction, steam trap maintenance, and advanced controls on boilers
Process Heat	Process Heating	Upgrades and add-ons to gas furnaces and ovens, including infrared (IR), furnace configuration, and advanced controls
Heat Recovery	Process Heating	Capturing “waste heat,” produced primarily from gas boilers, and using it in other phases of the industrial process
Insulation	Process Heating	Insulation or improved insulation on boiler equipment, storage tanks, and other process piping
Chiller	Process Refrigeration	Chiller upgrades including advanced controls, higher efficiency equipment, and overall system efficiency improvements
Refrigeration	Process Refrigeration	Advanced controls on refrigeration systems including floating head controls, evaporator fan controls, and condenser controls

Source: Navigant 2016

D.2 Agriculture

The following table describes the list of agricultural measures used in the diffusion model.

Measure Name	End-Use Category	Description
HVAC Ventilation (Fan Ventilation Improvement)	HVAC	Upgrade to more efficient fans, temperature and humidity controls, VFDs (includes post-harvest process fan aeration improvements)
HVAC Chiller Water Cooled	HVAC	Chiller upgrades including advanced controls, higher efficiency equipment, and overall system efficiency improvements
Ag Irrigation Pump	Machine Drive	Irrigation specific pump improvement, maintenance, and replacement designed to increase pump efficiency
Ag Pump VFD	Machine Drive	VFD for irrigation specific pumps (well, irrigation, booster, etc.)
Low Pressure Irrigation	Machine Drive	Conversion from high to low pressure irrigation (sprinkler to drip, low pressure nozzles, etc.)
Ag Pump Retrofit – Non-Irrigation	Machine Drive	Pump retrofits geared to all other pumps besides irrigation specific pumps
Ag Pump VFD - Dairy	Machine Drive	VFD for dairy specific pumps (vacuum, transfer, etc.)
Process Wastewater Aerator	Machine Drive	Replacing existing inefficient aerators on wastewater systems with higher efficiency aerator technologies
Exterior Lighting Upgrades	Lighting* ¹⁶³	Includes typical C&I exterior LED lighting measures as well as exterior security lights
Horticulture Interior LED Grow Lighting	Lighting	Indoor LED lamps and fixtures used for growing a variety of plants
Interior Lighting Upgrades - LED	Lighting	Includes typical C&I LED lighting measures and applications as well as agriculture-rated LEDs for animal health and animal-specific purposes
Interior Lighting Upgrades – Non-LED	Lighting	Includes typical C&I non-LED lighting measures and applications
Lighting Controls	Lighting	Occupancy sensors, photocells/timers, etc.
Greenhouse Process Heating Optimization	Process Heating	Heating optimization and equipment improvements for greenhouses (unit to bench heating conversion, boiler improvement measures, dynamic temperature controls, etc.)
Greenhouse Shell Improvements	Process Heating	Heating optimization improvements for greenhouses centered around shell improvements (thermal and shade curtains, insulation upgrades, IRAC film, etc.)
Post-Harvest Process Improvements	Process Heating	Gas improvements to post-harvesting such as more efficient heated grain drying, heat recovery, process controls

¹⁶³ All lighting is considered retrofit to allow for early retirement retrofits with the year 2019 for LED become baseline.

Measure Name	End-Use Category	Description
Pipe Insulation Hot Application	Process Heating	Insulation or improved insulation on boiler equipment, storage tanks, and other process piping
Process Refrigeration Retrofit - Dairy	Process Refrigeration	Refrigeration improvements to process milk cooling on dairies (plate coolers, scroll compressors)
Refrigeration Retrofit (Refrigeration System Optimization)	Process Refrigeration	Includes typical C&I refrigeration improvements to cold storage areas (floating head pressure controls, evaporator fan controls, evaporator fan ECMs, etc.)

Source: Navigant 2016

APPENDIX E. CODES & STANDARDS

Table E-1. C&S Modeled

Regulation	Code or Standard Name	Compliance Rate ¹⁶⁴	Effective Date	Policy View
2005 T-20	Commercial Refrigeration Equipment, Solid Door	70%	1/1/2006	On the books
2005 T-20	Commercial Refrigeration Equipment, Transparent Door	70%	1/1/2007	On the books
2005 T-20	Commercial Ice Maker Equipment	70%	1/1/2008	On the books
2005 T-20	Walk-In Refrigerators / Freezers	91%	1/1/2006	On the books
2005 T-20	Refrigerated Beverage Vending Machines	37%	1/1/2006	On the books
2005 T-20	Large Packaged Commercial Air-Conditioners, Tier 1	70%	10/1/2006	On the books
2005 T-20	Large Packaged Commercial Air-Conditioners, Tier 2	70%	1/1/2010	On the books
2005 T-20	Residential Pool Pumps, High Eff Motor, Tier 1	100%	1/1/2006	On the books
2005 T-20	Portable Electric Spas	70%	1/1/2006	On the books
2005 T-20	General Service Incandescent Lamps, Tier 1	69%	1/1/2006	On the books
2005 T-20	Pulse Start Metal Halide HID Luminaires, Tier 1(Vertical Lamps)	100%	1/1/2006	On the books
2005 T-20	Pulse Start Metal Halide HID Luminaires, Tier 2(All other MH)	100%	1/1/2008	On the books
2005 T-20	Modular Furniture Task Lighting Fixtures	70%	1/1/2008	On the books
2005 T-20	Hot Food Holding Cabinets	70%	1/1/2006	On the books
2005 T-20	External Power Supplies, Tier 1	100%	1/1/2007	On the books
2005 T-20	External Power Supplies, Tier 2	99%	7/1/2008	On the books
2005 T-20	Consumer Electronics - Audio Players	100%	1/1/2007	On the books
2005 T-20	Consumer Electronics - TVs	96%	1/1/2006	On the books
2005 T-20	Consumer Electronics - DVDs	31%	1/1/2006	On the books
2005 T-20	Water Dispensers	70%	1/1/2006	On the books
2005 T-20	Unit Heaters and Duct Furnaces	100%	1/1/2006	On the books
2005 T-20	Commercial Dishwasher Pre-Rinse Spray Valves	100%	1/1/2006	On the books
2006 T-20	Residential Pool Pumps, 2-speed Motors, Tier 2	86%	1/1/2008	On the books
2006 T-20	General Service Incandescent Lamps, Tier 2 #1	87%	1/1/2008	On the books
2006 T-20	General Service Incandescent Lamps, Tier 2 #2	87%	1/1/2008	On the books

¹⁶⁴ Compliance rates are specific to 2016 for electric energy savings. Full details are available in the model.

2006 T-20	General Service Incandescent Lamps, Tier 2 #3	89%	1/1/2008	On the books
2006 T-20	BR, ER and R20 Incandescent Reflector Lamps: Residential	82%	1/8/2008	On the books
2006 T-20	BR, ER and R20 Incandescent Reflector Lamps: Commercial	82%	1/8/2008	On the books
2008 T-20	Metal Halide Fixtures	95%	1/1/2010	On the books
2008 T-20	Portable Lighting Fixtures	93%	1/1/2010	On the books
2008 T-20	General Purpose Lighting -- 100 watt	88%	1/1/2011	On the books
2008 T-20	General Purpose Lighting -- 75 watt	40%	1/1/2012	On the books
2008 T-20	General Purpose Lighting -- 60 and 40 watt	85%	1/1/2013	On the books
2009 T-20	Televisions - Tier 1	98%	1/1/2011	On the books
2009 T-20	Televisions - Tier 2	99%	1/1/2013	On the books
2011 T-20	Small Battery Chargers – Tier 1 (consumer with no USB charger or USB charger <20 watt-hours)	90%	2/1/2013	On the books
2011 T-20	Small Battery Chargers – Tier 2 (consumer with USB charger ≥20 watt-hours)	88%	1/1/2014	On the books
2011 T-20	Small Battery Chargers – Tier 3 (non-consumer)	85%	1/1/2017	On the books
2011 T-20	Large Battery Chargers (≥2kW rated input)	78%	1/1/2014	On the books
Unevaluated T-20	Residential Faucets & Aerators - Lavatory w/ Natural Gas Water Heating - Tier 1	88%	9/1/2015	On the books
Unevaluated T-20	Residential Faucets & Aerators - Lavatory w/ Electric Water Heating - Tier 1	88%	9/1/2015	On the books
Unevaluated T-20	Residential Faucets & Aerators - Lavatory w/ Natural Gas Water Heating - Tier 2	88%	7/1/2016	On the books
Unevaluated T-20	Residential Faucets & Aerators - Lavatory w/ Electric Water Heating - Tier 2	88%	7/1/2016	On the books
Unevaluated T-20	Residential Faucets & Aerators - Kitchen w/ Natural Gas Water Heating	88%	1/1/2016	On the books
Unevaluated T-20	Residential Faucets & Aerators - Kitchen w/ Electric Water Heating	88%	1/1/2016	On the books
Unevaluated T-20	Public Lavatory Faucets	88%	1/1/2016	On the books
Unevaluated T-20	Showerheads - w/ Natural Gas Water Heaters - Tier 1	88%	7/1/2016	On the books
Unevaluated T-20	Showerheads - w/ Electric Water Heaters - Tier 1	88%	7/1/2016	On the books
Unevaluated T-20	Showerheads - w/ Natural Gas Water Heaters - Tier 2	88%	7/1/2018	On the books
Unevaluated T-20	Showerheads - w/ Electric Water Heaters - Tier 2	88%	7/1/2018	On the books
Unevaluated T-20	Commercial Toilets	88%	1/1/2016	On the books
Unevaluated T-20	Residential Toilets	88%	1/1/2016	On the books

Unevaluated T-20	Urinals	88%	1/1/2016	On the books
Unevaluated T-20	Dimming Ballasts	88%	7/1/2016	On the books
Unevaluated T-20	GSLs - Original Scope - Tier 2	88%	1/1/2018	On the books
Unevaluated T-20	Small Diameter Directional Lamps	88%	1/1/2018	On the books
Unevaluated T-20	LED Lamps - Tier 1	88%	1/1/2018	On the books
Unevaluated T-20	LED Lamps - Tier 2	88%	7/1/2019	On the books
Unevaluated T-20	Computers - Workstations	88%	1/1/2018	On the books
Unevaluated T-20	Computers - Small Scale Servers	88%	1/1/2018	On the books
Unevaluated T-20	Computers - Notebooks	88%	1/1/2019	On the books
Unevaluated T-20	Computers - Desktops - Tier 1	88%	1/1/2019	On the books
Unevaluated T-20	Computers - Desktops - Tier 2	88%	7/1/2021	On the books
Unevaluated T-20	Displays - Monitors	88%	7/1/2019	On the books
Unevaluated T-20	Air Filter Labeling	88%	4/1/2019	On the books
Unevaluated T-20	Portable Electric Spas - Rigid	88%	6/1/2019	On the books
Unevaluated T-20	Portable Electric Spas - Inflatable	88%	6/1/2019	On the books
Unevaluated T-20	Portable ACs	88%	1/1/2021	On the books
Future Title 20	Fans & Blowers	88%	1/1/2022	Possible
Future Title 20	GSFLs (T12 Loophole)	88%	1/1/2020	Possible
Future Title 20	Compressors	88%	1/1/2020	Possible
Future Title 20	Hearth Products	88%	1/1/2021	Possible
Future Title 20	Irrigation Controllers	88%	1/1/2022	Possible
Future Title 20	Residential fans (exhaust, whole house, etc.)	85%	1/1/2024	Possible
Future Title 20	Small Network Equipment	85%	1/1/2025	Possible
Future Title 20	Single-Speed Residential Filtration	85%	1/1/2021	Expected
Future Title 20	Commercial Clothes Dryers	85%	1/1/2022	Expected

Future Title 20	Commercial Imaging equipment	85%	1/1/2027	Possible
Future Title 20	Residential Imaging equipment	85%	1/1/2027	Possible
Federal	Electric Motors 1-200HP	91%	12/1/2010	On the books
Federal	Refrigerated Beverage Vending Machines	37%	8/31/2011	On the books
Federal	Commercial Refrigeration	70%	1/1/2012	On the books
Federal	Residential Electric & Gas Ranges	100%	4/9/2012	On the books
Federal	General Service Fluorescent Lamps #1	95%	7/14/2012	On the books
Federal	Incandescent Reflector Lamps	65%	7/14/2012	On the books
Federal	Commercial Clothes Washers #1	94%	1/8/2013	On the books
Federal	Residential Pool Heaters	95%	4/16/2013	On the books
Federal	Residential Direct Heating Equipment	95%	4/16/2013	On the books
Federal	Residential Refrigerators & Freezers	95%	9/15/2014	On the books
Federal	Residential Room AC	91%	6/1/2014	On the books
Federal	Fluorescent Ballasts	80%	11/14/2014	On the books
Federal	Small Commercial Package Air-Conditioners ≥ 65 and < 135 kBtu/h	100%	6/1/2013	On the books
Federal	Large and Very Large Commercial Package Air-Conditioners ≥ 135 kBtu/h	100%	6/1/2014	On the books
Federal	Computer Room ACs $\geq 65,000$ Btu/h and $< 760,000$ Btu/h	100%	10/29/2013	On the books
Federal	Residential Dishwashers	99%	5/30/2013	On the books
Federal	Residential Clothes Dryers	99%	1/15/2015	On the books
Federal	Residential Gas-fired water heater	98%	4/16/2015	On the books
Federal	Residential Electric storage water heater	88%	4/16/2015	On the books
Federal	Residential Gas-fired instantaneous water heater	87%	4/16/2015	On the books
Federal	Residential Oil-fired storage water heater	85%	4/16/2015	On the books
Federal	Small Electric Motors	35%	3/9/2015	On the books
Federal	Residential Clothes Washers (Front Loading)	100%	3/7/2015	On the books
Federal	Residential Clothes Washers (Top Loading) Tier I	100%	3/7/2015	On the books
Federal	Residential Central AC, Heat Pumps and Furnaces	99%	1/1/2015	On the books
Federal	ASHRAE Products (Commercial boilers)	95%	3/2/2012	On the books
Federal	Single package vertical AC and HP - $> 65,000$ Btu/hr and $< 240,000$ Btu/hr	95%	10/9/2015	On the books
Federal	Distribution transformers	95%	1/1/2016	On the books
Federal	External Power Supplies	95%	2/10/2016	On the books
Federal	Electric Motors	95%	6/1/2016	On the books
Federal	Microwave ovens	95%	6/17/2016	On the books
Federal	Commercial CAC and HP - $< 65,000$ Btu/hr	95%	1/1/2017	On the books
Federal	Metal Halide Lamp Fixtures	95%	2/10/2017	On the books

Federal	Commercial Refrigeration Equipment	95%	3/27/2017	On the books
Federal	Walk-in coolers and freezers	95%	6/5/2017	On the books
Federal	Commercial Clothes Washers	95%	1/1/2018	On the books
Federal	GSFLs	95%	1/26/2018	On the books
Federal	Residential Clothes Washers - Top-loading	95%	1/1/2018	On the books
Federal	Commercial CAC and HP - 65,000 Btu/hr to 760,000 Btu/hr - Tier 1	95%	1/1/2018	On the books
Federal	Commercial CAC and HP - 65,000 Btu/hr to 760,000 Btu/hr - Tier 2	95%	1/1/2023	On the books
Federal	Commercial Ice Makers	95%	1/28/2018	On the books
Federal	Pre-rinse Spray Valves	95%	1/28/2019	On the books
Federal	Refrigerated beverage vending machines #2	95%	1/8/2019	On the books
Federal	Dehumidifiers	95%	6/13/2019	On the books
Federal	Furnace fans	95%	7/3/2019	On the books
Federal	Single package vertical AC and HP - <65,000 Btu/hr	95%	9/23/2019	On the books
Federal	Wine chillers	95%	10/28/2019	On the books
Federal	Ceiling Fans	95%	1/21/2020	On the books
Federal	Ceiling Fan Light Kits	95%	1/21/2020	On the books
Federal	Commercial and Industrial Pumps	95%	1/27/2020	On the books
Federal	Residential Boilers - Gas-fired Hot Water and Electric Hot Water	95%	1/15/2021	On the books
Federal	Residential Boilers - Gas-fired Steam and Electric Steam	95%	1/15/2021	On the books
Federal	Pool Pumps	95%	7/19/2021	On the books
Federal	Dedicated-Purpose Pool Pumps	95%	7/19/2021	On the books
Federal	Commercial Furnaces	95%	1/1/2023	On the books
Federal	Residential Central AC, HP, and Furnaces	95%	1/1/2023	On the books
Federal	Water-Source Heat Pumps	95%	1/1/2026	On the books
Future Federal	GSLs - Expanded Scope	76%	1/1/2020	Possible
Future Federal	Commercial Boilers	95%	1/1/2023	Possible
Future Federal	Residential Electric & Gas Ranges	95%	1/1/2023	Possible
Future Federal	Circulator Pumps	95%	1/1/2023	Possible
Future Federal	Fluorescent Ballasts	95%	11/14/2025	Possible
Future Federal	Residential Clothes Dryers	95%	1/15/2025	Possible
Future Federal	Residential Room ACs	95%	6/1/2025	Possible
Future Federal	Residential Furnaces	95%	3/1/2026	Possible

Future Federal	Residential central AC (not heat pumps)	85%	1/1/2031	Possible
Future Federal	Ranges and ovens (gas)	85%	1/1/2030	Possible
Future Federal	Commercial package AC and heating equipment	85%	1/1/2031	Possible
Future Federal	Commercial water heaters	85%	1/1/2029	Possible
Future Federal	High efficiency gas storage water heaters	85%	1/1/2025	Possible
Future Federal	High efficiency gas tankless water heaters	85%	1/1/2025	Possible
Future Federal	Residential heat pump water heaters	85%	1/1/2025	Possible
Future Federal	Residential Refrigerators and Freezers	85%	1/1/2026	Possible
Future Federal	Small Motors	85%	1/1/2025	Possible
Future Federal	Computer Room Air Conditioners (CRAC)	85%	1/1/2025	Possible
Future Federal	Ranges and ovens (electric)	85%	1/1/2030	Possible
Future Federal	Packaged Terminal AC (PTAC) and HP (PTHP)	85%	1/1/2028	Possible
2005 T-24	Time dependent valuation, Residential	0%	1/1/2006	On the books
2005 T-24	Time dependent valuation, Nonresidential	0%	1/1/2006	On the books
2005 T-24	Res. Hardwired lighting	113%	1/1/2006	On the books
2005 T-24	Duct improvement	59%	1/1/2006	On the books
2005 T-24	Window replacement	80%	1/1/2006	On the books
2005 T-24	Lighting controls under skylights	8%	1/1/2006	On the books
2005 T-24	Ducts in existing commercial buildings	75%	1/1/2006	On the books
2005 T-24	Cool roofs	75%	1/1/2006	On the books
2005 T-24	Relocatable classrooms	100%	1/1/2006	On the books
2005 T-24	Bi-level lighting control credits	79%	1/1/2006	On the books
2005 T-24	Duct testing/sealing in new commercial buildings	82%	1/1/2006	On the books
2005 T-24	Cooling tower applications	88%	1/1/2006	On the books
2005 T-24	Multifamily Water Heating	78%	1/1/2006	On the books
2005 T-24	Composite for Remainder - Res	120%	1/1/2006	On the books
2005 T-24	Composite for Remainder - Non-Res	85%	1/1/2006	On the books
2005 T-24	Whole Building - Res New Construction (Electric)	120%	1/1/2006	On the books
2005 T-24	Whole Building - Non-Res New Construction (Electric)	0%	1/1/2006	On the books
2005 T-24	Whole Building - Res New Construction (Gas)	235%	1/1/2006	On the books

2005 T-24	Whole Building - Non-Res New Construction (Gas)	0%	1/1/2006	On the books
2008 T-24	Envelope insulation	123%	10/1/2010	On the books
2008 T-24	Overall Envelope Tradeoff	397%	10/1/2010	On the books
2008 T-24	Skylighting	397%	10/1/2010	On the books
2008 T-24	Sidelighting	397%	10/1/2010	On the books
2008 T-24	Tailored Indoor lighting	573%	10/1/2010	On the books
2008 T-24	TDV Lighting Controls	0%	10/1/2010	On the books
2008 T-24	DR Indoor Lighting	397%	10/1/2010	On the books
2008 T-24	Outdoor Lighting	83%	10/1/2010	On the books
2008 T-24	Outdoor Signs	83%	10/1/2010	On the books
2008 T-24	Refrigerated warehouses	83%	10/1/2010	On the books
2008 T-24	DDC to Zone	397%	10/1/2010	On the books
2008 T-24	Residential Swimming pool	83%	7/1/2010	On the books
2008 T-24	Site Built Fenestration	83%	10/1/2010	On the books
2008 T-24	Residential Fenestration	83%	7/1/2010	On the books
2008 T-24	Cool Roof Expansion	153%	10/1/2010	On the books
2008 T-24	MF Water heating control	0%	9/1/2010	On the books
2008 T-24	CfR IL Complete Building Method	571%	9/1/2010	On the books
2008 T-24	CfR IL Area Category Method	569%	9/1/2010	On the books
2008 T-24	CfR IL Egress Control	397%	9/1/2010	On the books
2008 T-24	CfR HVAC Efficiency	397%	9/1/2010	On the books
2008 T-24	CfR Res Cool Roofs	83%	9/1/2010	On the books
2008 T-24	CfR Res Central Fan WL	83%	9/1/2010	On the books
2013 T-24	NRA-Lighting-Alterations-New Measures	91%	7/1/2014	On the books
2013 T-24	NRA-Lighting-Alterations-Existing Measures	91%	7/1/2014	On the books
2013 T-24	NRA-Lighting-Egress Lighting Control	91%	7/1/2014	On the books
2013 T-24	NRA-Lighting-MF Building Corridors	91%	7/1/2014	On the books
2013 T-24	NRA-Lighting-Hotel Corridors	91%	7/1/2014	On the books
2013 T-24	NRA-Lighting-Warehouses and Libraries	91%	7/1/2014	On the books
2013 T-24	NRA-Envelope-Cool Roofs	83%	7/1/2014	On the books
2013 T-24	NRA-HVAC-Equipment Efficiency	83%	7/1/2014	On the books
2013 T-24	NRA-Process-Air Compressors	83%	7/1/2014	On the books
2013 T-24	NRNC-Lighting-Egress Lighting Control	83%	4/1/2015	On the books
2013 T-24	NRNC-Lighting-MF Building Corridors	83%	4/1/2015	On the books
2013 T-24	NRNC-Lighting-Hotel Corridors	83%	4/1/2015	On the books
2013 T-24	NRNC-Lighting-Warehouses and Libraries	83%	4/1/2015	On the books
2013 T-24	NRNC-Lighting-Parking Garage	83%	4/1/2015	On the books
2013 T-24	NRNC-Lighting-Controllable Lighting	83%	4/1/2015	On the books
2013 T-24	NRNC-Lighting-DR Lighting Controls	83%	4/1/2015	On the books
2013 T-24	NRNC-Lighting-Outdoor Lighting & Controls	83%	4/1/2015	On the books

2013 T-24	NRNC-Lighting-Office Plug Load Control	83%	4/1/2015	On the books
2013 T-24	NRNC-HVAC-Garage Exhaust	83%	4/1/2015	On the books
2013 T-24	NRNC-HVAC-Laboratory Exhaust	83%	4/1/2015	On the books
2013 T-24	NRNC-HVAC-Small ECM Motor	83%	4/1/2015	On the books
2013 T-24	NRNC-HVAC-Water & Space Heating ACM	83%	4/1/2015	On the books
2013 T-24	NRNC-HVAC-Cooling Towers Water	83%	4/1/2015	On the books
2013 T-24	NRNC-HVAC-Occupant Controlled Smart Thermostats	83%	4/1/2015	On the books
2013 T-24	NRNC-HVAC-Low-Temp Radiant Cooling	83%	4/1/2015	On the books
2013 T-24	NRNC-HVAC-Evap Cooling Credit	83%	4/1/2015	On the books
2013 T-24	NRNC-HVAC-Outside Air	83%	4/1/2015	On the books
2013 T-24	NRNC-HVAC-Acceptance Requirements	83%	4/1/2015	On the books
2013 T-24	NRNC-Refrigeration-Warehouse	83%	4/1/2015	On the books
2013 T-24	NRNC-Refrigeration-Supermarket	83%	4/1/2015	On the books
2013 T-24	NRNC-Process-Process Boilers	83%	4/1/2015	On the books
2013 T-24	NRNC-Process-Air Compressors	83%	4/1/2015	On the books
2013 T-24	NRNC-Process-Data Centers	83%	4/1/2015	On the books
2013 T-24	NRNC-DHW - Hotel DHW Control and Solar	83%	4/1/2015	On the books
2013 T-24	NRNC-DHW-Solar Water Heating	83%	4/1/2015	On the books
2013 T-24	NRNC-Solar-Solar Ready	83%	4/1/2015	On the books
2013 T-24	NRNC-Whole Building	93%	4/1/2015	On the books
2013 T-24	RNC-Lighting	0%	1/1/2015	On the books
2013 T-24	RNC-DHW - MF DHW Control and Solar	83%	4/1/2015	On the books
2013 T-24	RNC-DHW - High Efficiency Water Heater Ready	83%	1/1/2015	On the books
2013 T-24	RNC-DHW - Solar for Electrically Heated Homes	83%	1/1/2015	On the books
2013 T-24	RNC-Solar - Solar Ready & Oriented Homes	83%	1/1/2015	On the books
2013 T-24	RNC-SF Whole Building	67%	1/1/2015	On the books
2013 T-24	RNC-MF Whole Building	83%	4/1/2015	On the books
2013 T-24	RA-SF Whole Building	67%	7/1/2014	On the books
2013 T-24	RA-MF Whole Building	83%	7/1/2014	On the books
2016 T-24	NRA-Lighting-Alterations	85%	2/1/2017	On the books
2016 T-24	NRA-Lighting-Outdoor Lighting Controls	85%	2/1/2017	On the books
2016 T-24	NRA-Lighting-ASHARE Measure-Elevator Lighting & Ventilation	85%	2/1/2017	On the books
2016 T-24	NRA-Envelope-Opaque Wall (Roof Alterations)	85%	2/1/2017	On the books
2016 T-24	NRA-HVAC-ASHARE Measure-DDC	85%	2/1/2017	On the books
2016 T-24	NRA-HVAC-ASHRAE Equipment Efficiency	85%	2/1/2017	On the books
2016 T-24	NRA-Process-ASHARE Measure-Escalator Speed Control	85%	2/1/2017	On the books

2016 T-24	NRNC-Whole Building	85%	11/1/2017	On the books
2016 T-24	RNC-Single Family Whole Building	85%	7/1/2017	On the books
2016 T-24	RNC-Multifamily Whole Building	85%	7/1/2017	On the books
2016 T-24	RA-Single Family Whole Building	85%	4/1/2017	On the books
2016 T-24	RA-Multifamily Whole Building	85%	4/1/2017	On the books
2019 T-24	NRA-Indoor Lighting-Alterations (Control)	85%	3/1/2020	On the books
2019 T-24	NRA-Indoor Lighting-Alterations (LPD)	85%	3/1/2020	On the books
2019 T-24	NRA-Indoor Lighting-New LPD	85%	3/1/2020	On the books
2019 T-24	NRA-Indoor Lighting-New Controls	85%	3/1/2020	On the books
2019 T-24	NRA- Outdoor Lighting-LPA (General Hardscape)	85%	3/1/2020	On the books
2019 T-24	NRA- Outdoor Lighting-LPA (Specific Applications)	85%	3/1/2020	On the books
2019 T-24	NRA-Outdoor Lighting-Controls	85%	3/1/2020	On the books
2019 T-24	NRA-MECH-ASHRAE 90.1	85%	3/1/2020	On the books
2019 T-24	NRA-MECH-Cooling Towers	85%	3/1/2020	On the books
2019 T-24	NRA-MECH-HE Fume Hoods in Lab Spaces	85%	3/1/2020	On the books
2019 T-24	NRA-MECH-Variable Exhaust Flow Control	85%	3/1/2020	On the books
2019 T-24	NRNC-Indoor Lighting-LPD	85%	10/1/2020	On the books
2019 T-24	NRNC-Indoor Lighting-Controls	85%	10/1/2020	On the books
2019 T-24	NRNC- Outdoor Lighting-LPA (General Hardscape)	85%	10/1/2020	On the books
2019 T-24	NRNC- Outdoor Lighting-LPA (Specific Applications)	85%	10/1/2020	On the books
2019 T-24	NRNC-Outdoor Lighting-Controls	85%	10/1/2020	On the books
2019 T-24	NRNC-Envelope-Dock Seals	85%	10/1/2020	On the books
2019 T-24	NRNC-MECH-Adiabatic Condensers for Refrigeration	85%	10/1/2020	On the books
2019 T-24	NRNC-MECH-ASHRAE 90.1	85%	10/1/2020	On the books
2019 T-24	NRNC-MECH-Cooling Towers	85%	10/1/2020	On the books
2019 T-24	NRNC-MECH-Economizer FDD	85%	10/1/2020	On the books
2019 T-24	NRNC-MECH-HE Fume Hoods in Lab Spaces	85%	10/1/2020	On the books
2019 T-24	NRNC-MECH-Variable Exhaust Flow Control	85%	10/1/2020	On the books
2019 T-24	NRNC-MECH-Ventilation & IAQ	85%	10/1/2020	On the books
2019 T-24	RNC(SF)-Envelope-High Performance Attics	85%	7/1/2020	On the books
2019 T-24	RNC(SF)-Envelope-High Performance Walls	85%	7/1/2020	On the books
2019 T-24	RNC(SF)-Envelope-QII	85%	7/1/2020	On the books
2019 T-24	RNC(SF)-Envelope-Windows and Doors	85%	7/1/2020	On the books
2019 T-24	RNC(SF)-MECH-Quality HVAC	85%	7/1/2020	On the books

2019 T-24	RNC(MF)-Envelope-High Performance Attics	85%	9/1/2020	On the books
2019 T-24	RNC(MF)-Envelope-QII	85%	9/1/2020	On the books
2019 T-24	RNC(MF)-Envelope-Windows and Doors	85%	9/1/2020	On the books
2019 T-24	RNC(MF)-MECH-Quality HVAC	85%	9/1/2020	On the books
2019 T-24	RA(SF)-Envelope-High Performance Walls	85%	4/1/2020	On the books
2019 T-24	RA(SF)-Envelope-QII	85%	4/1/2020	On the books
2019 T-24	RA(SF)-Envelope-Windows and Doors	85%	4/1/2020	On the books
2019 T-24	RA(SF)-MECH-Quality HVAC	85%	4/1/2020	On the books
2019 T-24	RA(MF)-Envelope-QII	85%	4/1/2020	On the books
2019 T-24	RA(MF)-Envelope-Windows and Doors	85%	4/1/2020	On the books
2019 T-24	RA(MF)-MECH-Quality HVAC	85%	4/1/2020	On the books
2022 T-24	NRA	80%	1/31/2023	Expected
2022 T-24	NRNC-Whole Building	80%	10/31/2023	Expected
2025 T-24	NRA	80%	1/30/2026	Possible
2025 T-24	NRNC-Whole Building	80%	10/30/2026	Possible
2028 T-24	NRA	80%	1/29/2029	Possible
2028 T-24	NRNC-Whole Building	80%	10/29/2029	Possible

Table E-2 specifies all standards that are assumed to be superseded by other standards.

Table E-2. C&S Superseded Codes and Standards

Superseded Code or Standard	Superseding Code or Standard	Source
2005 T-20: Walk-in Refrigerators/Freezers	Fed Appliance: Walk-in coolers and freezers	Navigant Assumption
2005 T-20: Commercial Dishwasher Pre-Rinse Spray Valves	Fed Appliance: Pre-Rinse Spray Valves	Navigant Assumption
2005 T-20: Consumer Electronics - TVs	2009 T-20: Televisions - Tier 1	ISSM
2005 T-20: Commercial Refrigeration Equipment, Solid Door	Fed Appliance: Commercial Refrigeration	ISSM
2005 T-20: Commercial Refrigeration Equipment,	Fed Appliance: Commercial Refrigeration	ISSM
2005 T-20: Commercial Ice Maker Equipment	Fed Appliance: Commercial Refrigeration	ISSM
2005 T-20: Refrigerated Beverage Vending Machines	Fed Appliance: Refrigerated Beverage Vending Machines	ISSM
2006 T-20: Residential Pool Pumps, 2-speed Motors, Tier 2	Fed Appliance: Pool Pumps	Navigant Assumption
2006 T-20: BR, ER and R20 Incandescent Reflector Lamps: Residential	Fed Appliance: Incandescent Reflector Lamps	ISSM
2006 T-20: BR, ER and R20 Incandescent Reflector Lamps: Commercial	Fed Appliance: Incandescent Reflector Lamps	ISSM
2006 T-20: General Service Incandescent Lamps, Tier 2 #1	2008 T-20: General Purpose Lighting -- 100 watt	ISSM
2006 T-20: General Service Incandescent Lamps, Tier 2 #2	2008 T-20: General Purpose Lighting -- 75 watt	ISSM
2006 T-20: General Service Incandescent Lamps, Tier 2 #3	2008 T-20: General Purpose Lighting -- 60 and 40 watt	ISSM
2006 T-20: General Service Incandescent Lamps, Tier 2 #1	EISA	ISSM
2006 T-20: General Service Incandescent Lamps, Tier 2 #2	EISA	ISSM
2006 T-20: General Service Incandescent Lamps, Tier 2 #3	EISA	ISSM
2008 T-20: General Purpose Lighting -- 100 watt	EISA	ISSM
2008 T-20: General Purpose Lighting -- 75 watt	EISA	ISSM
2008 T-20: General Purpose Lighting -- 60 and 40 watt	EISA	ISSM
Unevaluated T-20: GSLs – Original Scope – Tier 2	Future Fed Appliance: GSLs - Expanded Scope	Navigant Assumption

APPENDIX F. IND/AG GENERIC CUSTOM & EMERGING TECHNOLOGIES

F.1 Ind/Ag Generic Custom Measure Forecast Methodology

F.1.1 Summary

Generic custom (GC) measures in the industrial sector are projects that tend to be specific to an industry segment or production method. Table F-1 provides the inputs for the GC measures in the 2019 Study and the proceeding discussion details the assumptions and methodology used to derive these inputs.

Table F-1. Industrial/Agriculture GC - Key Assumptions

Sector	Type	EUL Years	Savings		Cost		kW/kWh Savings Ratio
			kWh	therm	kWh	therm	
Ind	GC	15	0.0921%	0.1328%	\$0.33	\$2.25	0.000195
Ag			0.1995%	0.8996%			

F.1.2 Applicability and Penetration

Applicability of GC measures in the industrial and agricultural sectors is 100% because these measures are considered ubiquitous to all activities in all market segments. The approach to forecasting the penetration rate for GC measures changed for the 2019 model. In the 2017 Study (and prior years) penetration rates were held constant over the forecast horizon under the assumption that industrial facilities continually upgrade equipment and processes and therefore GC measures would be installed at the same rate as past program activity. Based on an analysis of EEStats data from 2013 through 2017 it was determined that GC savings are decreasing over time after separating out the contribution from RCx. As such, the penetration rate for GC measures was revised to show an annual decrease of approximately 2.1%.

The team conducted a literature review to define an approach to estimate savings from GC measures:

- 2004-2005 Statewide Nonresidential Standard Performance Contract Program Measurement and Evaluation Study¹⁶⁵
- 2006-2008 Evaluation Report for PG&E Fabrication, Process, and Manufacturing Contract Group¹⁶⁶

¹⁶⁵ California Public Utilities Commission. Itron, Inc. CALMAC Study ID: SCE0220.01

¹⁶⁶ California Public Utilities Commission. Itron, Inc. February 3, 2010. CALMAC Study ID: CPU0017.01

- 2006-2008 Evaluation Report for the Southern California Industrial and Agricultural Contract Group¹⁶⁷
- 2010-12 WO033 Custom Impact Evaluation Final Report¹⁶⁸
- 2010-12 WO033 Custom Net-to-Gross Final Report¹⁶⁹
- Final Report 2013 Custom Impact Evaluation, Industrial, Agricultural, and Large Commercial Submitted to California Public Utilities Commission¹⁷⁰
- Final Report 2014 Custom Impact Evaluation Industrial, Agricultural, and Large Commercial, California Public Utilities Commission¹⁷¹
- 2013 Ex-post Efficiency Savings and Performance Incentive (ESPI) Performance Statement Report¹⁷²
- 2014 Ex-Post ESPI Final Performance Statement Report¹⁷³
- E-4807 Draft Resolution¹⁷⁴
- CPUC EEstats and CEDARS data for net program savings for the 2013-2017 program cycles.

For the 2019 model, the definition of GC measures was revised from the 2017 Study to account for the following:

- There are a large number of measures that are defined but where any one measure contributes only a small percentage of portfolio savings (e.g., faucet aerator). These measures were aggregated, and the total impact was included within the generic measure category. A review of EEstats data for the 2013 – 2017 portfolio shows these smaller measures accounted for 9% of industrial sector and 8% of agricultural sector savings.
- The 2020 model separated out RCx savings from GC and considered RCx to be part of SEM savings because RCx is an integral part of effective SEM program designs. The 2017 Study included RCx as part of GC.
- The agricultural sector forecast is also impacted because the definition of which NAICS codes are to be included in the agricultural sector was redefined for the 2019 model to better align with the IEPR sector definition.

Considering these changes in the definition of the generic custom measure class, an analysis of data available through the EEstats portal for programs operating from 2013 through Q3 2017 indicating the GC savings have declined over time, while RCx savings have shown a positive trend as shown in Figure F-1.

¹⁶⁷ California Public Utilities Commission. Itron, Inc. February 3, 2010, CALMAC Study ID: CPU0018.01

¹⁶⁸ California Public Utilities Commission. Itron, Inc. July 14, 2014. 2010-12 WO033. CALMAC Study ID: CPU0072.01

¹⁶⁹ California Public Utilities Commission. Itron, Inc. September 24, 2014. CALMAC Study ID: CPU0072.03

¹⁷⁰ California Public Utilities Commission. Itron, Inc. July 17, 2015. CALMAC Study ID: CPU0147.01

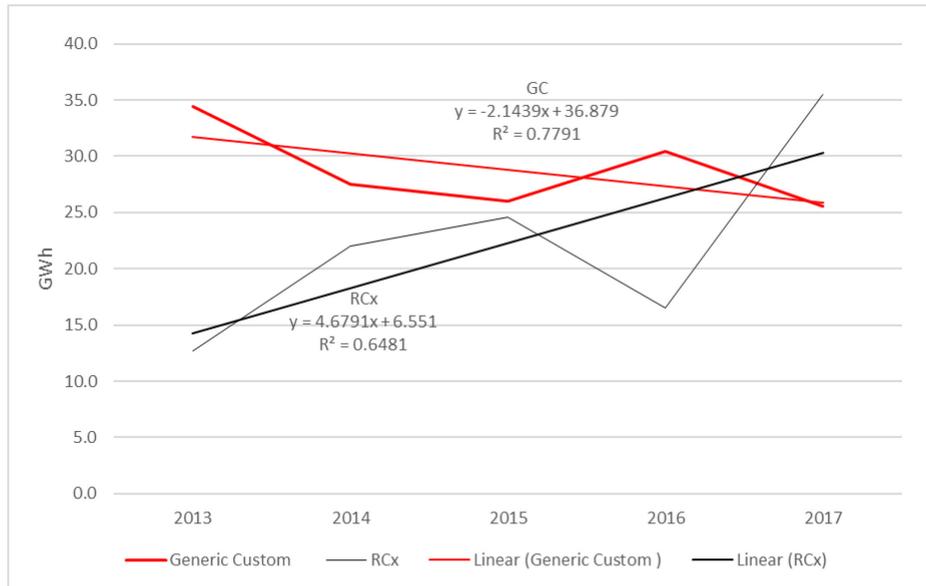
¹⁷¹ California Public Utilities Commission. Itron, Inc. April 29, 2016. CALMAC Study ID:

¹⁷² CPUC, June 15, 2015

¹⁷³ CPUC, August 1, 2016

¹⁷⁴ Resolution E-4807, CPUC, December 15, 2016

Figure F-1. Comparison of GC and RCx Savings Trends



After separating out the RCx savings and considering small measures to be part of GC, Navigant completed the assessment of the contribution of GC measures to the total savings in the industrial and agricultural sectors. For the industrial sector, data available through the California EESStats portal¹⁷⁵ for programs operating from 2013 through 2017 was analyzed, and it was determined that GC measures contributed 22% of net electricity savings and 49% of natural gas savings. Based on this analysis it was determined that GC measures saved an average of 28.8 GWh annually in the industrial sector and 4.4 MMtherms over the 5-year period spanning 2013 through 2017. A GC UES multiplier was then developed by dividing these annual average energy savings by average sector consumption forecast for 2017 through 2030. This methodology defined GC UES multipliers of 0.09% for annual industrial sector electricity usage and 0.13% of annual natural gas usage. The UES factors in the 2019 model are smaller than the UES factors used in the 2017 Study because they included EESStats savings values for 2016 and 2017, which are considerably lower than savings realized in 2013 through 2015. As such, the industrial sector UES factors in the 2019 model for electricity and natural gas are 40% and 24% lower than the factors used in the 2017 Study.

For the agricultural sector, data available through the California EESStats portal¹⁷⁶ for programs operating from 2013 through 2017 was also analyzed, from which it was determined that GC measures contributed 35% of net electricity savings and 41% of net natural gas savings. Based on this analysis it was determined that GC measures save an average of 31 GWh and 1.0 MMtherms annually. A GC UES multiplier was then developed by dividing annual average energy savings by average sector consumption forecast for 2017 through 2030. This defined GC UES multipliers of 0.20% for annual agricultural sector electricity usage and 0.90% of annual natural gas usage. As with the industrial sector, the agricultural sector UES factors in the 2019 model are smaller than the UES factors used in the 2017 Study because they included EESStats savings values for 2016 and 2017, which are considerably lower than savings

¹⁷⁵ <http://eestats.cpuc.ca.gov/Default.aspx>

¹⁷⁶ <http://eestats.cpuc.ca.gov/Default.aspx>

realized in 2013 through 2015. As such, the agricultural sector UES factors in the 2019 model for electricity and natural gas are 28% and 25% lower than the factors used in the 2017 Study.

The agricultural sector forecast is also impacted because the definition of which NAICS codes are to be included in the agricultural sector was redefined for the 2019 model to better align with the IEPR sector definition. This redefinition required that some agricultural market segments previously used in the agricultural forecast be accounted for in the commercial sector, and market segments addressing water pumping potential be added to the agricultural sector. Table F-2 provides a comparison of agricultural sector NAICS used in the 2018 and 2019 models, while Table F-3 provides additional details on NAICS that define water pumping in the IEPR agricultural forecast. NAICS that were defined in the agricultural sector forecast in the 2018 (and prior) models but that are now considered part of the commercial sector are provided in Table F-5. This redefinition reduced the number of potential measures and savings applicability for the agricultural sector because water pumping usage is centered primarily on motor loads and therefore has a more limited set of EE options than the more diverse sectors shifted to the commercial sector, such as post-harvest processing. The net effect of lower UES values and a reduced set of market segments present in the agricultural sector is a significantly lower forecast for agricultural potential than was presented in the 2018 forecast.

Table F-2. Comparison of Ag Sector NAICS Between Models

2019 Study		2017 Study	
Definition	NAICS	Definition	NAICS
Crop Production	111	Irrigated Agriculture	1111, 1119, 1112, 1113
		Wineries and Vineyards	111332
Animal Production	112	Concentrated Animal Feeding Operation	112
		Dairies	112120
Forestry and Logging	113	Not Included	
Fishing	114	Not Included	
Water Pumping	221	Not Included	

Table F-3. CEC Ag Sector Water Pumping NAICS

NAICS Category	NAICS Code	NAICS Code description	Utility		
			PGE	SCE	SDGE
Water Supply	221310	Water Supply and Irrigation Systems	71%	2%	93%
Water Supply	221311	Water pumping, municipal water supply	5%	96%	4%
Irrigation	221312	Water pumping, agriculture irrigation	24%	2%	3%

Table F-4. NAICS Codes Removed from the Ag Sector

Definition	NAICS	Percentage of 2018 Sector Usage
Post-Harvest Processing	115114, 115111	16.5%
Refrigerated Warehouses	493120	11.7%

The GC UES multipliers for both the industrial and agricultural sectors was held constant throughout the forecast horizon and was applied to the consumption forecast for each market segment level throughout the forecast horizon using the following equation:

Equation F-1. GC Segment Net Savings Potential

$$GC \text{ segment level EE net savings potential} = GC \text{ UES Multiplier} \times \text{Annual Segment Consumption}^{177}$$

F.1.3 Other Input Assumptions

Because GC measures tend to be larger capital investments that operate for long periods of time an EUL of 15 years was used in the forecasts.

A ratio of kW to kWh of 0.000195 was applied.

Finally, costs for electricity and natural gas savings are based on an analysis of industrial and agricultural programs operating throughout 2016. They are estimated at \$0.33/kWh and \$2.25/therm, and they are applied consistently across sectors and utilities.

F.2 Ind/Ag Emerging Technology Measures

F.2.1 Summary

In the context of the 2019 Study, emerging technologies (ETs) are new technologies that have demonstrated energy benefits to the industrial and agricultural sectors but are not yet widely adopted in the market. The team evaluated ETs at varying stages along the path to market readiness – some were just demonstrated in a laboratory or research setting, and others had been proven effective through pilot tests and are in early commercial adoption.

The 2019 Study is an update to the approach used for the 2017 Study. For the 2017 Study, Navigant identified approximately 1,100 potential ETs. These ETs were run through a screening process to rate energy technical potential, energy market potential, market risk, technical risk, and utility ability to impact market adoption. This process ultimately yielded 173 emerging technology processes¹⁷⁸ for final consideration within the model. For the 2019 Study Navigant reviewed the data source used in the 2017

¹⁷⁷ Electric (GWh) and natural gas (therm) from the 2017 IEPR forecast

¹⁷⁸ The emerging technologies represent a process for reducing energy consumption and not necessarily a specific technology.

Study to include measures that might have been added since the initial review, and updated measures originally identified for which there might be more recent data.

The following provides a description of the methodology used to evaluate the emerging technology market. The Assumptions and Methodology section discusses the process used to develop the model inputs for energy savings that are also summarized in Table F-5. Segment-specific electric and gas savings are consistently applied across all utilities. Costs, EUL, and the kW/kWh savings ratio are also universally applied.

Table F-5. Industrial/Agriculture ET - Key Assumptions

Sector	Type	EUL Years	Savings		Cost		kW/kWh Savings Ratio
			kWh	therm	kWh	therm	
AIMS (Ind/Ag)	Emerging Technologies (ET)	10	0.93% - 9.62%	0.0% - 14.21%	\$0.42	\$2.83	0.000195

F.2.2 Eligibility and Participation

Our 2020 assessment of eligibility and participation began with quality assurance and quality control efforts to review the 2017 Study inputs to assess data entry, technology assessment, classification and scoring, as well as Excel formula references. Although no major changes were made, our review revealed a small number of instances for minor clarification or revisions to NAICS assignment or end use applicability of savings. For instance, a lighting measure was reclassified from the broader category of irrigated agriculture sector to the more specific greenhouses sector. In another, a formerly universally applied building facade measure was amended to eliminate therm savings from refrigerated warehouses, while another measure for waste heat recovery from refrigerated systems was updated to better reflect its potential applicability for heating of non-refrigerated spaces. In all, 13 measures received such minor fixes that resulted in no appreciable differences.

The process to evaluate eligibility and participation was to first identify the portfolio of ETs applicable to the industrial and agricultural sectors. Defining this portfolio was accomplished through the following steps:

1. Collect data to assemble a broad portfolio of ETs.
2. Characterize ETs based on various savings potential and risk criteria.

To collect data, the team reviewed the following web sources:

- Emerging Technologies Coordinating Council¹⁷⁹
- CEC Publications Database¹⁸⁰

¹⁷⁹ <http://www.etcc-ca.com/reports>

¹⁸⁰ <http://www.energy.ca.gov/publications/searchReports.php?pier1=Buildings%20End-Use%20Energy%20Efficiency>

- DOE Research and Development Projects¹⁸¹
- DOE Energy Efficiency & Renewable Energy Emerging Technologies Database¹⁸²
- Broad web search which included independent research of topics and keywords that seemed of relevance to the team based on the initial web scrape results of the other sources.

This process yielded an Excel-based database with approximately 1,100 different ETs that captured several details including the name of the ET, a description of the technology, and key dates in the research process. Web scraping is an effective method to gather a broad wealth of information. However, it does not filter out irrelevant information. Therefore, the team refined the database by deleting certain entries or by enhancing information on select other ETs with additional research data from identified sources. As discussed under the appendix section on GC measures, the definition of agricultural sector was revised to better align with the IEPR agricultural sector definition. This included consideration of ETs most applicable to water pumping measures including:

- Ultra-Efficient and Power-Dense Motors
- Efficient Electronics Through Measurement and Communication, National Lab Buildings Energy Efficiency Research Projects
- Compressed Air to Blower Air
- Automated Hybrid Demand Control and Demand Response in Commercial Accounts
- Increasing the Market Acceptance of Smaller CHP Systems

Once the portfolio of ETs was prepared, each ET was characterized to determine if it is relevant to the industrial or agricultural sector and define how each ET might impact each market segment within those sectors. The team gave each relevant technology a unique ID and characterized it with the following criteria. Criteria were also weighted to prioritize their relevance as shown in Table E-3.

- Classification Information
 - Fuel savings (electricity/gas)
 - End-use
 - NAICS sector (3 or 4 digit)
 - Energy savings as a percent of sector consumption
- Evaluation Criteria (used to calculate overall impact evaluation score)
 - Energy technical potential
 - Energy market potential
 - Market risk
 - Technical risk

¹⁸¹ <https://energy.gov/eere/amo/research-development-projects>

¹⁸² <https://energy.gov/eere/buildings/emerging-technologies>

- Utility ability to impact outcome
- Non-energy benefits

The team gave each ET a score of 1 through 5 for each evaluation criteria, which were then weighted and summed to calculate the overall impact evaluation score. ETs that earn a higher score are expected to have a greater impact (i.e., greater energy savings) on the agricultural or industrial sectors. Table F-6 gives the scoring and weighting information for the evaluation criteria. The process ultimately yielded 173 emerging technology processes which were used to forecast the savings potential for ETs.

Table F-6. Emerging Technology Evaluation Criteria

Technology Characteristics	Weight	1	2	3	4	5
Energy Technical Potential	3	Low	Low	Medium	High	High
Energy Market Potential	3	Low	Low	Medium	High	High
Market Risk	2	High Risk	High Risk	Medium Risk	Low Risk	Low Risk
Technical Risk	2	High Risk	High Risk	Medium Risk	Low Risk	Low Risk
Utility Ability to Impact Market	1	Private sector will succeed without utility involvement	Utility is unlikely to be critical to adoption	Utility is likely to accelerate adoption	Utility is important in accelerating adoption	Utility is essential for catalyzing market
Non-Energy Benefits (NEBs)	1	Few or none NEBs	Some modest NEBs likely	Significant benefits, but difficult to quantify / not understood	1 or 2 quantified, well-documented NEBs	Extensive, quantified, well-understood NEBs

Source: Navigant analysis

The characterization process worked to distinguish between energy technical potential and energy market potential. The energy technical potential evaluates the energy savings of the specific technology, relative to the energy consumption of the baseline equivalent technology. The energy market potential takes a broader view and is a measure of the energy savings potential of that ET relative to the entire market energy consumption. ETs that have a high energy technical potential, but low energy market potential include technologies that drastically improve efficiency of a certain technology but have limited market application.

F.2.3 Savings

To estimate savings, the team calculated multipliers for each ET. These multipliers represent information on the total energy savings potential of the ET and other influential market data. The following formula was used to calculate the multiplier for each emerging technology that is then applied to a specific market segment and end-use energy consumption.

Equation F-2. Emerging Technology Multiplier

$$M_{e,i,j} = T_e \times E_{i,j} \times MT_j \times TW_j$$

Where:

$M_{e,i,j}$	=	multiplier for each ET, e , applied to end-use, i , and segment, j
e	=	subscript indicating the ET
i	=	subscript indicating the end-use
j	=	subscript indicating the market segment
T_e	=	technology energy savings percentage for ET, e
$E_{i,j}$	=	percentage of segment j energy attributable to end-use, i
MT_j	=	market trajectory for segment j
TW_j	=	segment energy consumption trend weight for segment j

- The technology energy savings percentage, T_e , was identified during the ET characterization process.
- The segment end-use percentage, $E_{i,j}$, is derived from California market data.¹⁸³
- The market trajectory for each sector, MT_j , is a value between 0 and 1 and is intended to define if a market segment is likely to stay active in California long enough for the ET to move up the adoption curve to a point where they make an impact on segment energy use. No specific timeline was defined, however the team assigned segments a weight:¹⁸⁴ For the 2019 model all measures have a market trajectory of 1 as a result of discussions with CEC in which it was determined that IEPR segment forecasts include considerations for reductions in electricity and natural gas that result from industries relocating outside of California, including offshoring.
 - 0.33. Indicates a segment is likely to move or remain offshore. It is not expected to benefit from the ET adoption cycle.
 - 0.67. Indicates a segment is close to the tipping point of moving out of California or the US. It is at risk of not benefitting from the ET adoption cycle.
 - 1.0. Indicates a segment is likely to remain in the California. It is expected to benefit from the ET adoption cycle.

The values of all applicable ET multipliers were summed for each market segment to define an ET UES multiplier, provided in Table F-7, to forecast segment level potential net savings using the following equation:

Equation F-3. Emerging Technology Segment Net Savings Potential

$$\text{ET segment level EE net savings potential} = \text{ET UES Multiplier} \times \text{Annual Segment Consumption}^{185}$$

Table F-7. Emerging Technologies UES Multipliers by Segment and Fuel

Segment	UES Multiplier (kWh)	UES Multiplier (therm)
Ind - Petroleum	0.17%	1.22%
Ind – Food	1.58%	9.18%
Ind - Electronics	2.45%	4.10%
Ind - Stone-Glass-Clay	0.97%	0.99%

¹⁸³ Energy use trend analysis provided by CEC.

¹⁸⁴ Sirkin, H. et al. *U.S. Manufacturing Nears the Tipping Point*, The Boston Consulting Group, March 2012.

¹⁸⁵ Electric (GWh) and natural gas (therm) from the 2017 IEPR Forecast

Segment	UES Multiplier (kWh)	UES Multiplier (therm)
Ind - Chemicals	0.93%	9.19%
Ind - Plastics	1.40%	5.37%
Ind - Fabricated Metals	1.45%	14.21%
Ind - Primary Metals	0.26%	8.61%
Ind - Industrial Machinery	2.90%	5.62%
Ind - Transportation Equipment	1.18%	1.94%
Ind - Paper	0.71%	1.87%
Ind - Printing & Publishing	0.99%	1.02%
Ind - Textiles	1.42%	2.85%
Ind - Lumber & Furniture	1.28%	2.74%
Ind - All Other Industrial	4.52%	4.58%
Ag - Irrigated Agriculture, vineyards, forestry and greenhouses	9.62%	0.00%
Ag - Dairies, fishing, hunting	0.96%	0.44%
Ag - Water pumping	3.40%	0.00%

Source: Navigant analysis

The ET UES multipliers were held constant throughout the 2019 Study forecast horizon. The team developed a reference and aggressive case forecast based on a CAGR by which the portfolio of ETs is expected to be adopted by the market (i.e., penetration). The reference case assumes a CAGR of 3.25%, achieving 8.6% market penetration within the forecast horizon ending in 2030. The aggressive case assumes a CAGR of 4.25%.

F.2.4 Other Input Assumptions

The model uses a universal EUL of 10 years to accommodate the broad range of emerging technology adoption curves.

A ratio of kW to kWh of 0.000195 was applied.

Finally, costs for electricity and natural gas savings are estimated at \$0.42/kWh and \$2.83/therm and are applied consistently for all utilities and across all industrial and agricultural sectors. Costs are based on an analysis of industrial and agricultural programs operating throughout 2016 and reflect costs that are higher than average for the portfolio based on the expectation that ETs will be more expensive than more established technologies, and so will require higher incentives and EM&V costs to verify performance.

APPENDIX G. FINANCING METHODOLOGY AND INPUTS

Financing has the potential to break through a number of market barriers that have limited the widespread market adoption of cost-effective energy efficiency (EE) measures. The PG Model is able to estimate the added effects of introducing EE financing on EE market potential and how shifting assumptions about financing affect the potential energy savings.

No updates relative to the 2017 Study have been made to the methodology or data inputs related to financing in the 2019 Study. This appendix replicates the same explanation of methods and inputs as the 2017 Study final report.

Examples of market barriers that can slow EE adoption¹⁸⁶ include:

- **Information Search Cost** - Even when information of new technologies is publicly available, it is costly for consumers to learn about the innovation.
- **Lack of Capital Access and Liquidity Constraint** - Lack of upfront capital or credit for EE investments.
- **Un-internalized Externalities** - Energy is heavily subsidized; consumers are not aware of the true cost of energy.
- **Split Incentives** - Party making the efficiency investment decision is not the party benefitting from the decision.
- **Hassle Factor** - This includes efforts invested in completing transactions such as the application process.
- **Behavioral Failures** - Consumers are not perfectly rational, resulting in consumer behavior inconsistent with utility maximization or energy cost minimization.

G.1 Financing Programs Background

California financing programs address some of these market barriers, such as lack of capital access and liquidity. Per the CPUC's PY2014 Finance Residential Market Baseline Study Report¹⁸⁷, more than half of homeowners (54%) believe that the higher upfront costs present a barrier to EE projects and one-third of respondents stated that financing could help reduce that barrier.

Furthermore, there is research to suggest that financing programs encourage deeper energy savings per project since consumers can take on larger projects with higher associated savings, beyond what they could have otherwise afforded in the absence of financing.¹⁸⁸ Among homeowners who made an energy upgrade and used financing, nearly three-quarters using financing indicated that the financing allowed

¹⁸⁶ Jaffe, Newell, and Stavins. Economics of Energy Efficiency. Encyclopedia of Energy Vol. 2: 79-89. 2004.

¹⁸⁷ PY2014 Finance Residential Market Baseline Study Report. Opinion Dynamics Corporation and Dunsky Energy Consulting. March 2016

¹⁸⁸ Southwest Energy Efficiency Project. Energy Efficiency Finance Options and Roles for Utilities. October 2011.

them to do a larger project or purchase higher quality equipment than what they would have done on their own.¹⁸⁹ For the non-residential sector, 83% of on-bill financing (OBF) loans were for projects exceeding 10% energy savings.¹⁹⁰

Financing may also reduce the hassle factor barrier that may affect a consumer's willingness to take on an EE project. In a California study of homeowners who chose to use financing, a clear majority (88%) felt that financing was the most convenient option for them.¹⁹¹

For non-residential customers, qualified customers can access 0% OBF through a statewide program administered by the investor-owned utilities (IOUs). The OBF programs use alternative underwriting criteria that considers utility bill repayment history as a measure of creditworthiness¹⁹². Participating in OBF and repaying the financed cost through a utility bill may be easier to understand and more convenient than applying for and repaying a conventional financing option.

Because a significant proportion of customers (46%) indicated a preference for 0% financing over rebates (34%),¹⁹³ PG&E is testing an OBF alternative pathway that will be paired with metered energy data instead of an incentive.¹⁹⁴ Because the incentive applications are where most problems occur in the application process, the alternate pathway program may further reduce the complexity and hassle barrier that some customers may associate with participating in utility EE programs.¹⁹⁵

G.2 Impact of Financing on Consumer Economics

Financing allows consumers to use private capital to fund EE projects; borrowers avoid the upfront cost and repay the project cost over time. We can evaluate the attractiveness of a financing option by looking at the annual cash flows for an efficient measure, compared to an efficient measure that is financed, and comparing the net present value of the options.

The net present value (NPV) is calculated by assigning costs and benefits, discounting future costs and benefits (future value, or FV) by an appropriate discount rate (i), and subtracting the present value total costs from the present value total benefits.¹⁹⁶

To discount future payments, we apply the annual consumer discount rate (i) per the equation below, where n is the number of years:

¹⁸⁹ PY2014 Finance Residential Market Baseline Study Report. Opinion Dynamics Corporation and Dunsky Energy Consulting. March 2016

¹⁹⁰ Disposition approving Advice Letter 3697-G /4812-E, 3697-G-A/4812-E-A, PG&E's On Bill Financing Alternative Pathway Program, as a High Opportunity Program. July 12, 2016.

¹⁹¹ PY2014 Finance Residential Market Baseline Study Report. Opinion Dynamics Corporation and Dunsky Energy Consulting. March 2016

¹⁹² Financing Energy Improvements on Utility Bills. Technical Appendix Case Studies. State and Local Energy Efficiency Action Network (SEE Action). May 2014.

¹⁹³ California 2010-2012 On-Bill Financing Process Evaluation and Market Assessment (CALMAC ID CPU0056.01),

¹⁹⁴ Commercial customers can receive up to a \$100,000 loan for 5 years, and government can receive up to a \$250,000 loan for 10 years. The alternative path will leverage existing infrastructure as well as the existing on bill financing program's revolving loan fund.

¹⁹⁵ 2010-2012 CA IOU On-bill Financing Process Evaluation and Market Assessment. May 2012.

¹⁹⁶ OMB Circular A-94. Available at: <https://www.wbdg.org/FFC/FED/OMB/OMB-Circular-A94.pdf>

Equation G-1. Present Value Equation

$$Present\ Value = Future\ Value \times (1 + i)^{-n}$$

We can evaluate the present value of an EE measure over the useful life of the equipment by comparing the NPV of the hypothetical costs of the equipment and energy. For example, Table G-1 shows the present value cost of a base efficiency technology (\$1,000) purchased in year 0, followed by energy costs for that unit of \$200 annually for 10 years. The total cash outflows are discounted by the assumed consumer discount rate, which for this example is 7%. The net present cost of the base technology is \$2,405.

The next calculation shows the net present cost of the efficient technology, which in this case costs \$1,250 to the consumer upfront after a 50% rebate on the incremental cost of the efficient technology whose original cost was \$1,500 (i.e., \$1,500 – [(\$1,500-\$1,000) x 50%] = \$1,250). The annual energy cost of the efficient technology is \$125 per year. The total cash outflows are discounted by the same consumer discount rate (7%), yielding a net present cost for the efficient technology is \$2,128. This total cost is less than the base technology.

Finally, the third calculation shows the net present cost of the efficient technology after financing. The efficient technology costs \$1,250 with the utility incentive. Assuming a consumer uses an EE loan at 4% for 10 years, the equipment and financing costs are spread over 10 years at \$148 per year. The annual energy cost of the efficient technology financed is still \$125 per year. The total cash outflows are discounted by the same consumer discount rate (7%), yielding a net present cost for the efficient technology with financing of \$1,992. This total cost is less than the base model and less than the efficient technology without financing.

Table G-1. Example Present Value Comparisons for Base and Efficient Technologies and Financing

Base Technology											
Year	0	1	2	3	4	5	6	7	8	9	10
Base Equipment Cost	\$1,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Energy Cost	\$0	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200
Total Cash Out	\$1,000	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200	\$200
Present Value	\$1,000	\$187	\$175	\$163	\$153	\$143	\$133	\$125	\$116	\$109	\$102
NPV Cost	\$2,405										

Efficient Technology											
Year	0	1	2	3	4	5	6	7	8	9	10
Efficient Equipment Cost	\$1,250	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Energy Cost	\$0	\$125	\$125	\$125	\$125	\$125	\$125	\$125	\$125	\$125	\$125
Total Cash Out	\$1,250	\$125	\$125	\$125	\$125	\$125	\$125	\$125	\$125	\$125	\$125
Present Value	\$1,250	\$117	\$109	\$102	\$95	\$89	\$83	\$78	\$73	\$68	\$64
NPV Cost	\$2,128										

Efficient Technology with Financing											
Year	0	1	2	3	4	5	6	7	8	9	10
Equipment Cost Financed	\$148	\$148	\$148	\$148	\$148	\$148	\$148	\$148	\$148	\$148	\$0
Energy Cost	\$0	\$125	\$125	\$125	\$125	\$125	\$125	\$125	\$125	\$125	\$125
Total Cash Out	\$148	\$273	\$273	\$273	\$273	\$273	\$273	\$273	\$273	\$273	\$125
Present Value	\$148	\$255	\$239	\$223	\$208	\$195	\$182	\$170	\$159	\$149	\$64
NPV	\$1,992										

The modified cash flows feed into the calculation of consumer willingness (described earlier in Section 2.1.1.4) by representing the effective present value of financing to the customer as a fraction of the upfront cost. Increasing willingness results in higher adoption of EE measures and thus more savings. The model does not estimate technical or economic potential of financing, only market potential.

The CPUC has recognized financing as an EE resource program.¹⁹⁷ However, as of March 2017 (when research for this study was finalized), no impact evaluations have been published to provide verified savings estimates. In the absence of impact studies, the input data to model financing was developed by Navigant leverage available market studies.

G.3 Residential Inputs

To develop the residential financing cash flow model inputs, Navigant considered the achievements to date of the existing Regional Finance Programs, and the key financing terms for the Residential Energy Efficiency Loan (REEL) Program lenders¹⁹⁸.

Table G-2. 2013-2015 Achievements by Regional Financing Program

Program	Start Date	Utility	Min. FICO	Avg. Rate	Avg. Term (yrs.)	Avg. Amount (\$)	Loans to Date
Golden State Financing Authority (GSFA) Energy Retrofit Program	Sep-12	PG&E	640	6.50%	15	25,612	201
emPower Central Coast	Nov-11	SCE, SCG, PG&E	590	5.85%	14.5	20,809	52
SoCalREN Home Energy Loans	Dec-13	SCE, SCG	660	5.87%	9.5	18,087	100

Source: *Regional Finance Program Attribution and Cost Effectiveness Study Evaluation Plan*.

G.3.1 Interest Rate

The interest rate is the percentage of the principal that a lender charges to a borrower for taking out a loan. Navigant considered the average discount rates of the Regional Financing Programs, and the range of interest rates available to borrowers of the REEL Program. Based on this information, Navigant assumed an interest rate of 6% for REELs in the cash flow model.

G.3.2 Loan Term

The loan term is the length of time of the loan agreement. REEL Program loans offer terms up to 15 years.¹⁹⁹ The average term of the Regional Finance Program loans ranges from 9.5 to 15 years. Based on this information, Navigant assumed a loan term of 12 years in the cash flow model.

G.3.3 Consumer Discount Rate

The discount rate is the rate by which future cash flows are discounted to determine the present value of the payment stream. Using a consumer discount rate allows multiple payment streams to be compared in

¹⁹⁷ CPUC Decision 12-05-2015, May 8, 2012 and Decision Approving 2013-14 Energy Efficiency Programs and Budgets, October 9, 2012

¹⁹⁸ REEL Lenders Chart. Available at: <http://www.thecheef.com/lender-chart>

¹⁹⁹ Ibid.

the same timeframe. A low discount rate indicates that the value of future cash flows is low compared to the value now. We use the real discount rate, instead of the nominal discount rate, to eliminate the effect of inflation.

Estimating the discount rate for residential customers is not straightforward, and may vary by demographic factors such as credit score, income, race, and household size. The Office of Management and Budget (OMB) has prescribed a discount rate of 7% for benefit-cost analysis, and the US Department of Energy (DOE) uses 3% and 7% in the analyses for residential appliance standards.²⁰⁰ Other government organizations use discount rates in this range. For example, the Northwest Power and Conservation Council, which used 3% in the Seventh Power and Conservation Plan, and a lighting study by the DOE calculated a consumer discount rate of 5.6%.

However, the estimated discount rate for residential customers may be much higher than the range of 3-7% used in regulatory analysis. For example, one study looked at the observed discount rates for individuals and their preferences for EE and found that “a simple fact emerges that in making decisions which involve discounting over time, individuals behave in a manner which implies a much higher discount rate than can be explained in terms of the opportunity costs of funds available in credit markets.”²⁰¹ Based on these considerations, Navigant used a consumer discount rate of 7% for the financing model.

G.3.4 Eligible Population

Navigant updated the residential population eligibility in the 2015 Potential and Goals Study using Experian Consumer Credit data, accessed in November 2014. The 2015 Study identified the residential population eligibility at 98%. Like the 2015 Potential Study, Navigant assumes that residential customers with FICO credit scores above 580 are eligible for financing, and that 98% of single-family customers are eligible for financing. The credit requirement aligns with the REEL program, which requires a minimum FICO score of 580 with income verification, and a FICO score of 640 without income verification.

Following the approach to eligibility assumptions for the multifamily sector in the 2013 and 2015 Potential Studies, Navigant estimated multifamily sector eligibility to be 5% based on the proportion of the segment that is affordable housing.²⁰²

In summary, the Navigant team used the following inputs for the residential cash flow model:

²⁰⁰ For example, see: <http://www.gao.gov/assets/690/682586.pdf>

²⁰¹ Hausman, Jerry. Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables. *The Bell Journal of Economics*, Vol. 10, No. 1. Spring 1979.

²⁰² The affordable housing market segment is the current focus of the proposed EE financing programs. Due to legal and regulatory issues, OBR is not a viable option except master-metered properties.

Table G-3. Key Inputs to Residential Financing Cash Flow Model

Model Input	Assumption	Source
Interest Rate	6%	Navigant analysis of California IOU financing programs data ¹
Loan Term	12 years	Navigant analysis of California IOU financing programs data ¹
Discount Rate	7%	OMB Circular No. A-94
Eligible Population	98% of single-family customers 5% of multifamily customers	2015 California Potential and Goals Study

Source: Navigant analysis of the Regional Finance Program Attribution and Cost-effectiveness Study: Evaluation Plan

G.4 Commercial Inputs

G.4.1 Interest Rate

Non-residential customers can access 0% financing through the statewide OBF program. The projects are designed to be bill neutral, such that the monthly payment is less than the projected energy savings.²⁰³ Based on these guidelines, Navigant assumed an interest rate of 0% in the cash flow model for OBF loans for the commercial and industrial sector.

G.4.2 Loan Term

The OBF program offers 0% financing for loans up to 5 years for the small and large commercial sector, and up to 10 years for the government sector. Given that our model does not distinguish between the commercial and government sector, we apply a single assumption for the commercial sector.

G.4.3 Consumer Discount Rate

For non-residential customers, the discount rate is the weighted average cost of capital for companies (WACC) who use both debt and equity to fund their investments.

In summary, the Navigant team used the following inputs for the commercial and industrial cash flow model:

²⁰³ SEEaction OBF report, Appendix A

https://www4.eere.energy.gov/seeaction/system/files/documents/publications/chapters/onbill_financing_appendix.pdf

Table G-4. Key Inputs to Commercial and Industrial Financing Cash Flow Model

Model Input	Assumption	Source
Interest Rate	0%	California OBF program terms
Loan Term	5 years	California OBF program terms
Discount Rate	5.8%	2016 LBNL Commercial Discount Rate Estimation for Efficiency Standards

APPENDIX H. DETAILED SCENARIO RESULTS

H.1 PG&E

Table H-1. PG&E Electric Energy Savings (GWh/year)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	153	196	224	220	223	220	205	198	192	179	180
BROs	200	214	228	288	311	332	355	381	411	445	484
Low Income	21	22	23	22	20	18	16	13	12	12	12
Incentive Programs (Subtotal)	374	432	475	530	554	570	577	592	616	636	676
C&S*	625	630	619	622	591	571	532	495	444	386	328
Total	998	1,062	1,094	1,152	1,145	1,141	1,109	1,087	1,060	1,022	1,003
PG Alternative Scenario 1											
Equipment Rebates	199	240	241	236	237	233	217	209	202	187	187
BROs	200	214	228	288	311	332	355	381	411	445	484
Low Income	21	22	23	22	20	18	16	13	12	12	12
Incentive Programs (Subtotal)	421	476	492	547	568	583	589	603	626	644	683
C&S*	625	630	619	622	591	571	532	495	444	386	328
Total	1,045	1,106	1,111	1,169	1,159	1,154	1,121	1,098	1,069	1,030	1,010
PG Alternative Scenario 2											
Equipment Rebates	134	180	184	183	187	188	180	177	180	168	169
BROs	200	214	228	288	311	332	355	381	411	445	484
Low Income	21	22	23	22	20	18	16	13	12	12	12
Incentive Programs (Subtotal)	355	416	435	493	518	539	552	572	604	625	665
C&S*	625	630	619	622	591	571	532	495	444	386	328
Total	980	1,046	1,055	1,115	1,109	1,110	1,083	1,067	1,048	1,011	992
PG Alternative Scenario 3											
Equipment Rebates	157	201	229	225	227	222	207	199	193	179	180
BROs	245	302	328	356	389	448	492	542	603	674	759
Low Income	23	24	24	22	20	18	16	13	13	12	12
Incentive Programs (Subtotal)	425	527	582	603	635	689	715	754	809	866	951
C&S*	625	630	619	622	591	571	532	495	444	386	328
Total	1,050	1,157	1,201	1,224	1,227	1,260	1,247	1,249	1,252	1,252	1,279
PG Alternative Scenario 4											
Equipment Rebates	218	254	256	250	249	243	226	217	210	194	193
BROs	245	302	328	356	389	448	492	542	603	674	759
Low Income	23	24	24	22	20	18	16	13	13	12	12
Incentive Programs (Subtotal)	486	580	609	628	658	710	734	773	826	880	964
C&S*	625	630	619	622	591	571	532	495	444	386	328
Total	1,111	1,210	1,228	1,250	1,249	1,280	1,266	1,267	1,269	1,266	1,292

*Includes interactive effects

Table H-2. PG&E Demand Savings (MW)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	35	41	44	42	43	42	40	39	38	36	36
BROs	37	39	42	45	47	49	51	53	55	58	60
Low Income	16	17	17	16	15	13	12	10	9	9	9
Incentive Programs (Subtotal)	88	97	103	103	105	105	103	102	103	103	105
C&S*	128	135	133	140	134	130	122	115	104	95	86
Total	216	232	236	243	239	235	225	217	207	198	191
PG Alternative Scenario 1											
Equipment Rebates	45	52	50	48	48	47	45	43	42	39	39
BROs	37	39	42	45	47	49	51	53	55	58	60
Low Income	16	17	17	16	15	13	12	10	9	9	9
Incentive Programs (Subtotal)	98	108	110	109	110	110	108	106	106	106	107
C&S*	128	135	133	140	134	130	122	115	104	95	86
Total	226	243	243	249	244	240	230	221	210	200	193
PG Alternative Scenario 2											
Equipment Rebates	31	39	39	37	38	38	36	36	36	34	34
BROs	37	39	42	45	47	49	51	53	55	58	60
Low Income	16	17	17	16	15	13	12	10	9	9	9
Incentive Programs (Subtotal)	84	96	98	98	99	100	99	98	101	101	103
C&S*	128	135	133	140	134	130	122	115	104	95	86
Total	213	231	231	238	234	230	221	213	205	196	189
PG Alternative Scenario 3											
Equipment Rebates	36	42	44	43	44	43	41	39	39	36	36
BROs	44	46	49	52	56	62	67	72	78	85	94
Low Income	18	19	18	16	15	14	12	10	10	9	9
Incentive Programs (Subtotal)	97	106	112	111	114	118	119	121	126	131	139
C&S*	128	135	133	140	134	130	122	115	104	95	86
Total	225	241	245	251	248	248	241	236	230	226	225
PG Alternative Scenario 4											
Equipment Rebates	48	54	53	50	50	49	46	44	42	39	38
BROs	44	46	49	52	56	62	67	72	78	85	94
Low Income	18	19	18	16	15	14	12	10	10	9	9
Incentive Programs (Subtotal)	109	119	120	118	120	124	125	126	130	134	141
C&S*	128	135	133	140	134	130	122	115	104	95	86
Total	237	254	253	258	254	254	246	240	234	228	227

*Includes interactive effects

Table H-3. PG&E Gas Energy Savings (MMtherm/year)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	5.4	6.5	7.3	8.7	8.4	7.7	7.1	7.1	7.0	6.5	7.1
BROs	7.2	7.6	7.9	8.4	8.8	9.1	9.4	9.8	10.3	10.7	11.2
Low Income	2.3	2.3	2.2	2.1	2.0	2.0	2.0	1.9	1.7	1.7	1.7
Incentive Programs (Subtotal)	14.8	16.3	17.5	19.1	19.2	18.8	18.5	18.9	19.0	18.9	20.0
C&S*	13.4	13.6	13.7	14.0	14.6	14.2	11.8	10.5	9.8	8.6	8.6
Total	28.2	30.0	31.2	33.1	33.7	33.0	30.3	29.4	28.8	27.5	28.7
PG Alternative Scenario 1											
Equipment Rebates	9.0	10.2	9.8	9.2	9.1	9.7	9.1	9.0	8.6	7.6	8.1
BROs	7.2	7.6	7.9	8.4	8.8	9.1	9.4	9.8	10.3	10.7	11.2
Low Income	2.3	2.3	2.2	2.1	2.0	2.0	2.0	1.9	1.7	1.7	1.7
Incentive Programs (Subtotal)	18.4	20.1	20.0	19.7	19.9	20.8	20.5	20.8	20.6	20.1	21.0
C&S*	13.4	13.6	13.7	14.0	14.6	14.2	11.8	10.5	9.8	8.6	8.6
Total	31.8	33.7	33.7	33.7	34.4	34.9	32.3	31.3	30.3	28.7	29.7
PG Alternative Scenario 2											
Equipment Rebates	3.9	4.9	4.5	4.4	4.6	4.7	4.9	5.2	6.5	6.2	6.8
BROs	7.2	7.6	7.9	8.4	8.8	9.1	9.4	9.8	10.3	10.7	11.2
Low Income	2.3	2.3	2.2	2.1	2.0	2.0	2.0	1.9	1.7	1.7	1.7
Incentive Programs (Subtotal)	13.3	14.8	14.7	14.8	15.4	15.8	16.3	16.9	18.5	18.6	19.7
C&S*	13.4	13.6	13.7	14.0	14.6	14.2	11.8	10.5	9.8	8.6	8.6
Total	26.7	28.4	28.4	28.8	30.0	29.9	28.0	27.4	28.3	27.2	28.4
PG Alternative Scenario 3											
Equipment Rebates	5.4	6.5	7.3	8.6	8.3	7.6	7.0	7.1	7.0	6.5	7.2
BROs	8.5	8.9	9.5	10.2	10.9	12.1	13.2	14.4	16.0	17.8	20.0
Low Income	2.3	2.4	2.2	2.1	2.1	2.0	2.0	1.8	1.8	1.7	1.7
Incentive Programs (Subtotal)	16.2	17.8	19.1	20.9	21.3	21.7	22.2	23.3	24.8	26.1	28.9
C&S*	13.4	13.6	13.7	14.0	14.6	14.2	11.8	10.5	9.8	8.6	8.6
Total	29.6	31.4	32.8	34.9	35.8	35.9	34.0	33.9	34.5	34.7	37.6
PG Alternative Scenario 4											
Equipment Rebates	9.5	10.5	10.0	9.3	9.0	9.6	9.1	9.0	8.6	7.7	8.3
BROs	8.5	8.9	9.5	10.2	10.9	12.1	13.2	14.4	16.0	17.8	20.0
Low Income	2.3	2.4	2.2	2.1	2.1	2.0	2.0	1.8	1.8	1.7	1.7
Incentive Programs (Subtotal)	20.3	21.8	21.7	21.6	22.0	23.7	24.2	25.2	26.3	27.3	30.0
C&S*	13.4	13.6	13.7	14.0	14.6	14.2	11.8	10.5	9.8	8.6	8.6
Total	33.7	35.4	35.4	35.6	36.6	37.9	36.0	35.7	36.1	35.8	38.7

*Includes interactive effects

H.2 SCE

Table H-4. SCE Electric Energy Savings (GWh/year)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	188	220	229	226	228	226	211	203	197	178	175
BROs	169	185	201	218	235	253	272	291	312	333	354
Low Income	29	31	31	30	28	25	22	16	15	14	13
Incentive Programs (Subtotal)	385	435	461	474	490	504	505	510	523	525	542
C&S*	644	650	638	642	610	589	549	510	458	398	338
Total	1,030	1,085	1,099	1,115	1,100	1,093	1,054	1,020	981	924	880
PG Alternative Scenario 1											
Equipment Rebates	203	244	252	246	246	246	231	224	215	192	187
BROs	169	185	201	218	235	253	272	291	312	333	354
Low Income	29	31	31	30	28	25	22	16	15	14	13
Incentive Programs (Subtotal)	401	459	483	494	509	524	525	531	542	540	554
C&S*	644	650	638	642	610	589	549	510	458	398	338
Total	1,045	1,109	1,122	1,135	1,119	1,113	1,073	1,041	999	938	892
PG Alternative Scenario 2											
Equipment Rebates	170	202	214	213	217	218	205	197	192	175	172
BROs	169	185	201	218	235	253	272	291	312	333	354
Low Income	29	31	31	30	28	25	22	16	15	14	13
Incentive Programs (Subtotal)	368	418	445	461	480	496	499	504	518	522	539
C&S*	644	650	638	642	610	589	549	510	458	398	338
Total	1,012	1,068	1,084	1,103	1,090	1,085	1,047	1,014	976	921	877
PG Alternative Scenario 3											
Equipment Rebates	194	226	235	230	230	227	211	203	197	178	175
BROs	205	234	265	297	337	361	388	419	457	501	554
Low Income	32	33	33	30	27	25	17	16	15	14	14
Incentive Programs (Subtotal)	431	493	534	557	595	613	616	638	668	693	743
C&S*	644	650	638	642	610	589	549	510	458	398	338
Total	1,075	1,142	1,172	1,199	1,205	1,202	1,164	1,148	1,126	1,091	1,081
PG Alternative Scenario 4											
Equipment Rebates	217	260	268	259	258	255	238	231	221	196	192
BROs	205	234	265	297	337	361	388	419	457	501	554
Low Income	32	33	33	30	27	25	17	16	15	14	14
Incentive Programs (Subtotal)	454	527	566	586	622	641	643	666	692	711	759
C&S*	644	650	638	642	610	589	549	510	458	398	338
Total	1,098	1,177	1,205	1,227	1,232	1,230	1,192	1,176	1,150	1,110	1,097

*Includes interactive effects

Table H-5. SCE Demand Savings (MW)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	41	48	47	45	45	45	43	42	42	39	39
BROs	30	33	36	39	42	45	49	52	56	60	64
Low Income	18	19	18	17	16	14	13	9	9	9	8
Incentive Programs (Subtotal)	89	99	101	101	103	104	104	104	107	108	111
C&S*	128	133	132	137	132	127	120	112	102	93	83
Total	217	233	233	239	234	232	224	217	209	201	195
PG Alternative Scenario 1											
Equipment Rebates	47	58	57	55	54	55	52	51	50	46	45
BROs	30	33	36	39	42	45	49	52	56	60	64
Low Income	18	19	18	17	16	14	13	9	9	9	8
Incentive Programs (Subtotal)	94	109	111	111	112	114	114	113	115	115	117
C&S*	128	133	132	137	132	127	120	112	102	93	83
Total	223	242	243	248	244	241	233	226	217	208	201
PG Alternative Scenario 2											
Equipment Rebates	36	43	43	42	42	43	42	41	41	39	38
BROs	30	33	36	39	42	45	49	52	56	60	64
Low Income	18	19	18	17	16	14	13	9	9	9	8
Incentive Programs (Subtotal)	84	94	97	98	100	103	103	103	106	107	110
C&S*	128	133	132	137	132	127	120	112	102	93	83
Total	212	228	229	235	232	230	223	215	208	200	194
PG Alternative Scenario 3											
Equipment Rebates	42	49	48	46	46	45	44	43	42	40	39
BROs	37	42	48	54	59	63	68	74	80	88	98
Low Income	20	20	19	17	16	14	10	10	9	9	9
Incentive Programs (Subtotal)	98	111	115	117	120	123	122	126	132	137	145
C&S*	128	133	132	137	132	127	120	112	102	93	83
Total	226	244	247	254	252	250	242	239	234	230	229
PG Alternative Scenario 4											
Equipment Rebates	49	61	61	57	57	57	55	54	52	48	47
BROs	37	42	48	54	59	63	68	74	80	88	98
Low Income	20	20	19	17	16	14	10	10	9	9	9
Incentive Programs (Subtotal)	106	123	128	128	132	135	134	137	142	145	153
C&S*	128	133	132	137	132	127	120	112	102	93	83
Total	234	256	260	265	263	262	253	250	243	238	236

*Includes interactive effects

H.3 SCG

Table H-6. SCG Gas Savings (MMtherm/year)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	5.5	6.5	8.8	8.5	8.1	8.1	7.6	7.3	6.9	6.9	7.8
BROs	7.9	8.2	8.5	8.8	9.1	9.5	9.8	10.3	10.7	11.2	11.8
Low Income	3.8	3.9	2.5	2.5	2.5	2.5	2.4	2.3	2.3	2.2	2.2
Incentive Programs (Subtotal)	17.2	18.5	19.7	19.8	19.7	20.1	19.9	19.9	19.9	20.4	21.8
C&S*	21.4	21.8	21.9	22.5	23.4	22.7	18.8	16.8	15.6	13.8	13.8
Total	38.6	40.3	41.7	42.3	43.1	42.8	38.7	36.7	35.6	34.2	35.6
PG Alternative Scenario 1											
Equipment Rebates	9.1	9.4	9.3	9.0	8.6	10.3	9.5	8.9	9.7	9.1	9.3
BROs	7.9	8.2	8.5	8.8	9.1	9.5	9.8	10.3	10.7	11.2	11.8
Low Income	3.8	3.9	2.5	2.5	2.5	2.5	2.4	2.3	2.3	2.2	2.2
Incentive Programs (Subtotal)	20.8	21.5	20.3	20.3	20.2	22.2	21.8	21.5	22.7	22.5	23.2
C&S*	21.4	21.8	21.9	22.5	23.4	22.7	18.8	16.8	15.6	13.8	13.8
Total	42.3	43.3	42.2	42.8	43.5	44.9	40.6	38.3	38.3	36.3	37.1
PG Alternative Scenario 2											
Equipment Rebates	4.6	4.8	4.8	5.2	5.4	5.4	7.1	6.7	6.4	6.4	6.9
BROs	7.9	8.2	8.5	8.8	9.1	9.5	9.8	10.3	10.7	11.2	11.8
Low Income	3.8	3.9	2.5	2.5	2.5	2.5	2.4	2.3	2.3	2.2	2.2
Incentive Programs (Subtotal)	16.3	16.8	15.7	16.5	17.0	17.3	19.3	19.3	19.5	19.9	20.8
C&S*	21.4	21.8	21.9	22.5	23.4	22.7	18.8	16.8	15.6	13.8	13.8
Total	37.8	38.6	37.6	39.0	40.3	40.0	38.2	36.2	35.1	33.7	34.7
PG Alternative Scenario 3											
Equipment Rebates	5.5	6.5	8.9	8.5	8.1	8.1	7.6	7.2	6.8	6.9	7.8
BROs	8.9	9.5	10.3	11.0	12.2	13.2	14.4	15.7	17.2	19.1	21.2
Low Income	4.0	4.0	2.5	2.6	2.6	2.5	2.5	2.4	2.4	2.3	2.2
Incentive Programs (Subtotal)	18.4	20.1	21.7	22.1	22.8	23.8	24.4	25.3	26.5	28.2	31.2
C&S*	21.4	21.8	21.9	22.5	23.4	22.7	18.8	16.8	15.6	13.8	13.8
Total	39.8	41.8	43.6	44.6	46.2	46.5	43.3	42.1	42.1	42.0	45.0
PG Alternative Scenario 4											
Equipment Rebates	9.8	10.1	9.9	9.6	9.0	10.7	9.8	9.0	9.7	9.0	9.2
BROs	8.9	9.5	10.3	11.0	12.2	13.2	14.4	15.7	17.2	19.1	21.2
Low Income	4.0	4.0	2.5	2.6	2.6	2.5	2.5	2.4	2.4	2.3	2.2
Incentive Programs (Subtotal)	22.7	23.6	22.7	23.2	23.8	26.4	26.6	27.1	29.3	30.4	32.6
C&S*	21.4	21.8	21.9	22.5	23.4	22.7	18.8	16.8	15.6	13.8	13.8
Total	44.1	45.4	44.7	45.7	47.2	49.1	45.4	43.9	44.9	44.1	46.5

*Excludes interactive effects

H.4 SDG&E

Table H-7. SDG&E Electric Energy Savings (GWh/year)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	30.8	38.2	40.0	42.4	43.9	44.1	42.3	41.9	41.2	39.7	38.9
BROs	58.8	64.0	67.3	70.4	73.8	77.3	80.9	84.6	88.8	93.2	98.1
Low Income	4.6	4.9	5.1	5.1	4.6	4.2	3.8	2.9	2.7	2.5	2.4
Incentive Programs (Subtotal)	94.2	107.1	112.3	117.9	122.3	125.6	127.0	129.4	132.7	135.4	139.5
C&S*	146.2	147.4	144.9	145.6	138.4	133.6	124.5	115.8	103.9	90.4	76.7
Total	240.4	254.5	257.2	263.5	260.7	259.2	251.5	245.2	236.6	225.8	216.2
PG Alternative Scenario 1											
Equipment Rebates	35.9	44.4	46.4	47.1	48.4	48.4	45.7	45.3	44.7	40.4	40.2
BROs	58.8	64.0	67.3	70.4	73.8	77.3	80.9	84.6	88.8	93.2	98.1
Low Income	4.6	4.9	5.1	5.1	4.6	4.2	3.8	2.9	2.7	2.5	2.4
Incentive Programs (Subtotal)	99.3	113.3	118.7	122.6	126.7	129.8	130.4	132.9	136.2	136.1	140.7
C&S*	146.2	147.4	144.9	145.6	138.4	133.6	124.5	115.8	103.9	90.4	76.7
Total	245.5	260.8	263.6	268.2	265.1	263.5	254.9	248.6	240.0	226.5	217.4
PG Alternative Scenario 2											
Equipment Rebates	24.7	31.9	34.0	35.8	37.7	38.2	36.8	36.3	36.2	33.7	33.6
BROs	58.8	64.0	67.3	70.4	73.8	77.3	80.9	84.6	88.8	93.2	98.1
Low Income	4.6	4.9	5.1	5.1	4.6	4.2	3.8	2.9	2.7	2.5	2.4
Incentive Programs (Subtotal)	88.1	100.8	106.3	111.3	116.1	119.7	121.5	123.8	127.7	129.5	134.1
C&S*	146.2	147.4	144.9	145.6	138.4	133.6	124.5	115.8	103.9	90.4	76.7
Total	234.4	248.2	251.2	256.9	254.5	253.3	245.9	239.6	231.6	219.9	210.8
PG Alternative Scenario 3											
Equipment Rebates	31.6	39.2	41.1	43.5	44.9	44.9	42.9	42.5	41.7	40.1	39.2
BROs	64.3	69.0	75.9	82.1	95.8	104.5	114.3	125.7	139.4	155.7	175.3
Low Income	5.0	5.3	5.4	4.9	4.5	4.1	3.7	2.9	2.8	2.6	2.5
Incentive Programs (Subtotal)	100.9	113.5	122.3	130.5	145.3	153.5	160.9	171.1	183.8	198.3	217.0
C&S*	146.2	147.4	144.9	145.6	138.4	133.6	124.5	115.8	103.9	90.4	76.7
Total	247.2	261.0	267.2	276.1	283.7	287.2	285.4	286.8	287.7	288.7	293.7
PG Alternative Scenario 4											
Equipment Rebates	38.1	47.3	49.3	50.0	51.1	50.9	48.1	47.7	46.8	42.1	41.8
BROs	64.3	69.0	75.9	82.1	95.8	104.5	114.3	125.7	139.4	155.7	175.3
Low Income	5.0	5.3	5.4	4.9	4.5	4.1	3.7	2.9	2.8	2.6	2.5
Incentive Programs (Subtotal)	107.4	121.6	130.6	137.1	151.4	159.5	166.1	176.2	189.0	200.3	219.6
C&S*	146.2	147.4	144.9	145.6	138.4	133.6	124.5	115.8	103.9	90.4	76.7
Total	253.6	269.0	275.5	282.6	289.9	293.1	290.5	292.0	292.9	290.7	296.3

*Includes interactive effects

Table H-8. SDG&E Demand Savings (MW)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	6.1	7.4	7.5	7.8	8.1	8.1	7.9	8.0	7.9	7.6	7.5
BROs	10.4	11.1	11.6	12.2	12.7	13.3	13.9	14.5	15.2	16.0	16.8
Low Income	3.3	3.5	3.5	3.4	3.0	2.7	2.5	2.1	2.0	1.8	1.8
Incentive Programs (Subtotal)	19.8	22.1	22.7	23.4	23.8	24.2	24.3	24.6	25.0	25.4	26.0
C&S*	30.0	31.0	30.7	31.7	30.5	29.6	27.8	26.2	23.7	21.7	19.5
Total	49.8	53.1	53.4	55.1	54.4	53.7	52.1	50.8	48.8	47.0	45.6
PG Alternative Scenario 1											
Equipment Rebates	7.0	8.6	8.8	8.9	9.1	9.0	8.7	8.6	8.5	7.7	7.8
BROs	10.4	11.1	11.6	12.2	12.7	13.3	13.9	14.5	15.2	16.0	16.8
Low Income	3.3	3.5	3.5	3.4	3.0	2.7	2.5	2.1	2.0	1.8	1.8
Incentive Programs (Subtotal)	20.7	23.3	23.9	24.4	24.8	25.1	25.1	25.2	25.7	25.5	26.3
C&S*	30.0	31.0	30.7	31.7	30.5	29.6	27.8	26.2	23.7	21.7	19.5
Total	50.7	54.3	54.6	56.1	55.4	54.6	52.9	51.4	49.4	47.2	45.8
PG Alternative Scenario 2											
Equipment Rebates	4.8	6.1	6.2	6.5	6.8	6.8	6.6	6.6	6.6	6.2	6.2
BROs	10.4	11.1	11.6	12.2	12.7	13.3	13.9	14.5	15.2	16.0	16.8
Low Income	3.3	3.5	3.5	3.4	3.0	2.7	2.5	2.1	2.0	1.8	1.8
Incentive Programs (Subtotal)	18.6	20.7	21.4	22.0	22.5	22.8	23.0	23.2	23.8	24.0	24.7
C&S*	30.0	31.0	30.7	31.7	30.5	29.6	27.8	26.2	23.7	21.7	19.5
Total	48.6	51.7	52.1	53.7	53.0	52.4	50.8	49.4	47.5	45.6	44.3
PG Alternative Scenario 3											
Equipment Rebates	6.2	7.6	7.7	8.0	8.3	8.3	8.1	8.1	8.0	7.7	7.6
BROs	11.1	11.9	13.1	14.1	15.9	17.3	18.8	20.5	22.6	25.0	27.9
Low Income	3.6	3.8	3.7	3.3	3.0	2.7	2.4	2.1	2.0	1.9	1.8
Incentive Programs (Subtotal)	20.9	23.3	24.4	25.4	27.2	28.3	29.3	30.7	32.6	34.6	37.4
C&S*	30.0	31.0	30.7	31.7	30.5	29.6	27.8	26.2	23.7	21.7	19.5
Total	50.9	54.3	55.1	57.1	57.7	57.8	57.1	56.9	56.3	56.3	56.9
PG Alternative Scenario 4											
Equipment Rebates	7.3	9.1	9.2	9.3	9.5	9.5	9.1	9.0	8.9	8.0	8.1
BROs	11.1	11.9	13.1	14.1	15.9	17.3	18.8	20.5	22.6	25.0	27.9
Low Income	3.6	3.8	3.7	3.3	3.0	2.7	2.4	2.1	2.0	1.9	1.8
Incentive Programs (Subtotal)	22.0	24.7	25.9	26.7	28.4	29.4	30.3	31.6	33.5	35.0	37.8
C&S*	30.0	31.0	30.7	31.7	30.5	29.6	27.8	26.2	23.7	21.7	19.5
Total	52.0	55.7	56.6	58.4	58.9	59.0	58.1	57.8	57.2	56.7	57.4

*Includes interactive effects

Table H-9. SDG&E Gas Energy Savings (MMtherm/year)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PG Reference Scenario											
Equipment Rebates	0.45	0.52	0.44	0.34	0.27	0.26	0.22	0.22	0.20	0.14	0.17
BROs	1.47	1.51	1.56	1.60	1.66	1.72	1.80	1.88	1.97	2.06	2.17
Low Income	0.43	0.43	0.41	0.40	0.39	0.38	0.37	0.36	0.32	0.31	0.30
Incentive Programs (Subtotal)	2.35	2.46	2.41	2.34	2.33	2.37	2.38	2.45	2.49	2.51	2.64
C&S*	1.52	1.55	1.56	1.60	1.66	1.61	1.34	1.19	1.11	0.98	0.98
Total	3.87	4.00	3.97	3.94	3.98	3.98	3.72	3.64	3.60	3.49	3.62
PG Alternative Scenario 1											
Equipment Rebates	0.52	0.60	0.48	0.37	0.31	0.32	0.26	0.22	0.31	0.27	0.31
BROs	1.47	1.51	1.56	1.60	1.66	1.72	1.80	1.88	1.97	2.06	2.17
Low Income	0.43	0.43	0.41	0.40	0.39	0.38	0.37	0.36	0.32	0.31	0.30
Incentive Programs (Subtotal)	2.41	2.54	2.46	2.38	2.37	2.42	2.42	2.46	2.59	2.65	2.78
C&S*	1.52	1.55	1.56	1.60	1.66	1.61	1.34	1.19	1.11	0.98	0.98
Total	3.93	4.09	4.01	3.97	4.02	4.03	3.76	3.65	3.70	3.62	3.76
PG Alternative Scenario 2											
Equipment Rebates	0.38	0.44	0.36	0.29	0.24	0.19	0.17	0.16	0.15	0.12	0.15
BROs	1.47	1.51	1.56	1.60	1.66	1.72	1.80	1.88	1.97	2.06	2.17
Low Income	0.43	0.43	0.41	0.40	0.39	0.38	0.37	0.36	0.32	0.31	0.30
Incentive Programs (Subtotal)	2.27	2.38	2.33	2.29	2.29	2.30	2.33	2.39	2.44	2.50	2.62
C&S*	1.52	1.55	1.56	1.60	1.66	1.61	1.34	1.19	1.11	0.98	0.98
Total	3.79	3.93	3.88	3.88	3.95	3.91	3.67	3.59	3.55	3.47	3.61
PG Alternative Scenario 3											
Equipment Rebates	0.45	0.51	0.42	0.32	0.25	0.25	0.21	0.21	0.21	0.15	0.18
BROs	1.55	1.64	1.77	1.90	2.11	2.30	2.54	2.82	3.17	3.59	4.10
Low Income	0.44	0.44	0.41	0.41	0.40	0.39	0.37	0.33	0.32	0.31	0.30
Incentive Programs (Subtotal)	2.44	2.59	2.60	2.62	2.77	2.94	3.12	3.37	3.70	4.05	4.59
C&S*	1.52	1.55	1.56	1.60	1.66	1.61	1.34	1.19	1.11	0.98	0.98
Total	3.96	4.14	4.16	4.22	4.42	4.55	4.46	4.56	4.81	5.03	5.57
PG Alternative Scenario 4											
Equipment Rebates	0.54	0.61	0.48	0.37	0.31	0.32	0.26	0.23	0.32	0.29	0.34
BROs	1.55	1.64	1.77	1.90	2.11	2.30	2.54	2.82	3.17	3.59	4.10
Low Income	0.44	0.44	0.41	0.41	0.40	0.39	0.37	0.33	0.32	0.31	0.30
Incentive Programs (Subtotal)	2.52	2.69	2.67	2.67	2.82	3.00	3.17	3.38	3.81	4.19	4.74
C&S*	1.52	1.55	1.56	1.60	1.66	1.61	1.34	1.19	1.11	0.98	0.98
Total	4.05	4.24	4.22	4.27	4.48	4.61	4.50	4.57	4.92	5.17	5.73

*Includes interactive effects