ALJ/JF2/VUK/lil **Date of Issuance 10/2/2017**

Decision 17-09-025 September 28, 2017

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking Concerning Energy Efficiency Rolling Portfolios, Policies, Programs, Evaluation, and Related Issues.	Rulemaking 13-11-005

DECISION ADOPTING ENERGY EFFICIENCY GOALS FOR 2018 - 2030

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DECISION ADOPTING ENERGY EFFICIENCY GOALS FOR 2018 - 2030

Summary

This decision:

1) adopts energy savings goals for ratepayer-funded energy efficiency program portfolios for 2018 and beyond based on assessment of economic potential using the Total Resource Cost test, the 2016 update to the Avoided Cost Calculator and a greenhouse gas adder that reflects the California Air Resources Board Cap-and-Trade Allowance Price Containment Reserve Price;
2) defers adoption of cumulative goals until Commission Staff can assess the viability of using a method for calculating savings persistence, to be developed by the California Energy Commission.

This proceeding remains open.

1. Background

Public Utilities (Pub. Util.) Code Sections (§) 454.55 and 454.56 require the Commission (or CPUC), in consultation with the California Energy Commission (CEC), to identify all potential achievable cost-effective electricity and natural gas efficiency savings and "establish efficiency targets" for electrical and gas corporations to achieve.[1] To this end, Commission Staff manages the development of a potential and goals study that provides the technical analysis for assessing the cost-effective energy savings potentially available in the State's residential and commercial building stocks, residential and commercial equipment and processes, industrial sector, and agricultural sector. We use this study to set energy savings goals, which in turn inform the planning activities of

[1] Cal. Pub. Util. Code § 454.55(a)(1): "The commission, in consultation with the Energy Commission, shall identify all potentially achievable cost-effective electricity efficiency savings and establish efficiency targets for an electrical corporation to achieve, pursuant to Section 454.5, consistent with the targets established pursuant to subdivision (c) of Section 25310 of the Public Resources Code." Cal. Pub. Util. Code § 454.56: "(a) The commission, in consultation with the Energy Commission, shall identify all potentially achievable cost-effective natural gas efficiency savings and establish efficiency targets for the gas corporation to achieve, consistent with the targets established pursuant to subdivision (c) of Section 25310 of the Public Resources Code."

the energy efficiency program administrators, Commission Staff in energy long term planning and procurement/integrated resource planning, and other State agencies, including the CEC, California Air Resources Board (CARB), and the California Independent System Operator.

Decision (D.) 15-10-028 established a "bus stop" approach to incorporating new information into required energy efficiency work products, such as the potential and goals study, on a regular basis.[2] Pursuant to D.15-10-028, the Commission needs to adopt goals for 2018 forward, and to incorporate new information that updates or modifies some of the inputs and approaches to estimating energy efficiency potential.

1.1. New Statute Reflected in the Potential Study

Importantly, two new pieces of legislation directly impact the modeling and development of the potential and goals study for post-2017 (hereafter, "Potential Study"). These are Assembly Bill (AB) 802 (Stats. 2015, Chap. 590) and Senate Bill (SB) 350 (Stats. 2015, Chap. 547).

AB 802 requires, among other things, that: (i) energy efficiency be achieved not only through equipment installations but also through operational, behavioral and retrocommissioning activities (often referred to as "BROs"); (ii) the Commission use existing conditions as the default baseline for determining energy efficiency savings; and (iii) investor-owned utilities (IOUs) are authorized to provide incentives for measures that bring buildings into compliance with (but do not necessarily exceed) applicable building standards code. In March 2016, Commission Staff published an analysis of potential energy efficiency savings from both operational efficiency and behavioral initiatives, and "to-code" savings (i.e., savings from measures that address below-code

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[2] D.15-10-028 established the current rolling portfolio framework for energy efficiency portfolios; central to this framework is the "bus stop" approach for the various technical aspects of energy efficiency work. *See* D.15-10-028 at 29, Finding of Fact 20, and Appendix 6.

equipment) that may be targeted as a result of AB 802 (AB 802 Technical Analysis).[3] The Potential Study reflects this work to estimate potential savings as required by AB 802, and incorporates a new subset of market potential, described as "below-code savings," or savings "that is not materializing in the market because there is no incentive [prior to AB 802] for the customer to upgrade their existing equipment."

In addition, SB 350 requires, among other things, that the CEC establish annual targets for statewide energy efficiency savings and demand reduction that will achieve a cumulative doubling of statewide energy efficiency savings in electricity and natural gas final end uses of retail customers by January 1, 2030. SB 350 specifies that these annual targets shall be based on the mid-case estimate of additional achievable energy efficiency in the 2015-2025 California Energy Demand Forecast, to the extent such is cost effective, feasible and will not adversely impact public health and safety.[4] SB 350 also specifies that the Commission set energy efficiency goals based on studies that are not restricted by past levels of savings.[5] Pursuant to this requirement, Staff has directed Navigant Consulting, Inc. (Navigant) to prepare a potential study that examines energy efficiency

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[3] Wikler et al. (2016). AB 802 Technical Analysis: Potential Savings Analysis. Retrieved from California Public Utilities Commission website: http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=11189 (as of August 8, 2017).

[4] Cal. Public Resources Code § 25310 (c)(1): "On or before November 1, 2017, the commission, in collaboration with the Public Utilities Commission and local publicly owned electric utilities, in a public process that allows input from other stakeholders, shall establish annual targets for statewide energy efficiency savings and demand reduction that will achieve a cumulative doubling of statewide energy efficiency savings in electricity and natural gas final end uses of retail customers by January 1, 2030. The commission shall base the targets on a doubling of the midcase estimate of additional achievable energy efficiency savings, as contained in the California Energy Demand Forecast, 2015-2025, adopted by the commission, extended to 2030 using an average annual growth rate, and the targets adopted by local publicly owned electric utilities pursuant to Section 9505 of the Public Utilities Code, extended to 2030 using an average annual growth rate, to the extent doing so is cost effective, feasible, and will not adversely impact public health and safety."

[5] Cal. Public Resources Code § 23510(c)(4): "In assessing the feasibility and cost-effectiveness of energy efficiency savings for the purposes of paragraph (1), the commission and 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."

potential under various scenarios/assumptions regarding cost-effectiveness and program engagement. In January 2017, the CEC opened Docket number 17-IEPR-06 in its 2017 Integrated Energy Policy Report proceeding to develop a framework for establishing the energy efficiency "doubling" targets as specified and required by SB 350.[6] The Potential Study is intended to inform the CEC's process, which will result in annual targets adopted on or before November 1, 2017.

1.2. New Commission Policy Reflected in the Potential Study

Two other important policy developments that we intended to pick up during this bus stop originate from the Commission's Integrated Distributed Energy Resources (IDER) proceeding, Rulemaking (R.)14-10-003. First, D.16-06-007 adopts several updates to the Commission's Avoided Cost Calculator and directs Staff to recommend updates to the Avoided Cost Calculator annually through the Commission's resolution process.[7] Importantly, D.16-06-007 specifies that the Avoided Cost Calculator, starting with the 2016 update, should apply to cost-effectiveness analyses of all distributed energy resources (including energy efficiency, demand response, and distributed generation).[8] Second, in February 2017, the assigned Administrative Law Judge (ALJ) in R.14-10-003 issued a ruling seeking comment on a Staff proposal for a Societal Cost Test of distributed energy resources (Staff Proposal).[9] Of particular import for the purpose of evaluating energy efficiency potential, the Staff Proposal includes incorporation of a

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[6] *See* footnote 4 for definition of "doubling" pursuant to SB 350.

[7] D.16-06-007 Decision to Update Portions of the Commission's Current Cost-Effectiveness Framework, issued June 15, 2016, Ordering Paragraph 2.

[8] D.16-06-007 Ordering Paragraph 1.h.

[9] R.14-10-003 Administrative Law Judge's Ruling Taking Comment on Staff Proposal Recommending a Societal Cost Test, issued February 9, 2017. Attachment A "Distributed Energy Resources Cost Effectiveness Evaluation: Societal Test, Greenhouse Gas Adder, and Greenhouse Gas Co-Benefits. An Energy Division Staff Proposal."

greenhouse gas (GHG) "adder" into the Commission's Avoided Cost Calculator.[10] The purpose of this GHG adder is to recognize the value of reduced carbon emissions made possible by distributed energy resources beyond the market value of Cap-and-Trade allowances and compliance with 2030 GHG reduction goals, which were enacted after the 2016 update of the Avoided Cost Calculator.[11]

On July 14, 2017, the assigned ALJ in R.14-10-003 issued a proposed decision to adopt an interim GHG adder value, based on the CARB Cap-and-Trade Allowance Price Containment Reserve price (Cap-and-Trade APCR Price), to enable the Commission to assess and adopt updated energy efficiency goals. On August 24, 2017, the Commission adopted this decision.[12]

2. Overarching Considerations in Setting 2018 - 2030 Goals

Our intent with respect to adopting energy efficiency goals is to use the best available assessment of what is realistically achievable, based on our most accurate assumptions regarding technical feasibility, cost-effectiveness and customer adoption.

2.1. Realistic, Aggressive Yet Achievable Goals

In past decisions that updated energy efficiency goals, the Commission determined that an assessment of market potential – not technical or economic potential – provided a reasonable basis for estimating what the ratepayer-funded programs could and should

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[10] While the Staff Proposal refers to a GHG adder, it acknowledges that "[t]he price of carbon allowances that energy utilities must use to comply with [the California Air Resources Board's] cap and trade program are already incorporated in the energy (MWh) value in the current [Avoided Cost Calculator]." The proposed GHG adder is intended to reflect "the full avoided cost of carbon that accrues to utility ratepayers." *See* Staff Proposal at 17-18.

[11] SB 32 (Stats. 2016, Chap. 249) adds: Cal. Health and Safety Code § 38566: "In adopting rules and regulations to achieve the maximum technologically feasible and cost-effective greenhouse gas emissions reductions authorized by this division, the state board shall ensure that statewide greenhouse gas emissions are reduced to at least 40 percent below the statewide greenhouse gas emissions limit no later than December 31, 2030."

[12] D.17-08-022 Decision Adopting Interim Greenhouse Gas Adder, issued August 31, 2017.

realistically achieve.[13] Technical potential reflects the universe of potential savings that could be achieved if the most efficient, technically applicable opportunities were immediately adopted. Economic potential is the subset of technical potential that is determined to be cost-effective, based on whether the cost-effectiveness ratio is greater than 0.85, or 0.5 for emerging technologies.[14] Market potential reflects the subset of economic potential that we could expect customers to adopt "in response to specific levels of incentives and assumptions about policies, market influences, and barriers."[15] D.15-10-028, which established post-2015 energy savings goals, discusses at length our reasons for using market potential as opposed to economic potential for setting goals.[16] Those reasons remain valid and we have no basis to deviate from past practice in this decision.

D.15-10-028 also articulated the objective of developing realistic goals for the program administrators to achieve and for the CEC and other relevant entities to reasonably rely on for resource planning purposes. D.15-10-028 states:

> Setting unrealistic goals for ratepayer-funded programs gives other governmental entities and market actors bad information for use in their own EE activities. Misplaced reliance on overoptimistic forecasts can

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[13] D.15-10-028 Decision Re Energy Efficiency Goals for 2016 and Beyond and Energy Efficiency Rolling Portfolio Mechanics, issued October 28, 2015 at 11-17; D.14-10-046 Decision Establishing Energy Efficiency Savings Goals and Approving 2015 Energy Efficiency Programs and Budgets (Concludes Phase I of R.13-11-005), issued October 24, 2014 at 15-16; D.12-05-015 Decision Providing Guidance on 2013-2014 Energy Efficiency Portfolios and 2012 Marketing, Education, and Outreach, issued May 8, 2012, at 81.

[14] This decision does not address cost-effectiveness substantively, but refers heavily to cost-effectiveness terminology and assumes a basic level of familiarity with the Commission's cost-effectiveness framework for demand-side/distributed energy resources. Commission Staff have made informational resources regarding the Commission's cost-effectiveness framework available on the Commission's website, http://www.cpuc.ca.gov/General.aspx?id=5267.

[15] The post-2017 potential and goals study includes one new type of potential, which is a subset of market potential and represents the amount of potential savings from bringing "below-code" equipment up "to-code." We discuss this below-code potential further in this section.

[16] D.15-10-028 Decision Re Energy Efficiency Goals for 2016 and Beyond and Energy Efficiency Rolling Portfolio Mechanics, issued October 28, 2015, at 11-17.

> lead to misallocated resources and reduced activity by other actors, to ratepayers' and to the environment's detriment. It can also compound the internal and external pressure to claim success regardless of real-world program impact. Finally, it can lead other actors to discount the validity of the Commission's EE savings forecasts in their planning activities, thereby rendering the Commission's goal-setting far less useful than if the Commission is realistic in the first instance.
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> Accordingly, as in D.14-10-046, we will set a single set of goals. That single set of goals will be "aggressive yet achievable," and will rest on data-based assumptions.

In terms of what is realistic, past decisions have adopted goals based not only on cost-effectiveness (economic potential) but also on reasonable assumptions regarding whether customers will in fact adopt a given technology (market potential). These assumptions are informed by evaluations of the extent to which past programs succeeded in increasing customer adoption beyond the level that would have otherwise occurred.

Another closely related standard we have used for setting goals is that they should be "aggressive yet achievable," reflecting our intent to both provide reliable estimates of energy savings for resource planning purposes, as well as to set ambitious expectations for ratepayer-funded programs.[17]

SB 350 directs the Commission, and the CEC, to consider energy efficiency potential studies that are not restricted by past levels of savings.[18] While this direction would seem to conflict with our intent to set realistic, aggressive yet achievable goals,[19] it

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[17] D.07-09-043 Interim Opinion on Phase 1 Issues: Shareholder Risk/Reward Mechanism for Energy Efficiency Programs, issued September 25, 2007, at 26, 108.

[18] Cal. Public Resources Code § 23510(c)(4): "In assessing the feasibility and cost-effectiveness of energy efficiency savings for the purposes of paragraph (1), the commission and 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."

[19] D.07-09-043, at 108.

is also constrained by the mandate, again in SB 350, to set goals based on feasibility, cost-effectiveness and having no adverse public health and safety impacts.[20]

2.2. Accuracy and Consistent Valuation of Distributed Energy Resources

We must also acknowledge another policy mandate in SB 350, for the Commission to adopt a process for all jurisdictional load serving entities to submit integrated resource plans that "identify a diverse and balanced portfolio of resources needed to ensure a reliable electricity supply that provides optimal integration of renewable energy in a cost-effective manner."[21] A necessary component of portfolio optimization is consistent valuation of all resources, so that load serving entities and the Commission can consider the least-cost mix of resources that meet, among other objectives, the electricity sector's GHG emissions reduction targets to be established by the CARB. Consistent valuation of clean energy resources is a key focal point of both R.16-02-007 (Integrated Resource Plan, or IRP) and the IDER proceeding.

2.3. Comments on the Draft Study and Goals

To update energy efficiency goals, Commission Staff secured the services of Navigant and conducted a series of activities, many under the auspices of the Demand Analysis Working Group (DAWG). The Commission's website provides a summary of the meetings that occurred, and topics discussed at each meeting, in the preparation of the draft Potential Study.[22] On June 15, 2017, the assigned ALJ issued a ruling in this proceeding to invite formal comments on the draft Potential Study.

The draft Potential Study includes energy efficiency savings potential estimates resulting from five different scenarios:

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[20] Cal. Public Resources Code § 25310(c)(1).

[21] Cal. Pub. Util. Code § 454.51.

[22] 2018 Potential & Goals Study, http://www.cpuc.ca.gov/General.aspx?id=6442452619.

1. Total Resource Cost (TRC) Reference, or "TRC Reference," which uses the current Avoided Cost Calculator (reflecting avoided cost values adopted in 2016) as the cost-effectiveness screen for determining economic potential.
2. A modified TRC (mTRC) that uses the current Avoided Cost Calculator and includes a GHG adder based on the CARB Cap-and-Trade APCR Price, or "mTRC (GHG Adder #1) Reference."
3. A mTRC that uses the current Avoided Cost Calculator and includes a GHG adder based on the IDER Staff Proposal, which is in turn based on the preliminary RESOLVE model results developed in the Integrated Resource Planning proceeding, R.16-02-007.[23] The study refers to this scenario as "mTRC (GHG Adder #2) Reference."
4. Program Administrator Cost (PAC) Reference, or "PAC Reference," which uses the current Avoided Cost Calculator.
5. "PAC Aggressive," which uses the current Avoided Cost Calculator and assumes an enhanced level of program engagement.[24]

The June 15, 2017 ruling also invited parties to comment on whether to adopt cumulative savings goals.

On July 7, 2017, the following parties filed and served opening comments on the draft Potential Study: Association of Bay Area Governments on behalf of Bay Area Regional Energy Network (BayREN), California Energy + Demand Management Council (CEDMC), Natural Resources Defense Council (NRDC), the Office of Ratepayer Advocates (ORA), Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), Southern California Edison Company (SCE), Southern California Gas Company (SoCalGas), County of Los Angeles on behalf of the Southern

[23] The RESOLVE model is a capacity expansion model, based on linear programming techniques, used to identify least-cost portfolios of future resources that satisfy the multiple state policy goals required by the Integrated Resource Planning statute, including reducing greenhouse gas emissions and maintaining reliability.

[24] The TRC Test measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the program administrator's costs. The PAC Test measures the net costs of a demand-side management program as a resource option

Footnote continued on next page

California Regional Energy Network (SoCalREN), and The Utility Reform Network (TURN).

On July 14, 2017, the following parties filed and served reply comments: CEDMC, National Association of Energy Service Companies (NAESCO), NRDC, PG&E, SCE, SoCalREN, and the County of Ventura on behalf of the Tri-County Regional Energy Network (3C-REN).

We address those comments here, according to the two general issue areas for which we invited comments -- scenarios and cumulative savings goals -- and additional issues raised by parties.

2.3.1. Scenarios

The June 15, 2017 ruling invited parties to comment on the scenarios included in the draft Potential Study (referred to as the "Navigant Study" in the ruling). The ruling invited responses to the following questions:

1. Commission staff proposed five scenarios that attempt to capture a reasonable range of energy efficiency potential for 2018-2030.
    a. The Navigant study includes two scenarios considering a GHG adder to the 2016 Avoided Cost to screen measures for Economic Potential. Is it appropriate to use a GHG adder in the 2016 Avoided Cost? Why or why not?
    b. If you agree it is appropriate to use a GHG adder: which GHG adder value – either in the Navigant study or an alternative recommendation – is most appropriate to inform the 2018-2030 IOU energy efficiency goals? Please justify your recommendation.
    c. The Navigant study includes two scenarios using the PAC to screen measures for Economic Potential. Is it appropriate to consider energy efficiency goals based on the PAC? Why or why not?

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based on the costs incurred by the program administrator (including incentive costs) and excluding any net costs incurred by the participant.

d. Which scenario – either in the Navigant study or an alternative recommendation – is most appropriate to inform 2018-2030 goals? Please justify your recommendation.

e. If the Commission, in R.14-10-003, does not formally adopt (or otherwise reach a determination on) the interim valuation of costs to meet 2030 GHG reduction goals (GHG Adder) before the need in this proceeding to adopt 2018-2030 goals, does your recommendation change? If so, which scenario would you recommend the Commission use as basis for adopting 2018-2030 goals? Please justify your recommendation.

2.3.1.1. Positions of the Parties

2.3.1.1.1. Whether to Adopt Goals Based on a GHG Adder

SCE, SoCalGas and SDG&E do not explicitly oppose the use of a GHG adder, but recommend adopting goals that do not reflect any additional value for avoided GHG emissions, beyond the value that is embedded in the current Avoided Cost Calculator. These parties all observe that the draft Potential Study results do not reflect or indicate a potential disruption to the energy efficiency market, for which the Staff Proposal expresses concern. SCE asserts that "[a]pplying any interim value for [energy efficiency] is unnecessary and will continue to use divergent resource value streams that the IDER and IRP proceedings were established in part to standardize."[25] SCE further notes that "decreases in market potential created by the updated 2016 avoided cost [sic] are offset through new approaches, including expanded behavioral, retrocommissioning and operational offerings as well as a small amount of stranded potential."[26] SoCalGas states that large increases in spending require additional review through the IRP process "so that the benefits of GHG reduction are not exaggerated and that customers do not

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[25] R.13-11-005 Southern California Edison Company's (U 338-E) Comments on Administrative Law Judge's Ruling Inviting Comments on Draft Potential and Goals Study, filed July 7, 2017 (SCE opening comments) at 2.

[26] *Ibid*. at 2.

overpay for [energy efficiency] resources."[27] SDG&E states it is reasonable to delay incorporation of a GHG adder, not only to allow the Commission to consider the Staff Proposal in R.14-10-003, but also to allow time to assess demand for energy efficiency programs and Business Plan activities.

ORA reserves judgment on whether the Commission should incorporate a GHG adder, but in the event that the Commission determines to do so, ORA cautions against using a value that is "subject to factual dispute," with reference to the IDER Staff Proposal and to ORA's support for the IOU-proposed value reflecting the CARB Cap-and-Trade APCR Price.[28]

Nearly all other parties that submitted comments express support for a GHG adder, more specifically for accounting for the value of avoided GHG emissions consistent with the State's 2030 GHG reduction target. PG&E, SoCalREN and TURN recommend that the Commission base the GHG adder on the CARB Cap-and-Trade APCR Price. PG&E supports the inclusion of a GHG value, consistent with the Joint IOUs' recommendation in the IDER proceeding, "to acknowledge that the 2016 Avoided Cost update did not take into account SB 32's 2030 GHG reduction targets."[29] SoCalREN supports inclusion of a GHG adder but, like ORA, cautions against the preliminary results of the RESOLVE model ("GHG Adder #2"), arguing that using this value "could expose portfolios to a large jump in increasing values between 2021 and

[27] R.13-11-005 Opening Comments of Southern California Gas Company (U 904 G) on Administrative Law Judge's Ruling Inviting Comments on Draft Potential and Goals Study, filed July 7, 2017 (SoCalGas opening comments) at 2.

[28] R.13-11-005 Opening Comments of the Office of Ratepayer Advocates on the Administrative Law Judge's Ruling Inviting Comments on Draft Potential and Goals Study, filed July 7, 2017 (ORA opening comments) at 2.

[29] R.13-11-005 Comments of Pacific Gas and Electric Company (U 39 M) Regarding Energy Efficiency Potential and Goals for 2018 and Beyond in Response to Administrative Law Judge's Ruling Dated June 15, 2017, filed July 7, 2017 (PG&E opening comments), at 3.

2030 ... causing instability in budgets and programs over time."[30] TURN explains that the Avoided Cost Calculator "does not accurately represent the reasonably anticipated costs of mitigating GHG emissions subject to limits prescribed by state law (SB 32). The calculator includes a lower cost of GHG emissions, limited to the carbon allowance price embedded in future energy prices."[31] PG&E and SCE highlight this same point, i.e., that a value for avoided GHG emissions already exists in the current Avoided Cost Calculator and the relevant question the Commission should consider is whether to adopt an alternative value – not an adder on top of the existing value. PG&E further states that the Commission should make any further necessary adjustments to the Avoided Cost Calculator to ensure against overestimating the value of GHG reductions from energy efficiency, including avoided Renewable Portfolio Standard values.

BayREN, CEDMC, NAESCO, NRDC, 3C-REN also support consideration of a GHG adder, as well as alternative tests and/or scenarios to inform the Commission's decision on post-2017 goals.

BayREN suggests that the Potential Study incorporate the Societal Cost Test and GHG adder that is currently under development in the IDER proceeding (i.e., the Staff Proposal). BayREN argues that "GHG emissions and societal benefits must be accounted for so that the Study can provide [program administrators] and stakeholders a more accurate framework to determine what kind of programs and activities should be undertaken to achieve State goals."[32]

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[30] R.13-11-005 Comments of the County of Los Angeles, on Behalf of the Southern California Regional Energy Network (CPUC #940), on Administrative Law Judge's Ruling Inviting Comments on Draft Potential and Goals Study, filed July 7, 2017 (SoCalREN opening comments), at 4.

[31] R.13-11-005 Comments of The Utility Reform Network Responding to the Administrative Law Judge's Ruling Inviting Comments on Draft Potential and Goals Study for 2018 and Beyond, filed July 7, 2017 (TURN opening comments), at 3.

[32] R.13-11-005 Comments of the Association of Bay Area Governments, on Behalf of the San Francisco Bay Area Regional Energy Network (CPUC #940) to ALJ's Ruling Regarding Draft Potential and Goals Study, filed July 7, 2017 (BayREN opening comments) at 3.

CEDMC "urges" the Commission to adopt goals based on the PAC test, under the Aggressive scenario and with a GHG adder, stating that "even savings under the PAC Aggressive scenario are insufficient to meet a doubling of energy efficiency under SB 350."[33] CEDMC does not identify a specific GHG adder value to use, though it refers to the Staff Proposal. CEDMC requests that the study include four more scenarios, based on the PAC test (Reference and Aggressive), with both the GHG Adder #1 (Cap-and-Trade APCR Price) and the GHG Adder #2 (RESOLVE preliminary results).

NAESCO supports CEDMC's recommendation for additional scenarios based on the PAC and argues that "even these scenarios, in NAESCO's opinion, seriously underestimate the potential for available cost-effective [energy efficiency] in California."[34] NAESCO cites the American Council for Energy-Efficient Economy's 2016 State Energy Efficiency Scorecard, which shows electricity savings in California lower than in Massachusetts, reasoning that this difference is due in part to per capita spending on energy efficiency that is 43 percent less in California than in Massachusetts.

NRDC takes issue with recommendations to use the CARB Cap-and-Trade APCR Price, citing the basis for those recommendations as the reasonableness of the Cap-and-Trade APCR Price and, related, that the Cap-and-Trade APCR Price reflects an accurate value of the abatement cost of carbon. NRDC instead supports the use of the GHG adder value proposed in the Staff Proposal, arguing that this value represents the electric sector's share of costs to comply with state GHG reduction policy. While acknowledging the arguments by some parties in R.14-10-003 that the RESOLVE model

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[33] R.13-11-005 Comments of the California Efficiency + Demand Management Council on Administrative Law Judge's Ruling Inviting Comments on Draft Potential and Goals Study, filed July 7, 2017 (CEDMC opening comments) at 8.

[34] R.13-11-005 Reply Comments of the National Association of Energy Service Companies (NAESCO) on the Comments of Other Parties on the Draft Potential and Goals Study, filed July 14, 2017 (NAESCO reply comments) at 3.

and its inputs have not been vetted publicly, NRDC asserts that "CPUC Staff have conducted due diligence on RESOLVE."[35]

Without identifying a specific GHG adder value, 3C-REN states that adopting a GHG adder "will provide for a more accurate framework to best determine the type of activities and programs needed to meet statewide goals."[36]

2.3.1.1.2. Whether to Adopt a GHG Adder in Advance and Outside of the Integrated Distributed Energy Resources Proceeding, R.14-10-003

The question of whether parties' recommended scenario changes, based on the outcome of R.14-10-003, is only relevant to parties who agree that the Commission should adopt goals based on a value under consideration in R.14-10-003. Those parties are BayREN, CEDMC, NAESCO, NRDC, PG&E, SoCalREN, and TURN. Of those parties, four explicitly address the question and three elaborate on their response.

PG&E responds, "the Commission should not adopt an alternative cost-effectiveness treatment that would be inconsistent with what has been adopted in the IDER. Once a decision in IDER is available, it would be reasonable for the Commission to update the energy efficiency potential study and subsequently, if appropriate, the efficiency goals for 2018 and 2019."[37]

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[35] R.13-11-005 Reply Comments of the Natural Resources Defense Council (NRDC) on the Administrative Law Judge's Ruling Inviting Comments on the Draft Potential and Goals Study, filed July 14, 2017 (NRDC reply comments) at 3.

[36] R.13-11-005 Reply Comments of County of Ventura on Behalf of the Tri-County Regional Energy Network on Comments to ALJ's Ruling Inviting Comments on Draft Potential and Goals Study, filed July 14, 2017 (3C-REN reply comments) at 3. 3C-REN goes on to argue that "[t]aking only cost-effectiveness into account leads to program design consisting of quick, low-cost delivery and easy market penetration resulting in the hard to reach markets being unable to take advantage of programs and services," however cost-effectiveness requirements for energy efficiency portfolios is not at issue in this decision. Presumably 3C-REN intends to assert that considering only non-GHG avoided costs leads to sub-optimal program design.

[37] PG&E opening comments, at 6.

TURN, which recommends the same GHG adder value as PG&E, disagrees, reasoning that "the current avoided cost calculator undervalues [energy efficiency] by including lower costs associated with mitigating GHG emissions than can be reasonably anticipated based on current law. Thus, adopting a GHG adder to correct for this inaccuracy in determining [energy efficiency] economic potential is consistent with the mandates of California Public Utilities Code Sections 454.55 and 454.56…"[38]

SoCalREN agrees with TURN, noting that "the update [of the Avoided Cost Calculator] occurred prior to the adoption of Senate Bill (SB) 32 and, therefore, did not reflect the cost impacts of 2030 GHG targets now in state law."[39]

2.3.1.1.3. Use of the Program Administrator Cost Test to Set Goals

SCE, SoCalGas, and TURN all note the "mismatch" with the way that the Commission evaluates and determines portfolio cost-effectiveness (i.e., using both the PAC and the TRC) that would result if the Commission were to base economic potential on the PAC test. Therefore, if the Commission opts to set goals based on the PAC, these parties argue that the Commission should also revise its policy regarding portfolio cost-effectiveness requirements to also be based on the PAC.

CEDMC agrees that the portfolio cost-effectiveness test would need to be updated, stating that a "policy update to utilize the PAC test, with goals under the PAC Aggressive scenario, is the appropriate path to 2030 goals."[40]

PG&E also supports consistency among goal-setting, portfolio evaluation and resource planning, but recommends that the Commission continue to assess cost-effectiveness from the TRC perspective.

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[38] TURN opening comments, at 9.

[39] SoCalREN opening comments, at 3.

[40] R.13-11-005 Reply Comments of the California Efficiency + Demand Management Council on Administrative Law Judge's Ruling Inviting Comments on Draft Potential and Goals Study, filed July 14, 2017 (CEDMC reply comments), at 6.

PG&E and SoCalREN both highlight the importance of considering all ratepayer costs – both participant and non-participant (through revenues collected by the IOUs and used by the program administrators to administer energy efficiency programs) – to evaluate the cost-effectiveness of energy efficiency measures.

Although PG&E supports continued use of the TRC, it suggests there may be a need to "address cost issues in the TRC test that are unique to energy efficiency. These involve accounting for participant costs that are unrelated to energy savings and that customers incur for other reasons," with reference to a "Joint IOUs proposal" in the IDER proceeding and to its proposal in the business plan applications proceeding to estimate the amount of program-related costs that participants incur for non-program related benefits, such as comfort and aesthetic gratification.[41]

ORA opposes the use of the PAC Aggressive scenario as that scenario relies, ORA alleges, on an unrealistic set of assumptions. More specifically, ORA elaborates, the increases in electric and gas potential (23 and 57 percent, respectively) are not commensurate with the increased expenditure (more than 100 percent) required to achieve those additional savings. NAESCO takes issue with ORA's assertion, arguing that "this conclusion is constrained by past program performance," and "the cost-effectiveness of future incentive programs will also be significantly enhanced when the ratepayer-funded programs recognize all energy savings, not just above-code savings, as mandated by AB 802."[42]

SDG&E does not recommend use of the PAC test to set energy savings goals "because customer costs are a critical consideration influencing customer demand" and, SDG&E asserts, it is not clear whether the study assumes constant customer demand as potential increases, implying that customer demand is not constant for all levels of

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[41] PG&E opening comments, at 4.

[42] NAESCO reply comments, at 6.

savings potential.[43] In reply comments, NRDC counters SDG&E's suggestion that the economic potential screen should account for customer willingness to adopt by explaining that "[o]nce a measure qualifies as a programmatic offering [after it has passed the cost-effectiveness screen], a customer adoption model is then applied to this cost-effective measure ... the GHG adder does not impact the measure's payback period and does not impact the customer adoption algorithm for a measure."[44]

NRDC asserts that the PAC test with a GHG adder is the most appropriate scenario on which to base energy efficiency goals. NRDC argues that the PAC test is appropriate because the current IRP process uses the PAC to determine the lowest cost path – including both supply-side and demand-side resources -- to comply with state GHG reduction policy.

2.3.1.2. Discussion

As most parties acknowledge, while the 2016 update to the Commission's Avoided Cost Calculator -- specifically updates to the price of natural gas -- would decrease the cost-effectiveness of traditional energy efficiency programs, it does not reflect the value, or added benefit, of avoided GHG emissions pursuant to 2030 GHG reduction targets enacted in SB 32. Furthermore, we anticipate that the IDER proceeding will incorporate additional updates to the Avoided Cost Calculator to include a GHG adder and possibly other elements of the Staff Proposal (for a societal cost test) in the coming year. In that regard, if we did not incorporate a GHG adder here, we could potentially see a lower estimate of cost-effective energy efficiency programs over the next year, only to be followed by a potential increase in cost-effective energy efficiency if and when the IDER proceeding adopts a GHG adder. To provide more consistent guidance to the market and to be consistent with our intent to evaluate cost-effectiveness

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[43] R.13-11-005 San Diego Gas & Electric Company (U 902-M) Comments on Draft Potential and Goals Study, filed July 7, 2017 (SDG&E opening comments), at 7.

[44] NRDC reply comments, at 4.

accurately, we find it is appropriate to adopt goals based on a scenario that incorporates such a GHG adder until the IDER proceeding makes further updates to the Avoided Cost Calculator. Of course, in the event that the IDER proceeding does not adopt a GHG adder or other elements of the Staff Proposal, future updates to energy efficiency potential and goals studies should reconcile any misalignment with the Commission's cost-effectiveness framework.

The next issue to determine is which value is most appropriate to forecast the added value of GHG emissions reduction, or GHG adder. We have already stated our intent to value energy efficiency consistently for all distributed energy resources, therefore our preference is to use a value that the Commission has found to be appropriate in the IDER proceeding.

We adopt goals based on a GHG value that reflects the CARB Cap-and-Trade APCR Price. The question of this value's accuracy is more appropriately in the scope of the IDER rulemaking, but we note that the record there indicates this is the most reasonable value to use on an interim basis. Based on the record in that proceeding, the Commission proposed to adopt this value as an interim GHG adder, for the specific purpose of updating energy efficiency goals.

The Commission has adopted an interim GHG adder, based on the CARB Cap-and-Trade APCR Price, stating "[T]here is insufficient evidence in the record to determine if the Cap-and-Trade APCR Price can be equated with a marginal carbon abatement price.[45] However, because it represents the highest cost of compliance with California's cap and trade requirements, the Cap-and-Trade APCR Price is the best

[45] The final Potential Study, attached as Appendix 1 to the proposed decision, included a corresponding adjustment to the avoided RPS value, which Navigant anticipated the Commission would authorize in the IDER proceeding. Since the IDER proceeding did not authorize an adjustment to the avoided RPS value, Commission Staff directed Navigant to remove this adjustment to the avoided RPS value; this decision adopts goals that do not reflect an adjustment to the avoided RPS value.

interim value currently available to approximate the societal costs of greenhouse gas emissions."[46]

Because D.16-06-007 specifies that "[a] single avoided cost model should apply to all distributed energy resource proceedings,"[47] we should now incorporate the CARB Cap-and-Trade APCR Price into our assessment of energy efficiency cost-effectiveness.

The final issue to address, with respect to which scenario to base energy efficiency goals on, is the appropriateness of the PAC or other scenarios not included in the draft Potential Study.

We decline to adopt goals based on the PAC or similarly more aggressive scenarios (than the TRC), for multiple reasons.

First, we agree with parties who argue that the Commission should revise its portfolio cost-effectiveness requirements if it chooses to adopt goals based on the PAC. The question of whether to eliminate the TRC from portfolio cost-effectiveness requirements is beyond the scope of this decision; parties should have adequate opportunity to argue the merits of such a significant change to energy efficiency cost-effectiveness policy, if the Commission were to consider such a change. Moreover, such a change is more appropriately within the scope of the IDER rulemaking, given the Commission's emphasis on consistent valuation of distributed energy resources. We also note that the Commission Staff analysis in the Commission's Integrated Resources Plan rulemaking, R.16-02-007, also relies primarily on resource cost-effectiveness based on the TRC (not on the PAC, as NRDC states in opening comments).[48]

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[46] D.17-08-022, at 11.

[47] D.16-06-007 Ordering Paragraph 1.h.

[48] *See* Preliminary RESOLVE Modeling Results for Integrated Resource Planning at the CPUC, CPUC Energy Division presentation during July 19, 2017 workshop in R.16-02-007. Retrieved from California Public Utilities Commission website: http://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/irp/17/CPUC_IRP_Preliminary_RESOLVE_Results_2017-07-19_final.pdf (as of August 8, 2017), page/slide 34.

Second, we acknowledge that SB 350 directs the Commission to consider the results of energy efficiency potential studies that are not restricted by previous levels of utility energy efficiency savings, and for this reason Staff directed Navigant to include scenarios that reflect only the program administrator's costs and that further assume aggressive efforts at program engagement. What the Potential Study shows is that, for about 72 percent (Reference) and over 125 percent (Aggressive) additional expenditures in the short term and 37 percent and 88 percent in 2030 (compared to the TRC Reference scenario), the PAC scenarios show only 25 to 36 percent more savings in the short term to about nine percent (Reference) and 51 percent (Aggressive) in 2030, with similar performance for gas. This exercise shows, in general terms, diminishing returns for the PAC and large increases in projected expenditures. Choosing this scenario would be inconsistent with the Commission's responsibility to authorize prudent long-term investments on behalf of ratepayers.

Third, we disagree with those arguments for more aggressive goals based exclusively or primarily on the need to achieve the so-called doubling goals articulated in SB 350.[49] To be clear, this is entirely separate from our intention for energy efficiency program administrators and implementers to strive to execute all cost-effective, innovative programs that target deeper savings; this is our central focus in the current rolling portfolio business plans proceeding, Applications (A.) 17-01-013 et al. But comments advocating that the Commission adopt goals based on the scenario that estimates the highest savings, solely in order to reach SB 350's doubling goals, neglect the important work that the CEC is currently conducting to develop *targets* based on a

[49] SB 350 requires the CEC to set annual targets "that will achieve a cumulative doubling of statewide energy efficiency savings...by January 1, 2030," based upon "the midcase estimate of additional achievable energy efficiency savings, as contained in the California Energy Demand Forecast, 2015-2025... to the extent doing so is cost effective, feasible, and will not adversely impact public health and safety. Some comments characterize this as an absolute doubling of energy efficiency, which is technically imprecise.

goal of doubling energy efficiency "to the extent doing so is cost effective, feasible, and will not adversely impact public health and safety."

It is worthwhile then to make clear the sequence of activities among this (post-2017) potential study, the CEC's work on doubling targets, and future potential studies: First, the Commission adopts post-2017 goals, based on cost-effectiveness and a deliberate intent to provide realistic estimates for resource planning purposes. Then, the CEC utilizes the Commission's adopted goals as inputs to its determination of annual targets, pursuant to SB 350's doubling goal (this will constitute the targets for the IOUs for SB 350). According to the CEC draft staff paper for setting these targets, the CEC will also estimate some amount of enhanced/expanded savings (as well as non-IOU related savings such as Property Assessed Clean Energy, benchmarking, Codes & Standards), which also must be cost-effective, feasible, and not adversely impact public health and safety.[50]

Following the CEC's adoption of doubling targets, improving program efficiency and developing new approaches (third party, market transformation, etc.) can lead to increased savings, which ultimately could enable the program administrators to contribute to closing the "gap between the likely savings from utilities...and the cumulative doubling goal."[51] But the programs must invariably meet the Commission's cost-effectiveness requirements. We do not expect that program administrators will double past performance, cost-effectively, absent new program designs and delivery strategies, many of which have yet to be proposed or implemented, and which are the subject of the rolling portfolio business plan applications. We also emphasize here that

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[50] Giyenko, Elena, Cynthia Rogers, Michael Jaske, and Linda Schrupp. 2017. *Senate Bill 350 Energy Efficiency Target Setting for Utility Programs* ("draft staff paper"). California Energy Commission. Publication Number: CEC-200-2017-005-SD. Retrieved from the California Energy Commission website: http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220290-1_20170721T093759_Senate_Bill_350_Energy_Efficiency_Target_Setting_for_Utility_Pr.pdf (as of August 8, 2017).

[51] *Ibid.* at 32.

the goals adopted in this decision are a floor; if IOUs and other program administrators can develop strategies for deeper savings, we expect to count those towards the doubling goal.

Finally, we confirm that this proceeding is not the appropriate venue for resolving disputes regarding the reasonableness of the specific inputs to the RESOLVE model. Although the value coming out of the RESOLVE model *may* represent the best available valuation of GHG societal costs, that process will not conclude before the need in this proceeding to adopt goals in time for the CEC to appropriately discharge its load forecasting and target-setting responsibilities.

2.3.2. Cumulative Goals

Regarding cumulative goals, the June 15, 2017 ruling asked for responses to the following questions:

1. Cumulative goals: The Commission ordered in D.16-08-028 the consideration of cumulative goals if methods were developed. Commission staff worked with the DAWG to develop a method to propose cumulative savings, but was unsuccessful in identifying suitable approaches to inform this decision. Do you recommend that the Commission still adopt cumulative goals for 2018-2030? Why or why not? If you recommend that the Commission adopt cumulative goals:
    a. Should goals start to accumulate in 2018? Why or why not?
    b. How should the Commission deal with under/over achievement of cumulative goals?
    c. Persistence and decay are calculated based on participation informed by the Navigant Analytica model. Do you agree that cumulative goals are informed by this method? Why or why not?

2.3.2.1. Positions of the Parties

All parties responding to this question, except SCE, recommend against adopting cumulative goals at this time.[52]

Both ORA and TURN recommend that the Commission look to the CEC for development of a method to quantify cumulative goals, which SB 350 requires the CEC to conduct. ORA and TURN also recommend that, in the interim, the Commission should require the program administrators to include net lifecycle savings as a metric as part of their Business Plan metrics in A.17-01-013 et al. TURN further recommends that the Commission adopt annual first year net goals.

PG&E and SoCalGas assert that a reasonable method to account for decay has not been established.[53] However, PG&E goes on to recommend that the Commission consider "the impacts of decay in planning contexts, but not in setting IOU goals," which would seem to negate its concern about the lack of a reasonable method to calculate decay.[54] SDG&E recommends further discussion to develop cumulative goals, and "urges the Commission to work to inform a complete understanding of cumulative goals and how those can be achieved, specifically given budgetary constraints."[55] Similarly, SoCalREN suggests the need for workshops "to have a deeper discussion in regards to cumulative vs. annual."[56]

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[52] BayREN, CEDMC, NAESCO, NRDC and 3C-REN did not provide comments in response to Question 2 of the June 15, 2017 ruling.

[53] The Commission's Energy Efficiency Policy Manual (Version 5, July 2013) defines savings decay as "[t]he reduction of cumulative savings due to previous measure installations passing their Remaining Useful Life or Effective Useful Life. Per D.09-09-047 and until EM&V results inform better metrics, IOUs may apply a conservative deemed assumption that 50% of savings persist following the expiration of a given measure's life."

[54] PG&E opening comments, at 9.

[55] SDG&E opening comments, at 8.

[56] SoCalREN opening comments, at 6.

SCE recommends that the Commission adopt cumulative goals for 2018-2030, stating that cumulative goals are consistent with the state's legislative goals and energy efficiency program goals. SCE is indifferent as to the specific start year "as long as the start year for [energy efficiency] program goals and [energy efficiency] programs savings/achievement is aligned."[57] Further, SCE recommends that the Commission allow the program administrators to carry market potential over/under achievements forward to allow flexibility and to reward overachievement. SCE states the decay for rebate programs is reasonably addressed in the potential and goals model. In reply comments, SCE adds that the CPUC and CEC have distinct roles; the CPUC is responsible for adopting goals and targets, and the CEC for forecasting load, "which takes into account [energy efficiency] program goals." Therefore, SCE asserts, "the Commission should not defer setting cumulative [energy efficiency] saving goals to the CEC." Nevertheless, SCE acknowledges that SB 350 directs the CEC (not the CPUC) to "establish annual targets for statewide energy efficiency savings in electricity and natural gas final end uses of retail customers."[58]

2.3.2.2. Discussion

Given the CEC's responsibilities with respect to setting targets pursuant to SB 350, and its need to develop a means for estimating cumulative savings, we find it reasonable to refrain from adopting cumulative goals and instead defer such adoption until Commission Staff can assess the feasibility and reasonableness of using the methodology to be developed by the CEC, after it has been developed, for the purpose of setting cumulative goals.

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[57] SCE opening comments, at 6.

[58] R.13-11-005 Southern California Edison Company's (U 338-E) Reply Comments on Administrative Law Judge's Ruling Inviting Comments on Draft Potential and Goals Study, filed July 14, 2017 (SCE reply comments), at 2.

In the meantime, ORA and TURN's recommendation for the program administrators to measure and set targets for net lifecycle savings is a reasonable alternative, given our determination in D.16-08-019 to focus on long-term savings.

No parties objected to ORA and TURN's recommendation. We note that both ORA and TURN have repeated this recommendation in their opening comments on the revised sector-level metrics in the current business plan applications proceeding.[59] Based on the record in that proceeding, the Commission will determine whether to require the program administrators to set targets for, track and report on net lifecycle savings.

2.3.3. Other Issues

Parties raised a number of additional recommendations in their comments. Parties' recommendations can be generally characterized as either suggesting technical corrections, e.g., revisions to some aspect of the study's assumptions or data sources, or more substantive suggestions, e.g., suggesting a change to the scope or the policy reflected in the study. Navigant has made technical corrections in the final draft in response to some parties' comments, and included responses to each technical comment explaining whether and why it is appropriate and feasible (or not) to incorporate into the final draft of the post-2017 Potential Study. We address parties' more substantive recommendations here.

2.3.3.1. Correction for Discrepancies in Lighting

PG&E notes that a particular type of compact fluorescent light (CFL) specialty lamps constitutes an unexpectedly high proportion of savings in PG&E's rebate program portfolio, given that the draft Potential Study states that the Energy Independence and

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[59] A.17-01-013 et al. Opening Comments of the Office of Ratepayer Advocates on the Administrative Law Judge's Ruling Seeking Comment on Energy Efficiency Business Plan Metrics and the Administrative Law Judge's Ruling Requesting Comments on Energy Efficiency and Demand Response Integration Options, filed July 24, 2017, at 5-6; and Comments of The Utility Reform Network on the Program Administrators' Revised Sector Metrics, filed July 24, 2017, at 2-3.

Security Act (EISA) of 2007 standards should apply (and therefore such savings should not be included in the savings estimates).

Similarly, PG&E believes the potential for light-emitting diode (LED) lighting is high given Staff's 2017 Comprehensive Screw-in Lamp Workpaper Disposition (issued May 26, 2017).

Navigant clarifies now that a federal rulemaking, which concluded that most specialty lamps will be subject to the EISA standard, remained pending at the time that Navigant had completed its measure characterization activities.[60] The federal rulemaking concluded in January 2017, so it is appropriate now to adjust savings estimates for CFL specialty lamps.

The final draft of the Potential Study also addresses the LED baseline mix discrepancy with the 2017 Comprehensive Screw-in Lamp Disposition. Commission Staff, Navigant and the ex-ante review team discussed the issue and concluded that with rapid changes in the market and upcoming 2018 federal standards, the 2017 Comprehensive Screw-in Lamp Disposition would become outdated during the forecasted period. To account for the uncertainty in the future baseline mix, Navigant kept the current baseline in the study for gross savings and used the default Database for Energy Efficiency Resources (DEER) net to gross ratio for calculation of net savings. A more detailed discussion of the update can be found in Appendix I of the final Potential Study.

2.3.3.2. Inclusion of Financing Potential in Reference Scenarios

PG&E suggests that "it may be appropriate to include the savings potential modeled for financing in 2018 and beyond in the Reference cases," citing the 2013/14 On

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[60] U.S. Department of Energy, Energy Efficiency and Renewable Energy Office, 2017-01-19 Energy Conservation Program: Energy Conservation Standards for General Service Lamps; Final rule in Docket number EERE-2013-BT-STD-0051, https://www.regulations.gov/document?D=EERE-2013-BT-STD-0051-0097.

Bill Financing Program Impact evaluation and the fact that PG&E "anticipates claiming savings associated with OBF Alternative Pathway...and CAEATFA Financing Program. Additionally, PG&E will strive to account for savings attributable to financing coupled with rebate and incentives going forward."[61]

Including potential savings estimates from financing in the Reference scenarios is premature for this (post-2017) Potential Study. The financing programs remain relatively nascent and require a reliable method for savings quantification and attribution in order for the program administrators to claim savings. Once more data is available to evaluate the financing programs, the program administrators can offer proposals for savings claims, which (if approved) should inform future potential studies.

2.3.3.3. Energy Efficiency Potential Estimates for Non-IOU Program Administrators

BayREN raises a concern regarding the distribution of energy efficiency potential among the IOUs as opposed to a distribution by county, city or other jurisdiction. BayREN asserts that it "cannot be assigned goals based on the [Potential] study and cannot use the study to understand what opportunities and needs exist within BayREN's service area. The study needs to be more granular and should provide similar analysis for each of the program administrators currently operating in California."[62] 3C-REN supports BayREN's assertion that the Potential Study should present energy efficiency potential estimates by city, county or other jurisdiction in order to be useful to all program administrators (not just the IOUs).

While we agree that the Potential Study should be useful for all program administrators, and BayREN's request is within the scope of the potential study process, development of city-, county-, or other jurisdiction-level savings estimates requires additional data and modeling resources. The final Potential Study cannot adequately

[61] PG&E opening comments, Appendix A at A-6.

accommodate BayREN's request at this time. Staff should consider the necessary data collection and modeling in the scope of the next potential and goals study. All program administrators should actively participate in the early stakeholder development of future potential studies, to enable the consultant to properly scope the data collection and other necessary tasks from the outset.

2.3.3.4. Timing of Updates to Future Potential and Goals Studies

SCE recommends that the Commission adopt off-year updates to the potential and goals study, which would essentially change our bus stop approach from a two-year cycle to an annual one. SDG&E, on the other hand, states that "the study should be updated consistent with the needs of the [Integrated Energy Policy Report]," which we confirm is the process that D.15-10-028 adopted.[63]

Although more frequently updated results could be useful for program administrators and implementers, the study development process itself is both time- and resource-intensive and therefore would be difficult to convert to an annual process. Future iterations of the study may become more automated, in which case implementing more frequent updates of at least some portion(s) of savings estimates might become feasible. However, the modeling requirements could also become more complex and/or expanded, or could take an entirely different path, in which case it would be prudent to maintain the current two-year work plan. We will not adopt SCE's recommendation for off-year updates now but may reevaluate the merits of this option for future studies.

2.3.3.5. Public Sector Market Potential

PG&E, SCE, and SoCalGas observe that the Commission has directed the program administrators to develop strategies targeted specifically at the Public sector, but

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[62] BayREN opening comments, at 2.

[63] SDG&E opening comments, at 7.

the lack of potential savings estimates for this sector limit program administrators' ability to adequately fulfill the Commission's direction. In short, these parties recommend that the study include an analysis and savings estimates for Public sector market potential.

The data that is currently available for this study does not allow for an appropriate estimation of Public sector savings. At issue is the adequacy of data indicating either the number of customers or the amount of square feet needed to appropriately define the sector. We agree that such an analysis is useful and will direct Energy Division to oversee efforts to collect the necessary data to inform future potential studies on Public sector market potential.

2.3.3.6. Low Income Savings and Potential

Several parties observe that the Potential Study does not reflect an analysis of low-income potential, and therefore it does not comply with California Public Resources Code § 25310(c)(4) and D.16-11-022. NRDC asserts that funds allocated for the low-income potential analysis required by D.16-11-022 be utilized to complete this analysis. "The potential should include a breakdown of end uses, equipment, and indicate how the energy costs for common areas and in-unit energy use are paid (through utility bills) by owners versus tenants. This would not only provide additional economic and market potential information in low-income multifamily buildings, but also enable improved program designs to capture all cost-effective energy efficiency in this sector."[64]

Parties did not request a different approach to estimating low income savings during the early development of this study. Development of this study could not take account of D.16-11-022 (adopted in November 2016) in its entirety, without jeopardizing the schedule for timely completion.[65] The next update of the potential and goals study will include a low-income potential analysis as required by D.16-11-022. Ultimately,

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[64] NRDC opening comments, at 9.

[65] The Potential Study does quantify potential for retreatments, as ordered by D.16-11-022. *See* June 15, 2017 ruling, Appendix A, at 22, 73-74.

however, the Energy Savings Assistance Program's proceeding adopts goals that may or may not be informed by this study.

2.3.3.7. Accuracy of Spending Estimates, Access to Uncalibrated Model

NRDC understands that the Commission will use a calibrated model for this study. At this point, NRDC's primary concern is that the model is not using the most recent publicly available data on energy efficiency program expenditure for calibration. To explain, NRDC notes that the model estimates 2018 expenditures between $400 million and $1 billion, while program administrators' reported 2016 expenses are approximately $650 million and their forecasted 2018 budgets are approximately $827 million. NRDC reasons that the "model calibration and forecasts should be aligned with this recent data for the TRC reference scenario since the Program Administrators proposed these budgets based on a cost-effective portfolio under the TRC test."[66]

We confirm that Navigant used budget data from the 2013-2015 program years, due to the lack of a complete 2016 dataset at the time Navigant started the calibration task. However, the use of older budget data does not significantly impact the spending forecasts since expenditures were for the most part in line from 2013 to 2016, at approximately $650 million for resource programs. The way Navigant used expenditures was to check and make sure that the starting point of the forecasting was in line with where the market was (this is the purpose of calibration). Using the 2016 dataset would not have made any material difference, as the past trend was relatively flat.

We further clarify that the 2013-2016 budgets used older avoided cost assumptions and the forecasted scenarios use the 2016 update to the Avoided Cost Calculator. Therefore, we should expect that there is a difference between the forecast and actual spending, as the 2016 update reduced the valuation of benefits. Even though

[66] NRDC opening comments, at 7.

Navigant calibrates to old budgets to make sure the starting point of the forecast was in line with historical levels (to make sure the forecast is realistic), the actual forecast must use the updated avoided cost, which changed the number and type of measures that were cost-effective. The output of costs is a reflection of the new portfolio and should not necessarily be in line with historical spending since, after calibration, the model departs from the past and forecasts the future based on different parameters. Finally, we note that the simulated expenditure for the 2013-2015 period in the model is about $2,061 million (summed across all three years), which is relatively aligned with the $2,247 million that is reported on the Commission's energy efficiency data portal for that same 2013-2015 calibration period.[67]

2.3.3.8. Recommendations Not Within Scope of the Potential and Goals Study Process

2.3.3.8.1. Avoided Cost Calculator updates

CEDMC recommends that the Commission direct Energy Division Staff to update the Avoided Cost Calculator (in the scope of R.14-10-003) as soon as feasible. NAESCO supports CEDMC's recommendation, and further asserts that the Avoided Cost Calculator should "recognize and quantify the meta risks affecting gas price volatility."[68]

Recommendations for modifying either the inputs or the timing of Avoided Cost Calculator updates should be addressed to the Commission in the IDER rulemaking, R.14-10-003 (or a successor proceeding).

2.3.3.8.2. Peak Period Definitions

PG&E recommends that peak savings values be updated to align with the 2016 Avoided Costs peak period assumptions, and not with the definition in the Commission's DEER database. PG&E argues that use of the DEER definition causes a discrepancy

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[67] *See* http://eestats.cpuc.ca.gov/Views/EEDataPortal.aspx.

[68] NAESCO reply comments, at 5.

between measures pursued for cost-effectiveness and those pursued for peak reduction.

The peak definition discrepancy with avoided costs is in the scope of the DEER update, the most recent of which did not occur in time for incorporation into this (post-2017) Potential Study. The next update to the potential and goals study will align peak savings values with the then-current DEER database.

2.3.3.8.3. Alignment of Codes and Standards Evaluation Methods

PG&E, SCE and SoCalGas request that the Potential Study align its Codes and Standards evaluation method with the method used in the 2013-2015 Codes and Standards Impact Evaluation, the final version of which the Commission recently posted to the California Measurement Advisory Council website.[69]

The final draft of the study aligns the Codes and Standards evaluation method with that of the 2013-2015 Codes and Standards Impact Evaluation.

2.3.3.8.4. Commission Policy Regarding Energy Efficiency Incentives for Customers With Self-Generation

SDG&E notes that Commission policy "limits what can be supported by [energy efficiency] programs if the customer has self-generation," suggesting that the potential study account for "the increased market penetration and saturation of solar…and the locational distribution of the corresponding [energy efficiency] potential."[70]

This issue was not raised, and therefore not scoped, during the early stakeholder development process. To the extent the Commission continues the policy of limiting energy efficiency incentives for customers with self-generation, it could be useful and important to account for customer adoption of self-generation technologies. Future

[69] *See* http://calmac.org/default.asp.

[70] SDG&E opening comments, at 5.

updates to the potential and goals study may address this if adequate data and resources are available.

2.3.3.8.5. Non-Resource Related Costs

SoCalGas suggests the usefulness of estimating the full portfolio spending, i.e., inclusive of non-resource costs, in the study's budget projections. However, the Potential Study does not model non-resource interventions, so this change is not within scope of the study.

3. Overview of Energy Savings Goals

Today's decision adopts goals for the IOU territories based on the final draft of the post-2017 Potential Study; the final Potential Study is included in Appendix 1 to this decision. The post-2017 Potential Study period and the goals we adopt cover 13 years, but we expect these goals will be updated with new values by 2020 using the bus stop approach adopted in D.15-10-028.

In general, the goals adopted in this decision update forecasted incremental energy savings that were projected for goals in the post-2015 study and continue the upward trajectory of goals through 2030. The largest source of savings is from codes and standards throughout most of the forecasted period. In addition, in all scenarios, spending levels for resource programs are lower in the short run in some scenarios, but are projected to exceed historical levels in the long run. Finally, as in past potential studies, the commercial sector remains the largest source of savings, but only slightly more than the residential sector for electricity. The residential sector forecasts most savings for gas.

There are at least two issues that are worth noting from this study. First, as stated earlier in this decision, it is apparent that the 2016 update to the Avoided Cost Calculator decreased the cost-effectiveness of traditional energy efficiency programs. Savings from operational, behavioral and retrocommissioning programs appear to compensate for the decrease, however the majority of those savings are expected to come from Home Energy

Reports, which have short-lived savings (i.e., effective useful life is one to two years).[71] The decrease in cost-effectiveness of traditional energy efficiency programs, combined with the relative uncertainty of operational, behavioral and retrocommissioning savings estimates, has important implications for the structure and design of programs going forward.

Second, we also observe that the potential model results have not shown anticipated savings potential in the below-code space. Although the analysis of such savings is still fairly preliminary and more research and data are needed to develop better estimates, we should be prepared to adjust expectations for additional below-code savings to significantly contribute to total energy savings if and as we obtain more and better data.

Finally, we reiterate that the goals we adopt here represent a minimum amount of savings that we expect the program administrators and implementers to achieve. It is important to acknowledge, as the Potential Study does, that the model for estimating energy efficiency potential is just that – a model. The model is necessarily informed by assumptions, which in turn are based on historical cost and savings data. Both the assumptions about costs and savings, as well as actual costs and savings, can continuously be improved upon. We expect the program administrators and implementers to continuously seek to achieve greater savings, cost-effectively, and/or to develop more efficient methods to implement successful energy efficiency programs in

[71] Measure effective useful life, also referred to as expected useful life, is defined as "[a]n estimate of the median number of years that the measures installed under a program are still in place and operable." In Hall et al. (April 2006). *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals {aka Evaluators' Protocols}* Retrieved from California Public Utilities Commission website: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/EE_and_Energy_Savings_Assist/CAEnergyEfficiencyEvaluationProtocols.doc (as of August 4, 2017).

the rolling portfolio framework, in support of the State's clean energy goals and SB 350 in particular.

The following tables show the goals, as adopted in this decision on an annual basis for electricity (GWh), demand (MW) and natural gas usage (MMTherms).

Figure 1. IOU Territory Annual Savings Goals[72]

Table 1. Annual gWh

	Pacific Gas and Electric Company (PG&E)			Southern California Edison Company (SCE)			San Diego Gas & Electric Company (SDG&E)		
Year	**Incentive Programs**	**Codes & Standards**	**Total**	**Incentive Programs**	**Codes & Standards**	**Total**	**Incentive Programs**	**Codes & Standards**	**Total**
2018	448	535	983	409	552	961	76	125	201
2019	524	555	1,079	442	572	1,014	90	130	220
2020	517	559	1,076	451	577	1,028	94	131	225
2021	558	576	1,134	477	594	1,071	107	135	242
2022	568	560	1,128	494	578	1,072	115	131	246
2023	576	621	1,197	517	640	1,157	124	145	269
2024	588	595	1,183	562	613	1,175	134	139	273
2025	605	573	1,178	583	591	1,174	145	134	279
2026	614	538	1,152	597	554	1,151	152	126	278
2027	623	518	1,141	615	534	1,149	159	121	280
2028	637	471	1,108	631	486	1,117	167	110	277
2029	651	426	1,077	646	440	1,086	172	100	272
2030	668	381	1,049	653	393	1,046	177	89	266

72 Incentive programs include rebate programs; operational, behavioral and retrocomissioning, and low income estimates. The Potential Study (Appendix 1) and Excel-based Results Viewer (http://www.cpuc.ca.gov/General.aspx?id=6442452619) provide a more detailed breakout of savings estimates.

Table 2. Annual MW

	Pacific Gas and Electric Company (PG&E)			Southern California Edison Company (SCE)			San Diego Gas & Electric Company (SDG&E)		
Year	**Incentive Programs**	**Codes & Standards**	**Total**	**Incentive Programs**	**Codes & Standards**	**Total**	**Incentive Programs**	**Codes & Standards**	**Total**
2018	84	120	204	82	124	206	16	28	44
2019	100	122	222	91	125	216	19	28	47
2020	97	137	234	92	142	234	19	32	51
2021	106	163	269	100	168	268	22	38	60
2022	108	158	266	104	163	267	23	37	60
2023	110	194	304	110	200	310	25	45	70
2024	112	186	298	118	192	310	27	44	71
2025	116	180	296	124	186	310	29	42	71
2026	117	173	290	127	178	305	31	41	72
2027	119	169	288	131	174	305	32	40	72
2028	122	160	282	135	165	300	34	37	71
2029	125	152	277	138	157	295	34	36	70
2030	128	145	273	140	149	289	35	34	69

Table 3. Annual MMTherms

	Pacific Gas and Electric Company (PG&E)			Southern California Gas Company (SoCalGas)			San Diego Gas & Electric Company (SDG&E)		
Year	**Incentive Programs**	**Codes & Standards**	**Total**	**Incentive Programs**	**Codes & Standards**	**Total**	**Incentive Programs**	**Codes & Standards**	**Total**
2018	17	14	31	20	26	46	1.7	1.6	3.3
2019	19	14	33	22	26	48	2	1.6	3.6
2020	18	17	35	24	30	54	2.1	2	4.1
2021	20	20	40	26	34	60	2.3	2.2	4.5
2022	23	20	43	26	33	59	2.4	2.2	4.6
2023	24	20	44	30	33	63	2.8	2.3	5.1
2024	24	20	44	29	33	62	2.8	2.2	5
2025	24	20	44	29	32	61	3	2.2	5.2
2026	24	15	39	28	25	53	3	1.7	4.7
2027	24	13	37	27	22	49	3.2	1.5	4.7
2028	25	13	38	27	22	49	3.3	1.5	4.8
2029	25	13	38	27	21	48	3.4	1.4	4.8
2030	26	13	39	28	21	49	3.6	1.5	5.1

4. Conclusion

It is reasonable to adopt realistic, "aggressive yet achievable" energy efficiency goals for 2018 – 2030 based on the available market potential, as set forth in Figure 1 of this decision. This level of market potential is in turn based on an assessment of economic potential using the TRC test, the 2016 update to the Avoided Cost Calculator and a GHG adder that reflects the CARB Cap-and-Trade APCR Price.

It is also reasonable to defer adoption of cumulative savings goals until Staff can assess the viability of using the method, to be developed by the CEC, for calculating persistence decay.

5. Comments on Proposed Decision

The proposed decision in this matter was mailed to the service list of R.13-11-005 in accordance with Section 311 of the Public Utilities Code and comments were allowed pursuant to Rule 14.3 of the Commission's Rules of Practice and Procedure. On September 14, 2017, the following parties filed comments: CEDMC, NRDC, ORA, SCE, SDG&E on PG&E's and its own behalf, SoCalGas, and SoCalREN. On September 19, 2017, SoCalGas filed reply comments.

CEDMC recommends the Commission reconsider the proposed energy savings goals, on the basis that more aggressive action is needed immediately in order to provide notice to the market, to achieve greater benefits, and to achieve the state's doubling goals. For the reasons discussed in Section 2.3.1.2, we do not reconsider the energy savings goals presented in the proposed decision.

NRDC requests that we modify the proposed decision to clarify its desire to ensure that the most up to date program data are applied for calibration, not to reiterate its original request for an uncalibrated model at this stage of the study. As written, our discussion of this issue implies that we understood NRDC's request to be in reference to the next potential and goals update. NRDC's comments on the proposed decision clarify that its main interest is for the data used in calibration to be the most current data. This decision incorporates NRDC's requested modifications. NRDC also includes several recommendations for the next potential and goals update, which we will not address here but refer to Commission Staff who oversee the potential and goals study process.

ORA recommends we modify language in Section 1.2 to reflect the Commission's adoption of D.17-08-022, which approved an interim GHG adder based on the Cap-and-Trade APCR Price. Although we do not incorporate ORA's specific recommended modification, we clarify that we acknowledge the Commission's adoption of D.17-08-022.

ORA also expresses approval that "the [proposed decision] has chosen to adopt" ORA and TURN's recommendation regarding metrics for net lifecycle savings, to which SoCalGas responds that the proposed decision "does not indicate any adoption of such recommendation." SoCalGas is correct. Substantive arguments regarding whether to adopt ORA and TURN's recommendation regarding metrics for net lifecycle savings should remain in A.17-01-013 et al.

All four IOUs recommend a modification to the proposed decision's direction for utilities to file a Tier 1 advice letter describing their plans to collect and submit data for developing market potential estimates for the Public sector. Instead, the IOUs recommend that Energy Division Staff include Public sector data collection in the plan for the next potential and goals update. This change would clarify that Commission Staff would continue its oversight role of such data collection, planning and reporting, and would involve the CEC in such planning as appropriate, consistent with Energy Division's existing EM&V and reporting frameworks. We agree this is appropriate and have modified this decision accordingly.

SoCalREN recommends the Commission specify that the IOUs should and must coordinate with their regional program administrators in developing plans to collect and submit data necessary to develop estimates of Public sector market potential. In clarifying that Energy Division Staff must include Public sector data collection in the next potential and goals update, we make clear that all interested stakeholders will have an opportunity, through the Demand Analysis Working Group, to participate in this effort. We welcome and expect all program administrators' participation in the development of future potential and goals updates.

SCE recommends the Commission modify the proposed decision to re-evaluate the timing for future potential and goals studies within six months of issuing its decision on the business plan applications. We reiterate that the study development process for potential and goals must meet the needs of several critical State policy objectives, perhaps most importantly the CEC's demand forecasting and, increasingly in the future, the Commission's Integrated Resources Planning proceeding. Separately and more generally, the Commission adopted a bus-stop approach (for the rolling portfolio framework) in part to address issues of timing mismatches between updated evaluations/information and program implementation. SCE's recommendation implicates a significant change to our adopted bus-stop approach, which we are not inclined to address in this decision.

SDG&E and PG&E recommend the Commission confirm that adoption of the 2018-2030 goals should not require the program administrators to update or supplement their September 1, 2017 budget advice letters to reflect the new goals. Instead, SDG&E and PG&E suggest, reflection of the new goals should be done through the true-up advice letter outlined in the June 9, 2017 ruling in A.17-01-013 et al. The program administrators should reflect the goals contained in this decision in their next budget advice letter filing, whether that be a re-filing of their September 1, 2017 submissions, if so directed to be re-filed by Energy Division, or a true-up as indicated in the June 9, 2017 ruling in A.17-01-013 et al.

SoCalGas requests that the Commission allow program administrators to meet the new goals over a period of time "in order to accommodate the transition into the rolling portfolio framework, and file a new business plan application to propose new strategies and seek additional funding," noting a need to "ramp up" their portfolios to meet the new goals. The need for adjusting portfolios to account for updated goals is not unique to the rolling portfolio framework and indeed was a common feature of the previous, triennial cycle, framework. Our preference is for the program administrators to reflect updated goals, as adopted; therefore, we are not inclined to entertain SoCalGas's request. If there is a substantial gap between goals and performance in a given year, program administrators should document the main reasons for such discrepancies in program evaluations.

SoCalGas also recommends further revisions to the potential and goals study, specifically regarding the assumptions for its behavioral programs and for Industry Standard Practice baselines. We agree with SoCalGas's proposed percent incremental penetration for its behavioral programs, and Staff has adjusted the potential and goals study accordingly. However, insufficient time does not allow Staff and Navigant to perform due diligence on SoCalGas's proposed penetration rate adjustments for the Industrial and Agricultural generic custom savings potential.

SoCalGas also recommends the Commission delete Conclusion of Law 6, which states that Staff should consider the data and modeling needed to develop estimates specific to non-IOU program administrators' service areas. SoCalGas asserts the Commission must first "complete the evaluation of REN pilots" before considering data and modeling resources for city-, county-, or other jurisdiction-level savings potential. The Commission is considering three regional energy network business plan applications in A.17-01-013 et al. We will not prejudge the outcome of those applications but will modify Conclusion of Law 6 to state more broadly that Staff should consider the data and modeling needs to develop estimates applicable to all energy efficiency program administrators.

6. Assignment of Proceeding

Carla J. Peterman is the assigned Commissioner and Julie A. Fitch and Valerie U. Kao are the assigned ALJs in this proceeding.

Findings of Fact

1. The energy savings goals in Section 3 are aggressive yet achievable.
2. The Commission has determined it is reasonable to set energy efficiency goals based on market potential in past decisions. No party raises an issue with using market potential as opposed to economic or technical potential.
3. The current Avoided Cost Calculator does not reflect the costs of the 2030 GHG targets adopted in SB 32.
4. Without the revised costs of the new GHG targets taken into account in the Avoided Cost Calculator, the Potential Study and subsequent energy efficiency goals will be less accurate.
5. The Cap-and-Trade APCR Price represents the highest cost of compliance with California's cap and trade requirements.

6. The values derived from the interim use of the Cap-and-Trade APCR Price in the Avoided Cost Calculator more accurately inform the Potential Study than the current Avoided Cost Calculator.

7. The values derived from the interim use of the Cap-and-Trade APCR Price in the Avoided Cost Calculator allow the Commission to adopt timely energy efficiency goals better aligned with SB 32 than the current Avoided Cost Calculator.

8. The post-2017 Potential Study includes five scenarios that reflect different cost-effectiveness and participation assumptions, in order to present a reasonable range of energy efficiency potential from which to determine goals.

9. The "mTRC (GHG Adder #1) Reference" scenario includes a GHG adder proposed by parties in the IDER proceeding, R.14-10-003. This adder is based on the CARB Cap-and-Trade APCR price.

10. D.16-06-007 states that "[a] single avoided cost model should apply to all distributed energy resource proceedings."

11. D.17-08-022 adopted an interim GHG adder in R.14-10-003, based on the Cap-and-Trade APCR price.

12. D.16-08-019 finds that future potential and goals studies (beginning with this post-2017 study) should incorporate cumulative goals in addition to annual goals.

13. D.16-08-019 requests Commission staff and consultants, in coordination with the CEC, through the Joint Agency Steering Committee and the Demand Analysis Working Group, to update the methodology used to develop cumulative goals.

14. A reliable method for developing cumulative goals has not been developed.

15. CEC will need to develop a method for calculating decay as part of its SB 350 target-setting responsibilities.

16. The post-2017 Potential Study does not include energy efficiency potential estimates specific to non-investor owned utility program administrators' service areas. Further data and modeling resources are required to develop energy efficiency potential

estimates at the city, county or other jurisdiction level. These resources were not included early enough in the development of the post-2017 Potential Study.

17. The post-2017 Potential Study does not include energy efficiency potential estimates for the Public sector. Further data is needed to develop energy efficiency potential estimates for the Public sector. The necessary data collection task was not included early enough in the development of the post-2017 Potential Study.

18. The Commission adopted D.16-11-022, which requires a low-income potential analysis, after Navigant had completed its work for the post-2017 Potential Study.

19. The budget data used to forecast program expenditures in the post-2017 Potential Study are valid.

20. The most recent update to DEER will not be approved in time for incorporation to the post-2017 Potential Study. The next update to the potential and goals study will align peak savings values with the then-current DEER values, as provided by the bus stop approach adopted in D.15-10-028.

Conclusion of Law

1. Public Utilities Code Sections 454.55 and 454.56 require the Commission, in consultation with the CEC, to identify all potential achievable cost-effective electricity and natural gas efficiency savings and "establish efficiency targets" for electrical or gas corporations to achieve.

2. One of our statutory obligations is setting savings "targets," i.e., goals, for program administrators.

3. It is reasonable to establish goals that are "aggressive yet achievable," and that reflect an accurate estimation of energy efficiency cost-effectiveness.

4. It is reasonable to adopt energy efficiency goals for 2018 – 2030 based on the "mTRC (GHG Adder #1) Reference" scenario in the final draft of the post-2017 Potential Study.

5. It is reasonable to defer adoption of cumulative savings goals until Commission Staff can assess the viability of using the method for calculating persistence decay, to be developed by the CEC.

6. Commission Staff should consider the data and modeling resources needed to develop energy efficiency potential estimates applicable to all program administrators' service areas in future potential and goals studies.

7. Energy Division should oversee efforts to collect and submit the data needed to develop energy efficiency potential estimates for the Public sector for future potential and goals studies through the EM&V process.

8. Future potential and goals studies should include a low-income potential analysis, as required by D.16-11-022.

O R D E R

IT IS ORDERED that:

1. We adopt energy efficiency goals for 2018 and beyond based on the modified Total Resource Cost with a greenhouse gas adder that reflects the State's 2030 greenhouse gas reduction goals, referred to as the "mTRC (GHG Adder #1) Reference" scenario in the final draft of the post-2017 Potential Study.

2. We defer adoption of cumulative goals until Staff can assess the feasibility of using the method for estimating cumulative savings to be developed by the California Energy Commission as part of its energy efficiency doubling target-setting responsibilities.

3. The Energy Division will include Public sector data collection in the 2018 EM&V Plan to support the potential and goals study update. This effort will be funded through EM&V funds.

4. Rulemaking 13-11-005 remains open.

This order is effective today.

Dated September 28, 2017, at Chula Vista, California.

MICHAEL PICKER
President
CARLA J. PETERMAN
LIANE M. RANDOLPH
MARTHA GUZMAN ACEVES
CLIFFORD RECHTSCHAFFEN
Commissioners

APPENDIX 1

Energy Efficiency Potential and Goals Study for 2018 and Beyond

NAVIGANT

Energy Efficiency Potential and Goals Study for 2018 and Beyond

Final Public Report

Prepared for:

California Public Utilities Commission

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September 25, 2017

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Special thanks are due to the staff of California Public Utilities Commission and the many stakeholders for providing direction, guidance, insight, and data throughout the conduct of this study.

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DISCLAIMER

This report was prepared by Navigant Consulting, Inc. (Navigant) for the California Public Utilities Commission. The work presented in this report represents Navigant's professional judgment based on the information available at the time this report was prepared. Navigant is not responsible for the reader's use of, or reliance upon, the report, nor any decisions based on the report. NAVIGANT MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESSED OR IMPLIED. Readers of the report are advised that they assume all liabilities incurred by them, or third parties, as a result of their reliance on the report, or the data, information, findings and opinions contained in the report.

EXECUTIVE SUMMARY

Background

Navigant Consulting, Inc. along with its partners Tierra Resource Consultants LLC (collectively known as "the Navigant team") prepared this study ("2018 and Beyond Potential and Goals 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-2017 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) collectively referred to as investor owned utilities or IOUs. A key component of the 2018 Potential and Goals Study (2018 Study) is the Potential and Goals Model (PG Model), which provides a single platform in which to conduct quantitative scenario analysis that reflects the complex interactions among various inputs and policy drivers.

A significant number of recent policy changes in California are driving updates to the approach and methodology of the 2018 Study. These policy drivers include:

- **California Assembly Bill 802 (AB802)** - AB802 allows and incentivizes all energy savings (including those that are "below-code").[1] Furthermore, AB802 instructs energy efficiency be achieved not only though equipment installations but also through behavior and operational efficiency interventions.
- **California Senate Bill 350 (SB350)** - SB350 mandates a doubling of statewide energy efficiency savings in electricity and natural gas end uses by 2030 and that the goals not be constrained based on past EE program performance.
- **CPUC Cost Effectiveness Tests and Inputs Updates** - Multiple changes have been or are being considered though the Integrated Distributed Energy Resources (IDER) proceeding (R. 14-10-003). The CPUC has been considering the application of the California Standard Practice Manual tests for distributed energy resource needs including the use of a greenhouse gas (GHG) adder to be incorporated into the current avoided costs.[2]
- **CPUC Net Goals Direction** – The CPUC directed 2018 and beyond goals to be set net of free-ridership due to changes in baseline policy.[3]

The 2018 Study supports a number of objectives:

1. Informs the CPUC as it proceeds to adopt EE savings goals and targets, providing guidance for the next IOU EE program portfolios;

[1] "Below code" is synonymous with "to code" throughout this document. They can be used interchangeably.

[2] SCT staff proposal (http://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=173203676); GHG adder (http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M182/K363/182363230.PDF)

[3] Decision 16-08-019 (http://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=166232537)

2. Guides 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);
3. Informs strategic contributions to SB350 targets. The CEC has historically used the PG study to develop its forecast of Additional Achievable Energy Efficiency Potential (AAEE; SB350 requires doubling AAEE by 2030. The CEC will continue to rely upon the PG study as an input to AAEE; the PG study will also serve as an input to SB350 target setting; and
4. Identifies new EE savings opportunities under the guise of AB802.

The 2018 Study period spans from 2018-2030 based on the direction provided by CPUC and focuses on current and potential drivers of energy savings in IOU service areas. Analysis of energy efficiency savings in publicly owned utility service territories is not part of the scope of this effort.

Consistent with previous CPUC potential studies and consistent with common industry practice, the 2018 Study forecasts EE potential at three levels for rebate programs:

1. **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.
2. **Economic Potential:** Drawing from technical potential analysis, economic potential represents total EE potential available when limited to only cost effective measures.[4] All components of economic potential are a subset of technical potential.
3. **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.
    a. **Stranded Potential** is a subset of the Market Potential that was added to the 2018 Study to accommodate AB802. These savings are defined as the opportunities for EE that have not historically been captured by either EE program administrator (PA) rebate programs or codes and standards. Stranded Potential is below-code savings to AB802 that is not materializing in the market because there are no incentives for customers to upgrade their existing equipment given current program rebate policies.

This 2018 Study forecasts the potential energy savings from various EE programs as well as codes and standards advocacy efforts for the following customer sectors: Residential, Commercial, Agricultural, Industrial, Mining, and Street Lighting. The 2018 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 Navigant team engaged with stakeholders through the Demand Analysis Working Group[5] (DAWG) over the course of the 2018 Study to obtain data and incorporate feedback on scope, methodology, key assumptions, and interim results.

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[4] The default assumption for this study includes all non-emerging technologies with a TRC test threshold of 0.85; emerging technologies are included if they meet a TRC test threshold of 0.5 in a given year and also achieved a TRC test equivalent to the 0.85 threshold for non-emerging technologies within ten years of market introduction.

[5] http://demandanalysisworkinggroup.org/

Scenarios

In previous CPUC potential studies, a single forecast of EE potential was developed and used by policymakers to establish IOU goals. In these past studies, alternate scenarios were developed and passed along to the CEC to inform its load forecasting efforts. These scenarios were developed after the CPUC had established goals and were primarily driven by the needs of the CEC. The 2018 PG study considers multiple scenarios to explore how EE potential might change based on a number of alternative assumptions about policies, measures and market response.

SB350 directs the CPUC to adopt goals based on EE potential studies that are not restricted by previously accomplished EE program savings. Commission staff proposed to meet this direction by exploring scenarios reflecting alternative future outcomes based on variables that can be controlled by policy decisions or program influence. This study considers scenarios primarily built around policies and program decisions that are within the sphere of influence of the CPUC and IOUs collectively.

Commission staff and Navigant, with input from stakeholders, developed scenarios to determine alternative estimates of market potential based on the following considerations:

- Cost-effectiveness test: The Total Resource Cost (TRC) test, which considers costs incurred by both participants and program administrators and the Program Administrator Cost (PAC) test, which considers only those costs incurred by program administrators to deliver the various EE programs and measures relative to the monetary benefits of those programs and measures derived from traditional avoided costs, is the threshold test for determining market potential.
- Avoided costs: Two sets of greenhouse gas (GHG) abatement prices proposed under the IDER proceeding that account for the cost of achieving 2030 GHG targets are used as a modifier to the Total Resource Cost (TRC) test.
- Program engagement: Aggressive approaches to EE program engagement that include increases to the incentives paid to customers, enhanced marketing and outreach efforts, and innovative financing approaches are used to modify the rates of customer adoption.

Commission staff's intent was to keep the number of scenarios manageable but still provide a range of alternatives to bound the estimates of market potential. Therefore, one "business as usual" scenario and four alternative scenarios were developed and are listed in the table below.

Table ES- 1. Scenarios for Energy Efficiency Market Potential

Scenario	Cost Effectiveness Screen	Program Engagement
1: TRC | Reference	TRC test using 2016 Avoided Costs	Reference
2: mTRC (GHG Adder #1) | Reference	TRC test using 2016 Avoided Costs + IOU proposed GHG Adder	Reference
3: mTRC (GHG Adder #2) | Reference	TRC test using 2016 Avoided Costs + Commission staff proposed GHG Adder	Reference
4: PAC | Reference	PAC test using 2016 Avoided Costs	Reference
5: PAC | Aggressive	PAC test using 2016 Avoided Costs	Aggressive

The Scenario 1 (TRC Reference) represents "business as usual" and the continuation of current policies. Three of the alternate scenarios continue to assume the same program engagement strategies as the reference scenario but apply different cost effectiveness tests and avoided costs. The final Scenario 5 (PAC Aggressive) is meant to show an upper bound of the combination of program engagement and cost-effectiveness screens and can be used to compare against SB350 targets.

More information about the scenarios can be found in Section 4.1.

Results

Total Market Potential

Figure ES-1 and Figure ES-2 show the total market potential over time for electric and gas measures, respectively. Table ES-2 and Table ES-3 summarize the magnitude of the market potential for two points in time – 2018 and 2030. The figures illustrate the magnitude of market potential for each type of EE program delivery approach for each of the five scenarios.[6] A few important notes about these results:

- Equipment Rebate program savings[7] are different for each scenario based on parameters shown earlier in Table ES-1.
- Behavior, Retrocommissioning and Operational (BROs) savings, a subset of rebate programs, vary only in terms of Reference vs. Aggressive. Thus, four of the five scenarios have identical BROs savings. BROs savings do not vary by cost effectiveness screen in our model. The reference scenario is dominated by savings from residential home energy reports (HERs). Additional high impact interventions after HERS include web-based real time feedback, strategic energy management, retrocommissioning, and Building Energy Information Management Systems (BEIMs). HERS dominates savings as it is one of the largest, most well-studied existing interventions with reliable data upon which to base a forecast. Savings from all interventions increase over time as we expect enrollment in programs to gradually increase. The Aggressive BROs variation includes interventions less studied or not yet implemented in California but with conceivable savings potential.
- Codes and standards (C&S) and Low Income savings do not vary by scenario.

Total savings are dominated 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 and BROs programs. Results in tabular form for each year are available in Section 4.

Some notable takeaways from this study include:

- For Equipment Rebate programs, the savings appear to increase for each alternative scenario relative to the business as usual. This reflects the fact that more measures pass the economic screen as quantification of additional benefits (e.g. an interim GHG adder) are applied, cost-effectiveness tests are changed, and aggressive programmatic interventions are introduced.

[6] Note that this study categorizes the following EE program areas: (1) Rebates; (2) Behavior, Retro-commissioning and Operational Efficiency (BROs); (3) Low Income (LI); and (4) Codes and Standards (C&S). The first three program categories (Equipment Rebates, BROs, and LI) are bundled into a broader category referred to as *Incentive Programs*.

[7] Equipment rebate program savings include savings from discrete equipment, whole building and shell measures.

- For BROs programs, the growth in savings for each of the scenarios increases over time reflecting greater market adoption as incentives increase and consumers become more aware of such programs leading to higher levels of customer uptake. In 2030, savings in the BROs aggressive scenario is just short of a doubling of the BROs reference scenario.
- For Incentive programs (Equipment Rebates, BROs and Low Income), all three variations of the TRC test as represented in scenarios 1, 2 and 3 provide more savings per $ spent for both gas and electric savings than the PAC test in scenarios 4 and 5. This is because as the cost effectiveness threshold becomes less strict, more expensive measures are included in the portfolio. Thus, we generally observe diminishing returns on program investment when comparing PAC based scenarios to TRC based scenarios. Specifically:
    - For Scenario 4 (PAC Reference), while the 2030 expenditures increase by 36% compared with Scenario 1 (TRC Reference), the 2030 incremental incentive program savings only increase by 9% and 14% for electric and gas respectively.
    - For Scenario 2 (mTRC w/ GHG adder 1) and Scenario 3 (mTRC w/ GHG adder 2), 2030 expenditures increase by 7% and 32% respectively relative to Scenario 1 (TRC Reference), while incremental incentive program savings increase by 1.5% and 7% for electric, and 4% and 16% for gas.
- In comparison to the 2015 study (see section 5 for details), even though Equipment Rebate programs alone represent a drop from 2015, after adding BROs and Low Income program savings in, the results are at par or higher than the 2015 study results (depending on the scenario used). C&S savings are higher than in the 2015 study due to more standards being considered.
- By 2030, under Scenario 1 (TRC Reference), AB802 Stranded Potential and BROs interventions are expected to contribute about 42% of electric incentive program savings and 43% of gas incentive program savings, with most that coming from BROs measures.
- For C&S programs, savings remain constant during the early years of the potential study time horizon but eventually drop off as greater numbers of consumers naturally adopt codes and standards and fewer codes and standards are modeled because they are not yet “on the books.”

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

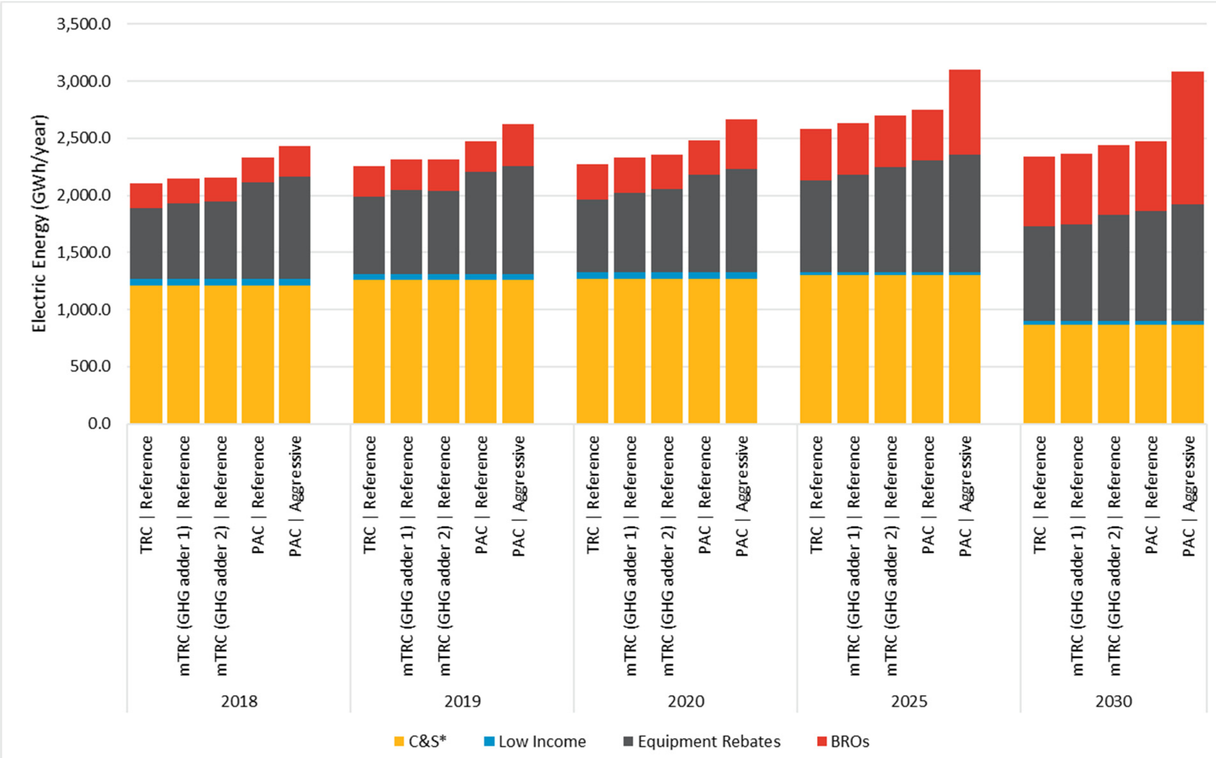


Table ES- 2. Statewide Net Incremental Electric Savings by Scenario

Electric Energy (GWh/year)										
Year:	**2018**	**2030**	**2018**	**2030**	**2018**	**2030**	**2018**	**2030**	**2018**	**2030**
Program Type	**Scenario 1: TRC Reference**		**Scenario 2: mTRC w/ GHG adder 1**		**Scenario 3: mTRC w/ GHG adder 2**		**Scenario 4: PAC Reference**		**Scenario 5: PAC Aggressive**	
Equipment Rebates	622	830	663	853	676	931	848	966	896	1,027
BROs	213	613	213	613	213	613	213	613	264	1,164
Low Income	57	33	57	33	57	33	57	33	57	33
Incentive Programs (Subtotal)	***893***	***1,476***	***933***	***1,498***	***946***	***1,577***	***1,118***	***1,611***	***1,217***	***2,224***
C&S*	1,212	864	1,212	864	1,212	864	1,212	864	1,212	864
Grand Total	**2,104**	**2,340**	**2,145**	**2,362**	**2,157**	**2,441**	**2,330**	**2,476**	**2,429**	**3,088**

*includes interactive effects

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

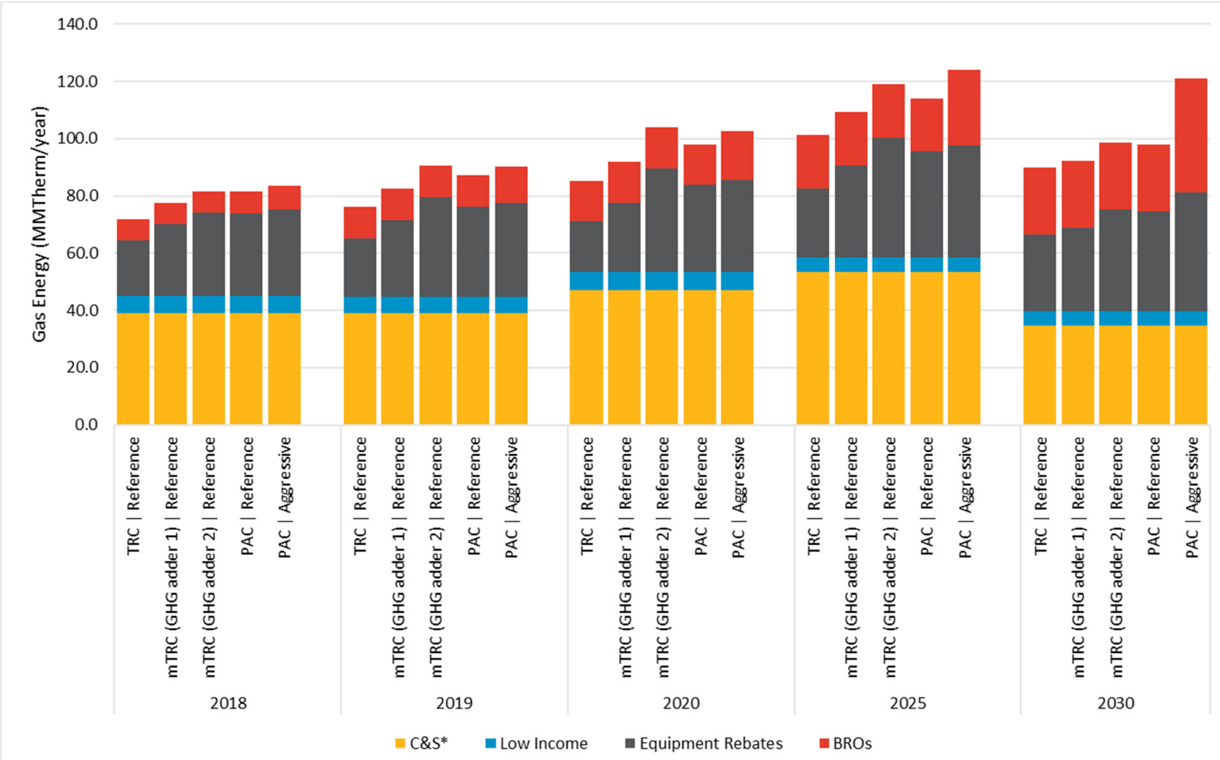


Table ES- 3. Statewide Net Incremental Gas Savings by Scenario

Gas Energy (MMTherm/year)										
Year:	**2018**	**2030**	**2018**	**2030**	**2018**	**2030**	**2018**	**2030**	**2018**	**2030**
Program Type	**Scenario 1: TRC Reference**		**Scenario 2: mTRC w/ GHG adder 1**		**Scenario 3: mTRC w/ GHG adder 2**		**Scenario 4: PAC Reference**		**Scenario 5: PAC Aggressive**	
Equipment Rebates	20	27	25	29	29	36	29	35	30	41
BROs	7	23	7	23	7	23	7	23	8	40
Low Income	6	5	6	5	6	5	6	5	6	5
Incentive Programs (Subtotal)	***33***	***55***	***38***	***58***	***42***	***64***	***42***	***63***	***44***	***87***
C&S*	39	35	39	35	39	35	39	35	39	35
Grand Total	**72**	**90**	**78**	**92**	**82**	**99**	**81**	**98**	**84**	**121**

*includes interactive effects

Market Potential as a Percent of Sales

Figure ES-3 and Figure ES-4 illustrate the market potential savings for incentive programs (Equipment Rebates, BROs and LI) as a percent of IOU sales for electric and gas, respectively. Table ES-4 and Table ES-5 report the year-by-year percentage reductions for each of the five scenarios for electric and gas, respectively. Savings as a percent of sales is a common metric provided in many potential studies. The percent savings serves as a useful benchmark when comparing market potentials to other jurisdictions and previous potential studies. It should be noted that savings from C&S were excluded from these calculations as per industry standard practice. The calculation uses net savings.

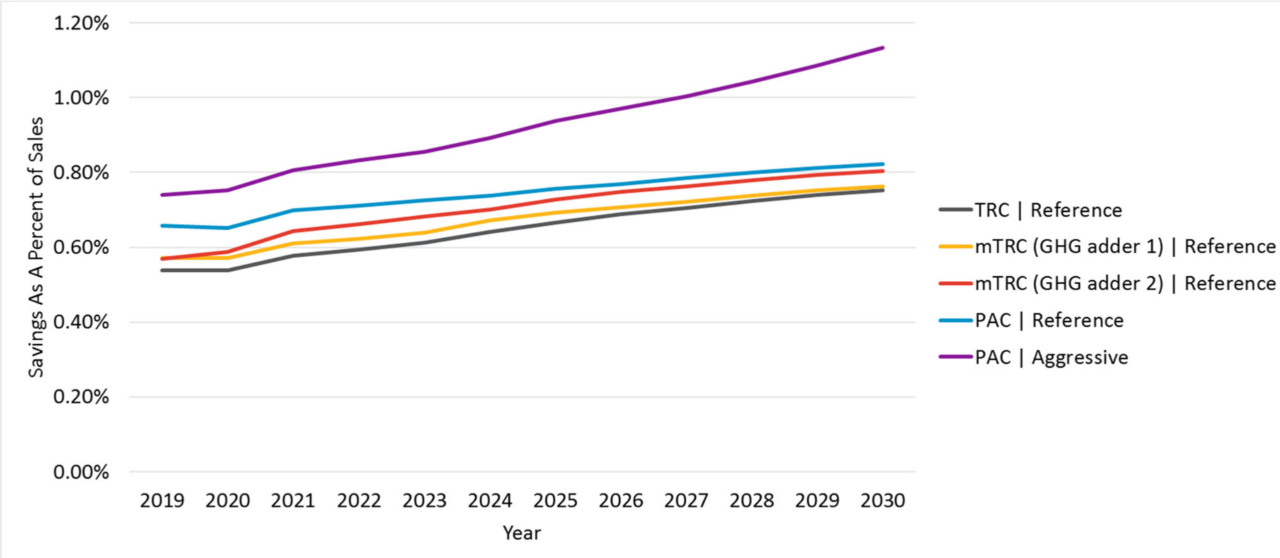
The following observations are noted for the electric results:

- Net market potential savings as a percentage of forecasted electric energy usage grows from 0.48% to 0.75% between 2018 and 2030 under Scenario 1 (TRC Reference). Under the most optimistic case, market potential grows from 0.66% in 2018 to 1.13% by 2030 under Scenario 5 (PAC Aggressive).
- Electric potential increases as the cost test used to screen measures accounts for additional benefits (addition of GHG abatement costs) or does not account for customer costs (PAC), with the TRC test yielding the least potential and the PAC test yielding the most potential. By 2030, Scenario 4 (PAC Reference) produces about 9% more electric savings than Scenario 1 (TRC Reference).
- Further, the electric results show that aggressive program engagement in the form of financing as well as increased marketing and incentives can yield additional savings beyond current program engagement as illustrated under Scenario 5 (PAC Aggressive), which produces about 38% more electric savings than Scenario 5 (PAC Reference).
- Finally, Scenario 5 (PAC Aggressive) produces about 51% more electric savings than Scenario 1 (TRC Reference).

The following observations are noted for the gas results:

- Market potential as a percentage of forecasted gas energy usage generally increases as the cost test used to screen measures becomes less stringent.
- For gas incentive program savings, Scenario 5 (PAC Aggressive) and Scenario 3 (mTRC w/ GHG adder 2) are roughly on par until 2023. This is because the GHG adder, which is high in Scenario 3, is applied uniformly to all gas measures. On the other hand, the impact of the adder on electric measures is loadshape-dependent, which means the benefits of the GHG adder vary by time of day and season. Beyond 2023, Scenario 5 starts to yield the highest gas potential as BROs participation starts to ramp up in the Aggressive scenario.
- By 2030, Scenario 3 (mTRC w/ GHG adder 2) produces about 16% more gas savings than Scenario 1 (TRC Reference).
- Another noteworthy trend for the gas results is that Scenario 5 (PAC Aggressive) surpasses Scenario 4 (PAC Reference) by about 36% at the end of the forecast period. This is attributable to aggressive program engagement. Overall, Scenario 5 (PAC Aggressive) produces about 56% more gas savings relative to Scenario 1 (TRC Reference) by 2030.

Figure ES-3. Incremental Net Electric Market Potential as a Percent of Sales

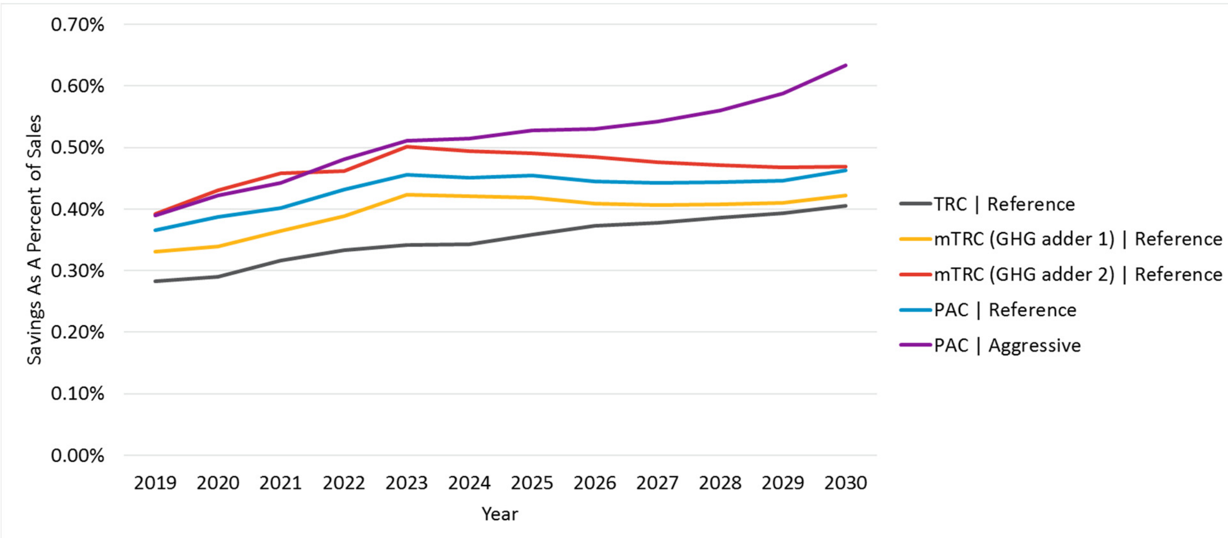


Note: Excludes C&S

Table ES- 4. Incremental Net Electric Market Potential as a Percent of Sales

Year	Scenario 1: TRC Reference	Scenario 2: mTRC w/ GHG adder 1	Scenario 3: mTRC w/ GHG adder 2	Scenario 4: PAC Reference	Scenario 5: PAC Aggressive
2018	0.48%	0.51%	0.51%	0.61%	0.66%
2019	0.54%	0.57%	0.57%	0.66%	0.74%
2020	0.54%	0.57%	0.59%	0.65%	0.75%
2021	0.58%	0.61%	0.64%	0.70%	0.81%
2022	0.59%	0.62%	0.66%	0.71%	0.83%
2023	0.61%	0.64%	0.68%	0.73%	0.86%
2024	0.64%	0.67%	0.70%	0.74%	0.89%
2025	0.67%	0.69%	0.73%	0.76%	0.94%
2026	0.69%	0.71%	0.75%	0.77%	0.97%
2027	0.71%	0.72%	0.76%	0.79%	1.00%
2028	0.72%	0.74%	0.78%	0.80%	1.04%
2029	0.74%	0.75%	0.79%	0.81%	1.09%
2030	0.75%	0.76%	0.80%	0.82%	1.13%

Figure ES-4. Incremental Net Gas Market Potential as a Percent of Sales



Note: Excludes C&S

Table ES- 5. Incremental Net Gas Market Potential as a Percent of Sales

Year	Scenario 1: TRC Reference	Scenario 2: mTRC w/ GHG adder 1	Scenario 3: mTRC w/ GHG adder 2	Scenario 4: PAC Reference	Scenario 5: PAC Aggressive
2018	0.25%	0.29%	0.32%	0.32%	0.34%
2019	0.28%	0.33%	0.39%	0.37%	0.39%
2020	0.29%	0.34%	0.43%	0.39%	0.42%
2021	0.32%	0.36%	0.46%	0.40%	0.44%
2022	0.33%	0.39%	0.46%	0.43%	0.48%
2023	0.34%	0.42%	0.50%	0.46%	0.51%
2024	0.34%	0.42%	0.49%	0.45%	0.51%
2025	0.36%	0.42%	0.49%	0.45%	0.53%
2026	0.37%	0.41%	0.48%	0.45%	0.53%
2027	0.38%	0.41%	0.48%	0.44%	0.54%
2028	0.39%	0.41%	0.47%	0.44%	0.56%
2029	0.39%	0.41%	0.47%	0.45%	0.59%
2030	0.41%	0.42%	0.47%	0.46%	0.63%

Market Potential by Sector

Figure ES-5 and Table ES-6 illustrates the electric market potential savings for incentive programs (Equipment Rebates, BROs and LI) separated for each of the six sectors assessed in this study (Residential, Commercial, Industrial, Agricultural, Mining, and Streetlighting). Figure ES-6 and Table ES-7 provides the comparable information for the gas market potential savings. Savings represented by sector helps to inform the magnitude of potential for each of the sectors. It should be noted that savings from C&S were excluded from these calculations. The rationale for the exclusion was that the CPUC adopts separate goals for C&S. Note further that the sector-specific results are only shown for Scenario 1 (TRC Reference). The rationale for reporting on only one scenario is that while the magnitude of savings for the other four scenarios differ, the relative share of savings across the various sectors does not vary significantly. Sector-level results for all scenarios are provided in section 4.

The following observations are noted about the electric results:

- As can be seen in the chart and table, the commercial and residential sector dominate the savings with the commercial 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 sectoral growth but also reflects greater levels of market uptake for BROs in the later years.
- Conversely, the incremental savings potential declines for the industrial, mining and streetlighting sectors. For industrial and mining, this savings decline is highly correlated with flat or negative customer growth rates during the time horizon. For streetlighting, the market potential for high efficiency measures becomes more saturated over time.

The following observations are noted about the gas results:

- The largest savings potential comes from the residential sector, with smaller savings for industrial and commercial, and minimal savings for the agricultural and mining sectors.
- Yearly savings potential for all sectors grows modestly over time with much of the growth coming from higher levels of market uptake for BROs in the outer years.

Figure ES- 5. Statewide Net Incremental Electric Market Potential for Incentive Programs by Sector for the TRC Reference Scenario

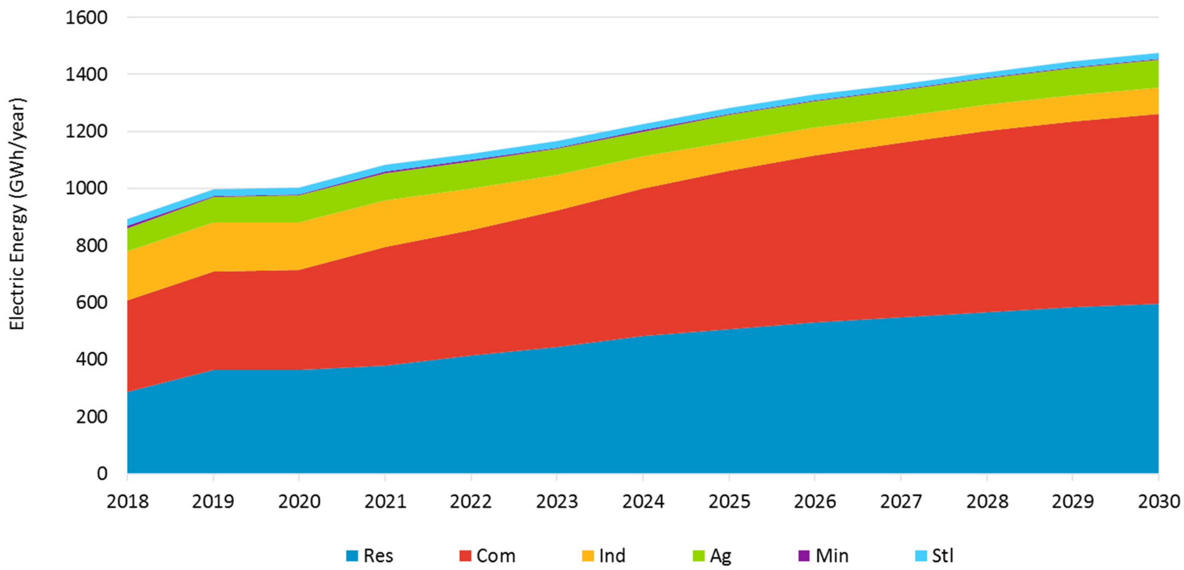


Table ES- 6. Statewide Net Incremental Electric Market Potential for Incentive Programs by Sector for the TRC Reference Scenario

Sector	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Res	288.42	363.72	364.89	379.77	414.97	445.20	481.69	506.66	530.09	548.55	566.71	583.29	595.86
Com	319.09	345.57	349.69	416.82	440.93	477.00	518.60	554.76	585.26	612.90	636.26	652.92	664.59
Ind	173.73	171.12	165.78	162.16	145.37	125.17	111.37	103.28	98.70	91.88	90.70	91.28	93.09
Ag	80.72	89.43	94.64	96.22	95.37	92.44	88.67	93.16	91.42	90.72	92.20	94.96	99.17
Min	6.24	5.02	4.76	4.67	4.53	4.37	4.20	4.03	3.87	3.61	3.43	3.29	3.15
Stl	24.29	23.70	23.02	22.37	21.74	21.14	20.57	20.04	19.54	19.08	18.65	19.05	19.90

Figure ES- 6. Statewide Net Incremental Gas Market Potential for Incentive Programs by Sector for the TRC Reference Scenario

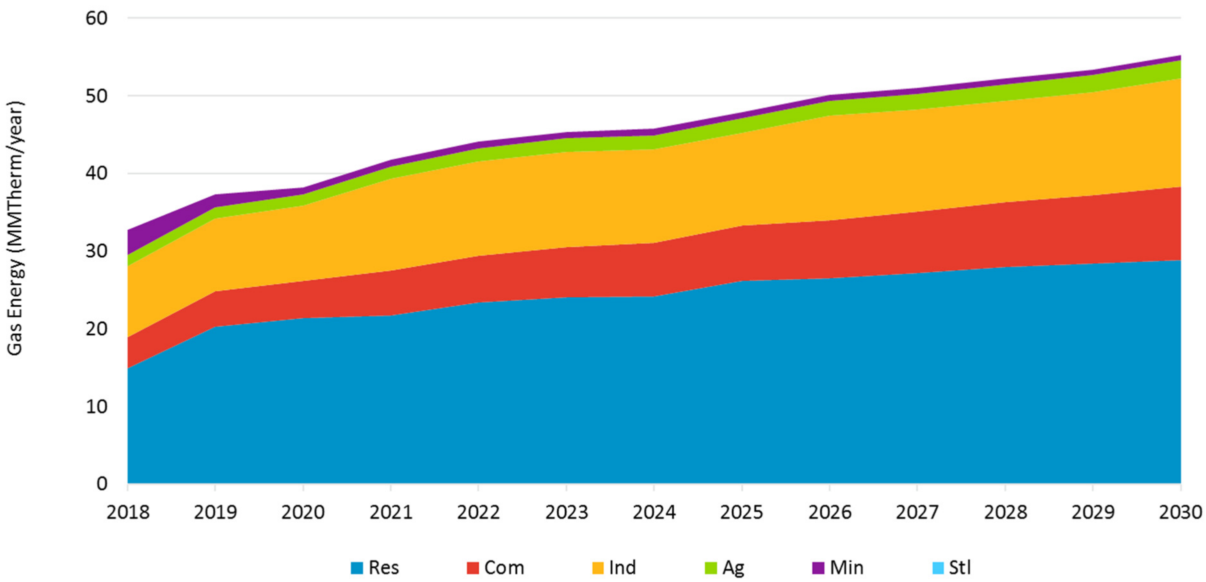


Table ES- 7. Statewide Net Incremental Gas Market Potential for Incentive Programs by Sector for the TRC Reference Scenario

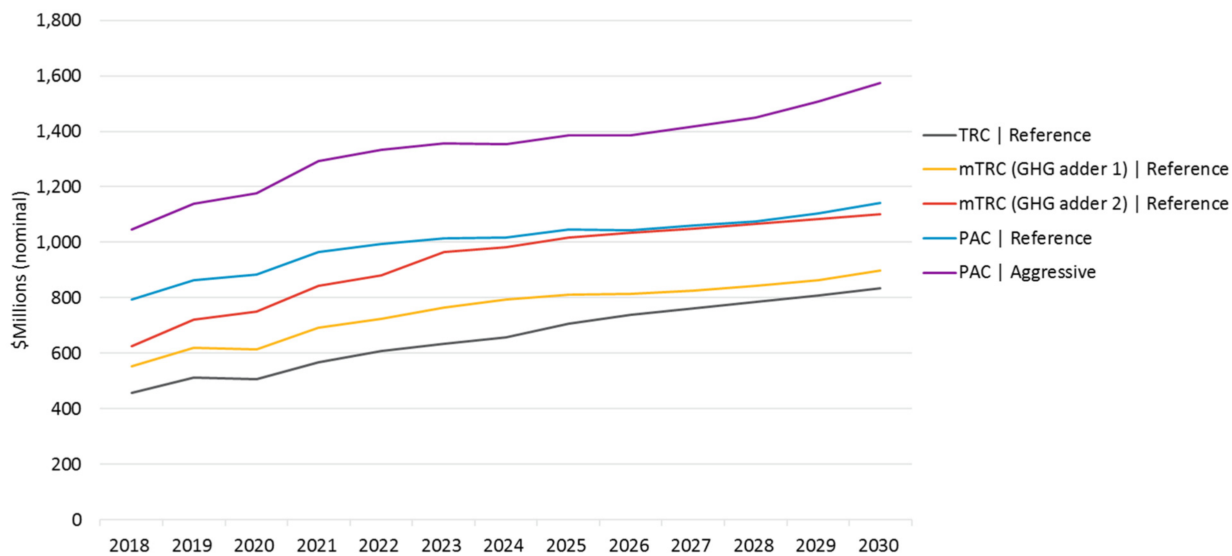
Sector	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Res	14.91	20.25	21.36	21.73	23.39	24.09	24.15	26.17	26.51	27.21	27.94	28.41	28.87
Com	4.10	4.68	4.89	5.76	6.07	6.53	6.95	7.24	7.56	8.01	8.43	8.90	9.51
Ind	9.06	9.31	9.67	11.88	12.23	12.32	12.14	11.93	13.46	13.11	13.03	13.25	13.94
Ag	1.49	1.50	1.51	1.57	1.64	1.72	1.79	1.93	2.01	2.10	2.19	2.28	2.39
Min	3.29	1.61	0.85	0.86	0.85	0.83	0.81	0.78	0.75	0.72	0.70	0.67	0.64
Stl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Expenditures

Figure ES-7 and Table ES-6 show projected statewide spending by scenario. Expenditures represent the costs for both rebates and program administration costs. Expenditures are only shown for Equipment Rebates and BROs costs[8]. No cost data is reported for LI and C&S programs. Cost increases over time for all scenarios are explained by forecasted increase in annual adoption (a function of rebates and increased awareness and willingness to adopt) as well as cost inflation. In addition, higher program acquisition costs are experienced due to greater shares of higher cost measures being rebated over time.

Since overall potential is driven by electric savings, the trend generally follows that of electric potential whereby Scenario 5 (PAC Aggressive) produces the most expensive portfolio for equipment savings, and Scenario 1 (TRC Reference), the least. By 2030, Scenario 4 (PAC Reference) is expected to cost about 36% more than Scenario 1 (TRC Reference). Aggressive program engagement further increases spending as illustrated by Scenario 5 (PAC Aggressive), which costs about 38% more than Scenario 4 (PAC Aggressive).

Figure ES- 7. Statewide Program Expenditures by Scenario for Incentive Programs



Note: Excludes C&S and Low Income

[8] It should be noted that this is the first time that the PG study has reported expenditures. As such, these cost outputs are for reference purposes and should not be used to determine budget requirements.

Table ES- 8. Statewide Spending by Scenario for IOU Rebate Programs (Million $)

Year	Scenario 1: TRC Reference	Scenario 2: mTRC w/ GHG adder 1	Scenario 3: mTRC w/ GHG adder 2	Scenario 4: PAC Reference	Scenario 5: PAC Aggressive
2018	456.0	554.2	624.3	793.8	1044.9
2019	512.2	620.9	720.4	863.2	1139.3
2020	506.5	614.0	751.2	884.2	1177.5
2021	568.8	692.9	843.8	965.6	1293.3
2022	607.8	723.4	879.6	994.2	1334.1
2023	633.5	765.7	964.5	1014.6	1355.7
2024	659.0	793.7	982.8	1016.5	1353.9
2025	706.4	810.8	1016.5	1047.6	1385.0
2026	738.7	812.9	1035.6	1044.8	1386.1
2027	762.6	825.7	1048.4	1060.6	1418.4
2028	785.9	844.7	1065.6	1075.9	1450.8
2029	808.9	862.4	1083.5	1104.1	1507.5
2030	835.6	897.7	1100.7	1140.7	1574.5

1. INTRODUCTION

1.1 Context of the Goals and Potential Study

Navigant Consulting, Inc. along with its partners Tierra Resource Consultants LLC (collectively known as "the Navigant team") prepared this study ("2018 and Beyond Potential and Goals 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-2017 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 2018 Potential and Goals Study (2018 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 2018 Study is the fourth consecutive potential study conducted by the Navigant team on behalf of the California Public Utilities Commission (CPUC). Navigant conducted the 2011[9] study, which informed the 2013-14 IOU program goals, and the 2013 Study,[10] which was used to inform the 2015 goals for California IOUs, and the 2015[11] study which informed the 2016 and beyond goals. A significant number of recent policy changes in California are driving updates to the approach and methodology of the 2018 study. These policy drivers include:

- **California Assembly Bill 802 (AB802)** has the potential to significantly shift the way California energy efficiency Program Administrators (PAs) rebate and claim energy savings from energy efficiency programs. Historically Investor Owned Utilities (IOU) programs have been mostly limited to seeking, rebating, and claiming energy efficiency savings for equipment that exceeds current code or standard. Furthermore, and with a few exceptions, the only energy savings that could be claimed was the difference between code or standard and the high efficiency installation; this is referred to as "above-code savings".[12] However, AB802 could shift away from this paradigm to allow and incentivize all energy savings (including those that are "below-code").[13] Furthermore, AB802 instructs energy efficiency be achieved not only though equipment installations but also through behavior and operational efficiency interventions. Navigant produced a Technical Analysis of AB802 (AB802 TA) in 2016. The AB802 TA did not inform goals but its methodological advances over prior studies serves as a basis for the 2018 PG study.
- **California Senate Bill 350 (SB350)** established California's 2030 greenhouse gas reduction target of 40 percent below 1990 levels. To achieve this goal, SB 350 sets 2030 targets for energy efficiency and renewable electricity, among other actions aimed at reducing greenhouse gas emissions. Of concern to the PG study, SB350 requires the state to double statewide energy

[9] Navigant. *Analysis to Update Energy Efficiency Potential, Goals, and Targets for 2013 and Beyond - Track 1.* May 2012.

[10] Navigant. *2013 California Energy Efficiency Potential and Goals Study*. February 2014.

[11] Navigant. *Energy Efficiency Potential and Goals Study for 2015 and Beyond.* September 2015

[12] "Above code savings" also refers to savings from energy efficiency equipment that exceeded the minimum efficiency appliance standards. "Above code" thus means "above building code or appliance standard"

[13] "Below code" is synonymous with "to code" throughout this document. They can be used interchangeably.

efficiency savings in electricity and natural gas end uses by 2030 and that the goals not be constrained based on past program performance.

- **CPUC Cost Effectiveness Tests and Inputs Updates** are currently underway though the Integrated Distributed Energy Resources (IDER) proceeding (R. 14-10-003). Multiple changes have been or are being considered. First, in mid-2016 the CPUC released updated energy avoided costs for use in all distributed energy resources, including energy efficiency program planning and budget approval. These avoided costs were generally observed to be lower than previous avoided cost thus potentially resulting in lower overall portfolio cost effectives through the Total Resource Cost (TRC) Test.[14] The CPUC has been considering the application of the California Standard Practice Manual tests for DER needs including the use of a GHG adder to be incorporated into the current avoided costs.[15]
- **CPUC Net Goals Direction** – The CPUC directed 2018 and beyond goals to be set net of free-ridership due to changes in baseline policy.[16] As such, all results, tables, and graphs shown in this document are reported as net of free-ridership unless otherwise noted.

The 2018 Potential and Goals Study supports multiple related efforts:

1. Inform the CPUC as it proceeds to adopt goals and targets, providing guidance for the next IOU energy efficiency 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.
2. Guide the IOUs in portfolio planning and the state' principal energy agencies in forecasting for procurement, including the planning efforts of the CPUC, California Energy Commission (CEC), and California Independent System Operator (CAISO). Although the model cannot be the sole source of data for IOU program planning activities, it can provide critical guidance for the IOUs as they develop their plans for the 2018 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.
3. Inform strategic contributions to SB350 targets. The 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 upon the PG study as an input to AAEE; the PG study will also serve as an input to SB350 target setting.

The study period spans from 2018-2030 based on the direction provided by CPUC and focuses on current and potential drivers of energy savings in IOU service areas. Analysis of energy efficiency savings in publicly owned utility service territories is not part of the scope of this effort.

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[14] Due to lower natural gas prices and GHG Cap-and-Trade prices. (http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=12504)

[15] SCT staff proposal (http://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=173203676); GHG adder (http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M182/K363/182363230.PDF)

[16] Decision 16-08-019 (http://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=166232537)

1.2 Types of Potential

Consistent with the 2015 Study and consistent with common industry practice, the 2018 Study forecasts energy efficiency potential at four levels for rebate programs:

1. **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 energy efficiency were taken, including retrofit measures, replace-on-burnout measures, 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, low income programs, whole building programs, and behavior/retrocommissioning/operational efficiency programs.
2. **Economic Potential:** Using the results of the technical potential analysis, the economic potential is calculated as the total energy efficiency potential available when limited to only cost effective measures.[17] All components of economic potential are a subset of technical potential. Like technical potential, economic potential can be represented as instantaneous or annualized. Economic potential screens considered in this study include:
    a. ***Total Resource Cost (TRC) Test*** - The CA Standard Practice Manual defines the TRC test as the measurement of the net benefits and costs that accrue to society (program administrator all its customers). It compares the benefits, which are the avoided cost of generating electricity and supplying natural gas, with the total costs, which include program administration and customer costs. The TRC does not include the costs of incentives.
    b. ***Modified TRC*** (**mTRC**) - The mTRC test builds upon the TRC test by including a GHG adder to the avoided cost of electricity and natural gas. The GHG adder is intended to estimate the value of the reduced carbon emissions that energy efficiency provide, and that the value of the GHG adder should be based on the marginal cost of abatement (i.e., the cost of achieving California's GHG reduction goals). The GHG cost included in the 2016 avoided cost reflects the values of the permits utilities are required to buy as part of California's Assembly Bill (AB) 32 cap and trade program for 2020 GHG targets. The GHG adder is intended to cover the anticipated additional costs to meet 2030 GHG targets.
    c. ***Program Administrator Cost (PAC) Test*** - The CA Standard Practice Manual defines the PAC test as the measurement of the net benefits and costs that accrue to the program administrator (i.e. the utilities). It compares the benefits, which are the avoided cost of generating electricity and supplying natural gas, with the total costs, which include program administration and incentive costs. The PAC does not include the additional out-of-pocket costs for equipment paid for by the customer.
3. **Market Potential:** The final output of the potential study is a market potential analysis, which calculates the energy efficiency savings that could be expected in response to specific levels of incentives and assumptions about existing CPUC policies, market influences, and barriers. All

[17] The default assumption for this study includes all non-emerging technologies with a C-E test result of 0.85 or greater; emerging technologies are included if they meet a threshold of 0.5 in a given year and also achieve the threshold for non-emerging technologies (0.85) within ten years of market introduction.

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' energy efficiency goals, as determined by the CPUC. Market potential has historically been used by the CPUC to inform the goal-setting process.

4. **Stranded Potential** is a subset of the Market Potential. These savings are defined as the opportunities for EE that have not historically been captured by either EE program administrator (PA) rebate programs or codes and standards. Stranded Potential is below-code savings that is not materializing in the market because there is no incentive for the customer to upgrade their existing equipment given current program rebate policy. Under AB802, PAs could start offering rebates for bringing existing equipment up to code thus potentially motivating a whole new subset of customers to install EE measures and thus capture the Stranded Potential.

Market potential is represented in the 2018 PG study two different ways; each is based on the same data and assumptions though each serve separate needs and provide necessary perspectives.

1. **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 incremental savings is necessary to understand what additional savings an individual year of energy efficiency programs will produce. This has historically been the basis for IOU program goals.
2. **Cumulative Savings** represent the total savings from energy efficiency program efforts from measures installed since 2015 including the current program year, and 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 EUL. Cumulative savings also account for the timing effects of codes and standards 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 energy efficiency, 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 energy efficiency programs and codes and standards across all customer sectors: Residential, 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 2015 PG Study as well as the AB802 TA. Notable updates to the 2018 PG study relative to the 2015 PG study include:

- **Fully accommodate calculation of Stranded Potential** – Modeling algorithms pioneered in the AB802 TA were adapted and improved upon in the 2018 PG study to capture the impacts of AB802 and quantify Stranded Potential

- **Present Scenarios to inform Goal Setting** – The 2018 PG study integrated scenario analysis at a much earlier stage in the project allowing the CPUC to consider scenarios in the goal setting process.
- **Refresh Residential and Commercial measure list** – The study conducted a holistic refresh of the rebated technologies to be included in the model. The previous measure list was not referenced when creating the new measure list to avoid any bias. Rather existing rebate programs, stakeholder feedback, IOU emerging technology programs, and potential studies elsewhere around the nation were primarily considered in developing a new list. The new list was designed to better accommodate modeling of Stranded Potential
- **Technology based model for Industrial/Agriculture sectors** – The 2015 PG model forecasted savings in the Industrial and Agriculture sectors primarily using end-use energy efficiency supply curves derived from regional data available from the U.S. Department of Energy. The 2018 PG model dives deeper and forecasts savings at a representative technology level (rather than just at the end use level).
- **Expand Consideration of Behavior, Operational, Retrocommissioning (BROs) Savings** – The model significantly expanded the consideration of BROs interventions in the residential and commercial sectors. Industrial Strategic Energy Management was also considered.
- **Report Potential on a Net Basis** – Past PG studies have reported potential on a gross basis for goal setting purposes. The CPUC is moving towards setting goals on a net basis[18]. Thus, all results are reported on a net basis. Because results are reported as net, and previous studies reported gross, direct comparison of results from this study to past studies may not be appropriate.

1.4 Stakeholder Engagement

The Navigant team engaged with stakeholders through the Demand Analysis Working Group[19] throughout the process of this study to request data, collect feedback on scope, methodology, and key assumptions. Table 1-1 below 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 in the study thus.

[18] Decision Providing Guidance for Initial Energy Efficiency Rolling Portfolio Business Plan Filings (D.16-08-019)

[19] http://demandanalysisworkinggroup.org/

Table 1-1: Stakeholder Meeting Schedule

Date	Topics of Discussion
July 19, 2016	Overview of the scope of the 2018 Potential and Goals Study
August 29, 2016	Residential, Commercial and AIMS Measure Selection
November 4, 2016	BROs intervention selection, Whole Building characterization methodology, and avoiding double counting
December 9, 2016	(Webinar) AIMS Methodology
December 12, 2016	(Webinar) Calibration, Scenarios, and Cumulative Savings
April 20, 2017	(Webinar) BROs Draft Results
April 28, 2017	(Webinar) Low Income Methodology/Data

1.5 Content of this Report

This report documents the data relied upon by and the results of the 2018 Study.

- **Section 2** provides an overview of the study's 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 2018 PG Model results.
- **Section 5** compares the 2018 PG Model results to the 2015 PG Study.
- **Appendices** provide additional details for key topic areas.

Aside from this report, the following are available to the public:

- 2018 PG Model File – an Analytica based file that contains the PG model used to create the results of this study;
- 2018 PG BROs Model File – a spreadsheet based file that contains the model used to create the BROs results for this study;
- 2018 PG Results Viewer – a spreadsheet viewer that contains detailed results at the end use level; and
- 2018 PG MICS – a spreadsheet version of the Measure Input Characterization System documenting all final values for all technologies forecasted in the model.

These additional documents and files can be found on the CPUC's website.[20]

[20] http://www.cpuc.ca.gov/General.aspx?id=6442452619

2. STUDY METHODOLOGY

The primary purpose of the 2018 Study is to provide the CPUC with information and analytical tools to engage in goal setting for the IOU energy efficiency portfolios. In addition, this study informs forecasts used for procurement planning. The model itself does not establish any regulatory requirements.

The 2018 model forecasts potential energy savings from a variety of sources within six distinct sectors: Residential, Commercial, Agricultural, Industrial, Mining, and Street Lighting. These sectors are also used in the CEC's IEPR forecast. Within some or all the sectors, sources of savings include:

- **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.
- **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, 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.
- **Residential Low Income:** The methodology for the low-income sector remains unchanged from the 2013 Study. Data was updated to reflect the most recent information available from the CPUC regarding savings per participant and forecasted participants.
- **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 forecasting 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 energy efficiency measures. The PG Model estimates the effects of introducing energy efficiency financing on market potential and how shifting assumptions about financing affect the potential energy savings.

AB802, SB350 and possible changes to the CPUC Cost Effectiveness policies have driven the PG study to update its methodology in several key areas. The modeling methodology leverages much of what was used in the 2015 Study but further builds upon the analysis presented in the AB802 Technical Analysis. The rest of this section discusses the 2018 Study methodology.

2.1 Modeling Methods

Table 2-1 below summarizes the modeling approach for each source of savings. The modeling approaches are 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
Rebated Technologies	Bass diffusion forecast competes below code, at code and above code technologies against each other.	Calibrated to historic program spending
Whole Building Packages	Bass diffusion forecast competes below code, at code and above code technologies against each other.	Calibrated to historic program spending
Industrial Custom Measures and Emerging Technologies	Trend forecast based on recent IOU custom project savings in the industrial sector. 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.
Behavior, Retrocommissioning, Operational Efficiency (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.
Residential Low Income	Forecast of participation based on IOU program filings, data gaps filled by Navigant through extrapolation.	Forecast is anchored in IOU program history and plans and thus inherently calibrated to current market conditions.
Codes and Standards (C&S):	Model replicates the algorithms of the CPUC's Integrated Standards Savings Model (ISSM)	Calibration not needed as evaluated results are used.
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

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 2018 PG model's forecast. Historically, rebate programs could mostly claim above-code savings for rebated technologies. However, with the introduction of AB802, rebate programs can now claim to-code savings for select technologies more broadly. Our approach to modeling rebated technologies has thus updated since the 2015 PG study to accommodate the modeling of to-code savings.

2.1.1.1 Types of Technologies

The PG study forecasts the adoption of more than 150 energy efficiency 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 baseline, and modeling consumer decisions and market adoption. These differences are further discussed throughout this section report. The types of measure installations are:

- **New Construction –** Equipment that is 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 instead replaced with a new piece of equipment. Appliance standards are applicable to some types of ROB equipment and apply to all new purchases. An example of an ROB measure is the light bulb.
        - **Accelerated Replacement –** Equipment that is beyond its EUL and is continuing to function in the market (likely because of repairs that a customer has conducted on the equipment to extend its life). The customer is not planning to replace the equipment on a "regular cycle" and thus programs are targeted at the customer to accelerate the equipment's replacement. Appliance standards are applicable to some types of Accelerated Repair equipment but only apply to new purchases (not the repair). Examples include measures such as boilers and chillers.
    - **Retrofit**
        - **Retrofit 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 stand-alone equipment and are not required for the operation of the existing equipment or building. Codes or standards may be applicable to some types of Retrofit 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. Examples include measures such as boiler controls, VFDs, and window film.
        - **Retrofit 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

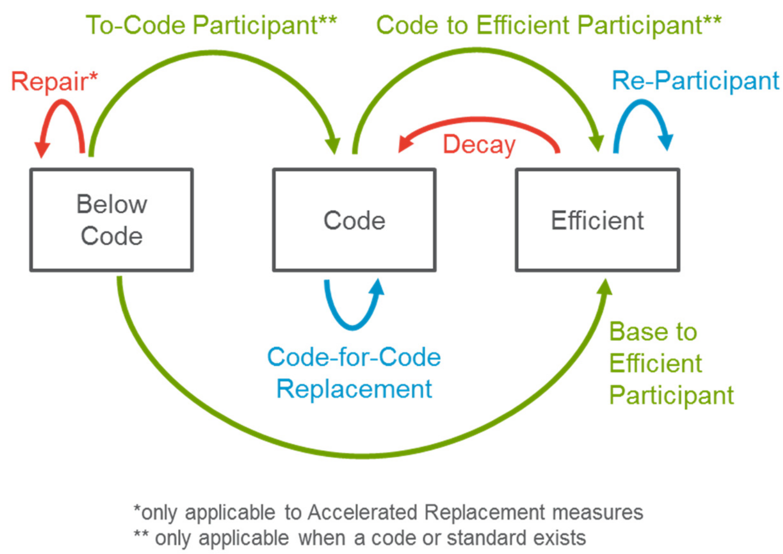
Within each technology type, multiple groups of technologies are formed and characterized. A technology group consists of multiple levels of efficiency of the same technology. An example or which is illustrated below in Table 2-2. Technologies within a technology group compete for installations. The advantage of characterizing technology-based inputs is that a technology group can have multiple baseline and efficient technologies, in contrast to specifically defined ones in measure-based inputs (as used in the 2015 PG study). 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 team considers 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 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 (discussed previously in section 2.1.1.1) the equipment in question falls in. Figure 2-1 below 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 is associated a unique unit energy savings, cost, and cost effectiveness of the decision.

Figure 2-1. Stock Flow within a Technology Group



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 energy efficiency were taken, including retrofit measures, replace-on-burnout 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 our 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 a 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 our study.

Using the results of the technical potential analysis, the economic potential is calculated as the total energy efficiency 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 additional considerations are factored into our 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.

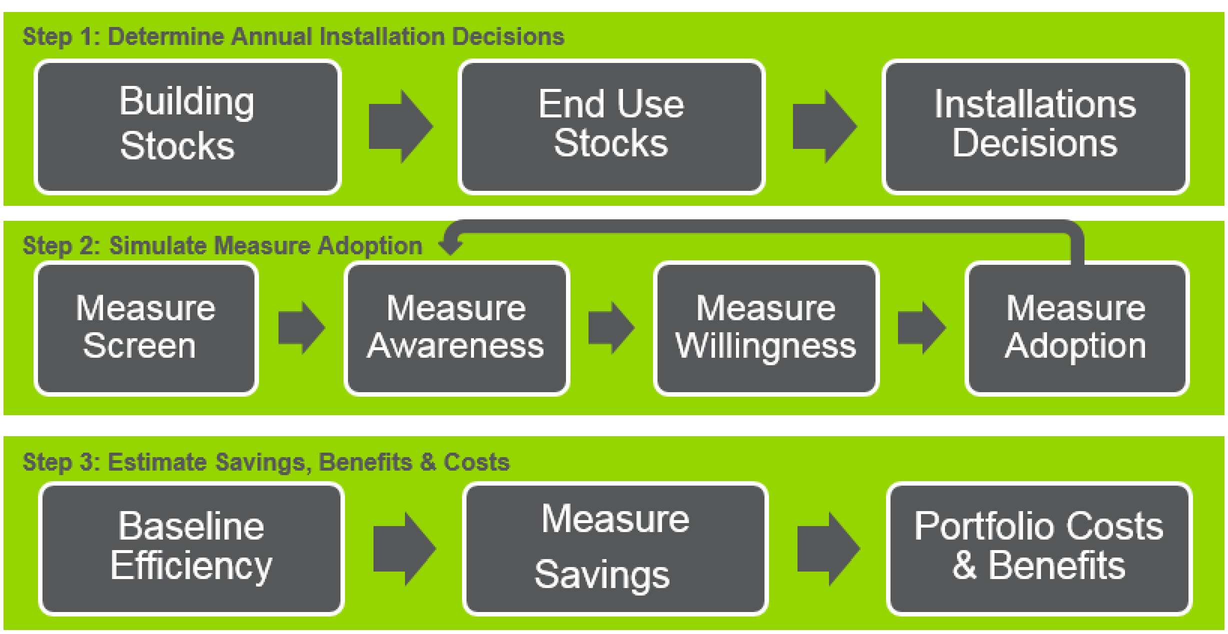
- Various cost effectiveness screens can be applied (previously discussed in Section 1.2); thus, economic potential can vary by scenario. Meanwhile, technical potential does not vary by scenario.

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 installations 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 accelerated replacement where equipment is past the EUL (e.g. commercial chillers), we model 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 cost-effectiveness 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 cost-effectiveness screen. It is in this step that the PG model employs the Bass Diffusion approach to simulate adoption that is 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.

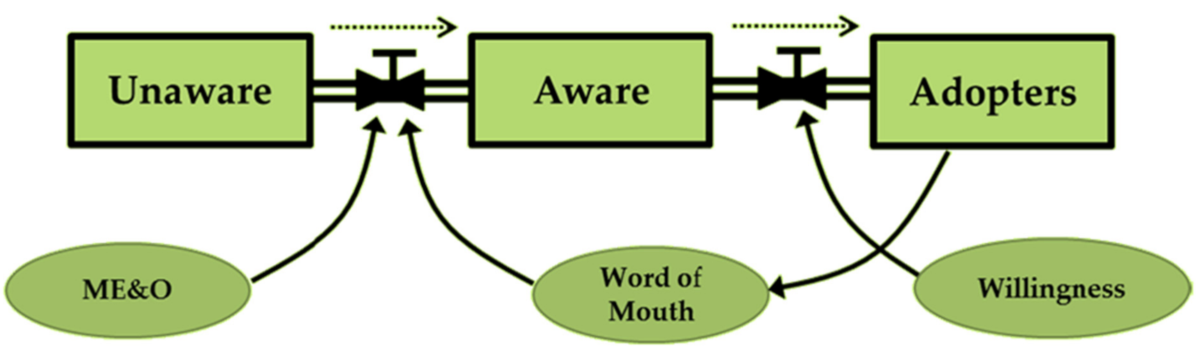
Figure 2-2. Three-Step Approach to Calculating Market Potential for Rebated Measures



As noted above, the model employs a bottom-up dynamic Bass Diffusion approach to simulate 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 leads 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 the figure below.

Figure 2-3. The Bass Diffusion Framework: A Dynamic Approach to Calculating Measure Adoption[21]



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:

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

- **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 levelized measure cost 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)[22]. The equation used to calculate the LMC is shown below.

Equation 1. Levelized Measure Cost Calculation

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

To calculate long-run market share or willingness as a function of the levelized measure cost for both base and efficient technologies, Navigant employed a logit decision-maker approach.[23] [24] This approach applies best practices in predicting consumer behavior and allows competition of multiple measures with different EULs for each end use.

Equation 2. Logit Decision Model[25]

$$W = \frac{e^{\beta\ LMC1}}{\sum_i^n e^{\beta\ LMCi}}$$

The figure below illustrates how consumer willingness changes as a function of the ratio of the efficient to base LMC. In this illustration, a 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 a 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.

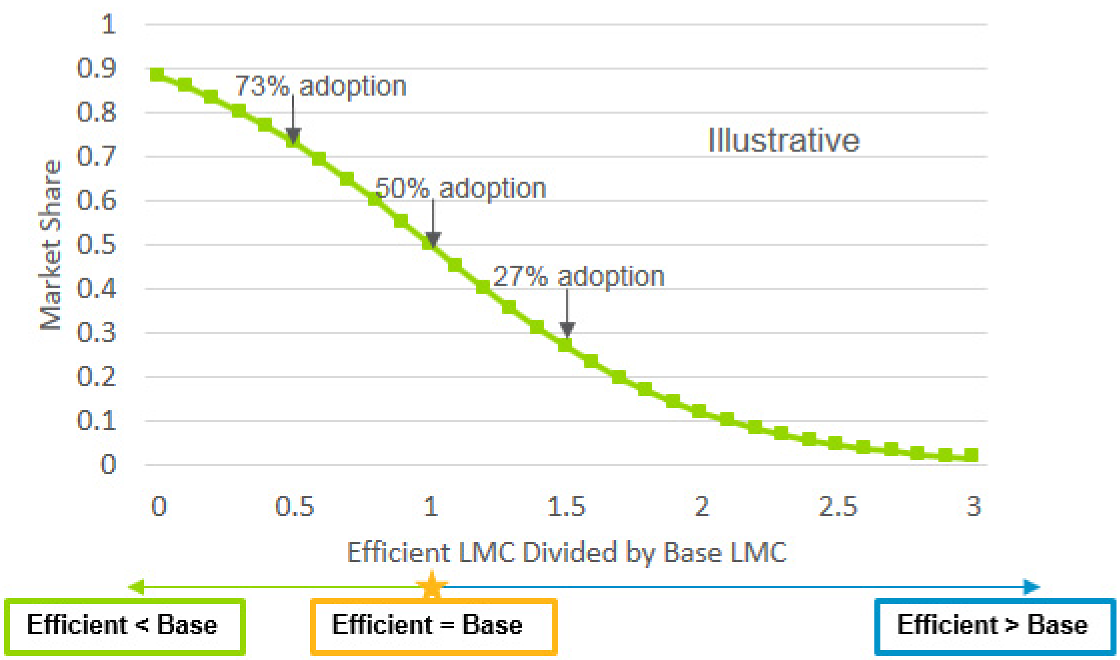
[22] See 2015 PG Study for details on the iDR

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

[24] *Train, Ken. "Discrete Choice Methods with Simulation." 2003. Cambridge University Press.*

[25] 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.

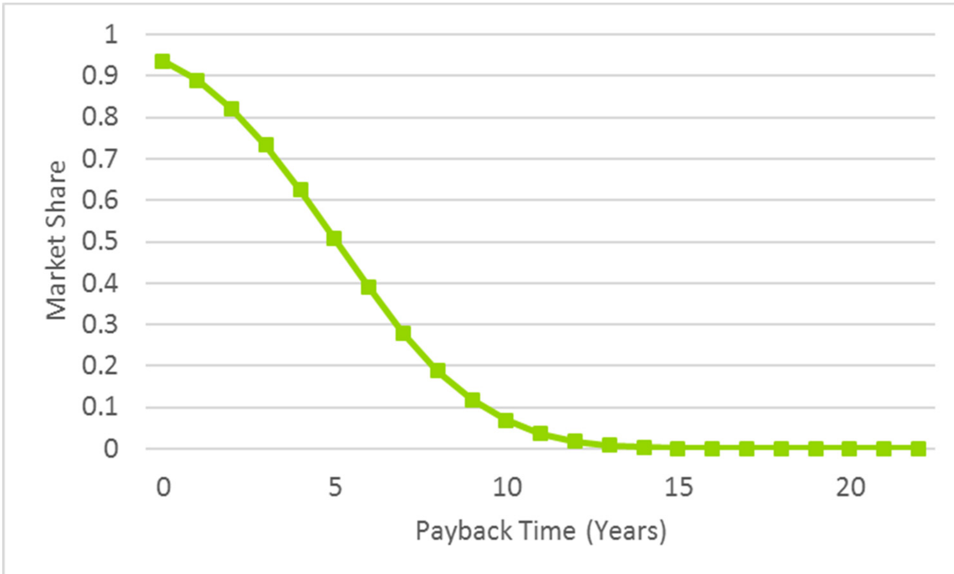
Figure 2-4. Illustration of Logit Willingness Curve



- **Payback-based Approach:** For the AIMS sectors, where information on baseline technology costs are not available, and where there isn't a need to explore the impacts of EE financing, Navigant used a payback-based approach to calculate willingness. Payback time reflects the length of time (years) required for an energy efficiency investment to recover the initial upfront cost in terms of energy savings. After calculating payback time, to estimate market share for the AIMS measures, Navigant relied on "payback acceptance" curves based on Navigant-led primary research in the US Midwest in 2012.[26] Though California-specific data were not available to estimate these curves, Navigant considers that the nature of 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.

[26] [26] A detailed discussion of the methodology and findings of this research are contained in "Demand Side Resource Potential Study," prepared for Kansas City Power and Light, August 2013.

Figure 2-5. Payback Acceptance Curve for AIMS sectors



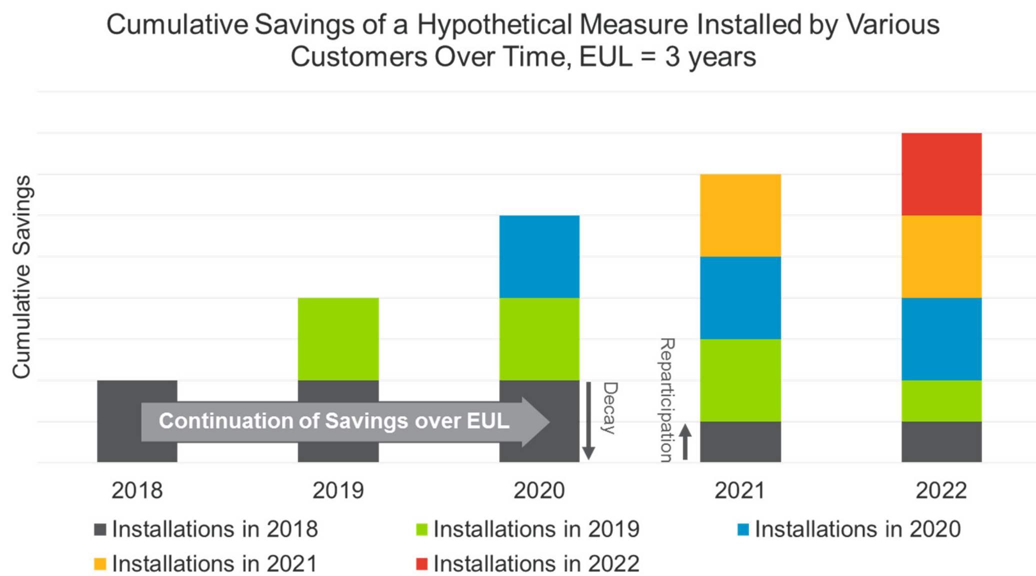
2.1.1.5 Calculating Cumulative Market Potential

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

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

Unlike annual savings, cumulative savings include savings from reparticipants. Incremental savings only considers that from first-time adopters. Sustained savings from re-adoptions needs to be counted in cumulative savings for the purposes of demand forecast. The PG model assumes reparticipants re-adopt measures at the same rate as new participants. The calculation of cumulative savings is illustrated in Figure 2-6.

Figure 2-6. Cumulative Savings Illustration



Navigant presented this information to stakeholders at a DAWG workshop in December 2016 and posed the following questions:

1. When should the PG model start cumulating savings?
2. There is no new research to inform treatment of decay/reparticipation in the PG model. What should we assume about decay?
    a. Starting with the 2013 PG model, reparticipation estimated based on market penetration rates (varies by measure)
    b. 2011 PG model assumed a blanket reparticipation rate of 50% based on CPUC D. 09-09-047
3. D. 09-09-047 required that the utilities make up 50% of the savings decay as measures expire.
    a. 2015 PG study annual market potential included only new participants
    b. Thoughts on how to how to reconcile this?

Comments were provided by NRDC and PG&E. NRDC supported re-examining the 50% policy for re-participation and requested further discussion be had regarding Navigant's alternate method and to better understand implications of the re-participation rate implications on goals. PG&E commented that decay "occurs much less frequently" than the 50% assumption indicates.

Given the comments, Navigant maintained its approach to calculating cumulative potential and set the "cumulation start year" to 2015 to be consistent with AAEE and SB350 needs.

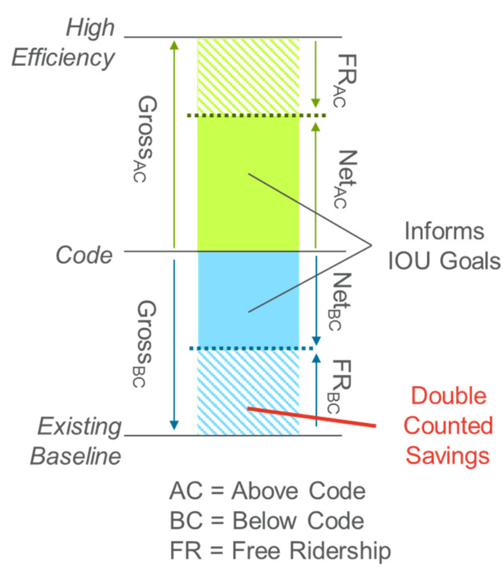
2.1.1.6 Avoiding Double Counted Savings

The PG study is required to avoid double counted savings between codes and standards and below-code rebate programs. These are the below-code savings generated from rebated equipment that would be realized even in the absence of PA 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 California Energy Commission Demand Forecast, thus further decrementing the forecast with this savings would be double counting. The AB802 TA took a top-down approach to highlight the end uses and sectors at risk for double counted savings. However, the 2018 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 Stranded Potential (for non-lighting equipment this is done by isolating the population that is older than its EUL). This equipment is that which 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 below 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 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 4th, 2016. A framework of basing the below code NTG on the above code NTG (NTG_{AC}) was presented. The following question was posed:

What is the appropriate below code NTG to assume (assumption may vary by measure type)?

a. $NTG_{BC} = 1$

b. $NTG_{AC} < NTG_{BC} < 1$

c. $NTG_{BC} = NTG_{AC}$

d. $NTG_{BC} < NTG_{AC}$

No specific feedback was provided by stakeholders.

Navigant can see arguments for a wide range of NTG_{BC}.

$NTG_{BC} < NTG_{AC}$

Navigant and Commission staff discussed this concept with the CPUC's Ex-Ante consultants who provided feedback that below code NTG is likely less than above code NTG. The Ex-Ante consultants further advised that NTG_{BC} is likely low for equipment with high capital cost where utility rebates are likely a small percentage of the full cost of the new equipment (such as HVAC equipment). In such situations, the argument is made, the utility rebate is a very small influence on the decision to come up to code such that the amount of savings attributed to the utility program (i.e. the NTG ratio) will be small. However, NTG_{BC} may be closer to NTG_{AC} for equipment that has low capital cost (such as lighting). In these situations, the argument is made, the utility rebate has a larger influence on customer decisions.

$NTG_{BC} \geq NTG_{AC}$

We define Stranded Potential as "the opportunities for energy efficiency that are ***not currently captured*** by either PA rebate programs or codes and standards. Stranded Potential is below-code savings that ***is not materializing in the market because there is no incentive for the customer*** to upgrade their existing equipment given current program rebate policy. Under AB802, PAs could start offering rebates for bringing existing equipment up to code thus ***motivating a whole new subset of customers to install energy efficiency*** and capturing the Stranded Potential." Our definition of stranded potential implies below code savings programs target customers who wouldn't have upgraded equipment in the first place. Thus, any influence the IOU has on the upgrade has limited free ridership. Under this argument it's also important to note that NTG is an average of the entire market and has been calculated as such in past evaluations. However, Stranded Potential is targeting a different population of customers who were not motivated to act on their own, thus imply a lower level of free ridership relative to the general population.

Based on the lack of data and high uncertainty in this area, Commission staff advised Navigant to follow a conservative approach and assume NTG_{BC} is less than NTG_{AC}. This would imply a lower market potential and a more conservative basis for setting IOU goals. We expect better data to become available after further research and evaluation of such programs.

We estimate NTG_{BC} to be some fraction of NTG_{AC} where:

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

Table 2-3 below indicates our assumptions for the NTG Adjustment factor. These are purely assumptions based on direction from the CPUC and commentary from the CPUC's Ex Ante Consultants. Lighting has a larger factor than all other end uses due to its low capital cost. Data centers have a smaller factor than all other end uses because of the multiple influences driving data center upgrade decisions. All others are assumed to be 0.5 for lack of better data.

Table 2-3. NTG Adjustment Factors

End Use Category	Res	Com
Data Center		0.25
HVAC	0.5	0.5
Lighting		0.75
WaterHeat	0.5	0.5

2.1.2 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.

2.1.3 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

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

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.
- **Unit Energy Savings** represented the percent savings expected from customers adopting technologies.
- **Penetration Rate** represents annual new participation and varies over time and can vary by scenario for Emerging Technologies.

Emerging technologies were screened for consideration based on an 8-level screening process considering the following factors:

1. Relevance to the industrial and agricultural sectors
2. Relevance by NAICS segment
3. End use application
4. Type of fuel savings
5. Potential energy savings percentage
6. Impact potential (including technical and market potential, risks, and non-energy benefits)

7. Segment energy consumption trends
8. Segment market trajectory

The Emerging Technologies that passed the screening criteria were used to derive ET UES values grouped by market segment (e.g. Petroleum, Food Processing, etc.) using the methodology defined in Appendix F. ET 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 sub-sector 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 sub-sector *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 technology energy savings percentage, T_e, was determined for each emerging technology. The sector end-use percentage, $E_{i,j}$, is derived from California market data. 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).[27] 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 California Energy Commission (CEC) shows electricity consumption trend for various industries from 1990 through 2015. Section 3.5 discussed the data inputs for this equation.

Industry Standard Practice's (ISP) are not forecasted 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 ISP.

2.1.4 Behavior, Retrocommissioning, 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. The market potential modeled for these initiatives is incremental to savings from equipment change-outs.

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

2.1.4.1 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

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

Where,

- **Population** is a global input that can be represented in two ways - number of homes and square feet of floor space or in 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 in percent 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 applied to the California IOUs' territories). The forecasts are the result of professional judgement based upon 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. Adjustments to penetration and applicability were made to avoid the double counting of savings.

This effort does not examine demand-focused programs, but does include demand savings that are associated with programs focused on energy efficiency using the energy savings from Equation 2-5 in Equation 2-6.

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

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

2.1.4.2 Costs

Similarly 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, but 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

$$Program\ Cost = Incremental\ Market\ Potential\ \times\ Cost\ Factor$$

2.1.5 Residential Low Income

The potential for energy efficiency in the low-income sector is forecast based on the Energy Savings Assistance program (ESAP). ESAP is offered by all four IOUs as a no cost direct installation of weatherization measures that also includes a wide range of energy efficiency equipment combined with energy efficiency education and referrals to other income qualified programs. The 2018 PG model forecast is an update to previous forecasts based on changes in the low-income market and regulatory environment that impact the ESAP offering. One of the major changes to the 2018 PG model is to include ESAP program savings for 'retreatment' installations as allowed by Decision 16-11-022 (the Decision).[28] The Decision allows the ESAP program to go-back and retreat households by installing new and updated measures in homes that have been served by past ESAP program activity. All past PG model low income forecast have only included estimates of potential for 'first time' installations on households that have never participated in ESAP.

Residential Low Income (LI) programs are modeled based on two key inputs: number of households (HH) forecasted to be treated and unit energy savings (UES) per treated household. The savings are calculated using Equation 2-8

Equation 2-8. General Equation for Calculating LI Savings

$$Low\ Income\ Program\ Savings = Households\ Treated\ x\ Unit\ Energy\ Savings$$

The forecast for Households treated is obtained from IOU plans. The team does not develop its own forecast. The savings potential reported for Low Income are not a true "Market Potential" but more of a "forecast of IOU planned activity". The model allows for disaggregation of savings by building type (Single Family, Multifamily, Mobile Home) based on IOU data provided.

The PG model reports LI savings separately from all other rebate programs. Though this may not be the case in the goal setting process.

2.1.6 Codes and Standards (C&S)

Codes and Standards (C&S) impacts on energy efficiency 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 decreases. 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 codes and standards in multiple formats, each for a different use:

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[28] November 10, 2016

» **Net C&S Savings** are the total energy savings estimated to be achieved from the updates to codes and standards 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 greenhouse gas targets. This informs the CEC forecast.

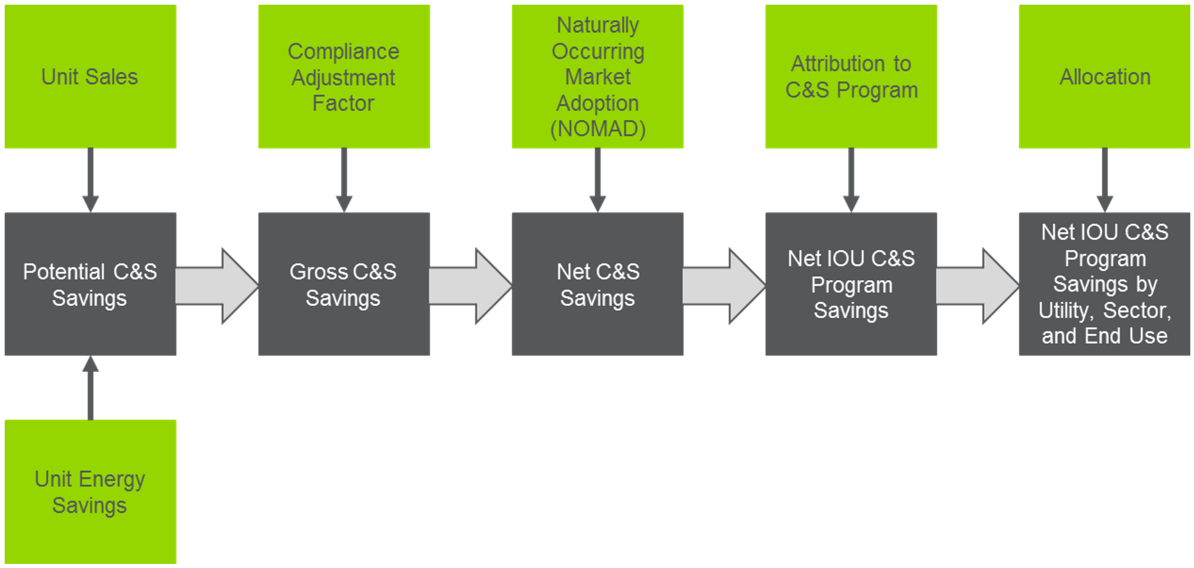
» **Net IOU C&S Program Savings** identifies the portion of the Net C&S Savings that can be attributed to the advocacy work of the IOU's C&S program. This result is used to inform the IOU program goals.

The modeling methodology of C&S savings was based on the Integrated Standards Savings Model (ISSM)[29] developed by CADMUS and DNV GL 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:

- **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.
- **Unit Energy Savings** – Unit energy savings 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 Navigant break down the savings into sectors and end uses.

[29] Cadmus and DNV GL. *Integrated Standards Savings Model (ISSM).* 2017.

Figure 2-8. C&S Savings Calculation Methodology



The 2018 study continued to use no layering when analyzing net IOU attributable C&S savings. In addition to the removal of layering as provided by ISSM data, the 2018 study analyzed all codes and standards included in the analysis and removed savings from standards that were superseded by other standards once the new standard took effect. This holistic approach to layering removal is a change in methodology relative to the 2015 study. A detailed table of C&S impacted by layering can be found in Appendix E.

2.1.7 Financing

Financing has the potential to break through a number of market barriers that have limited the widespread market adoption of cost-effective energy efficiency measures. The PG Model estimates the incremental effects of introducing energy efficiency financing on energy efficiency market potential and how shifting assumptions about financing affect the potential energy savings.

Examples of market barriers that can slow energy efficiency adoption[30] 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 up-front capital or credit for energy efficiency 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.

[30] Jaffe, Newell, and Stavins. Economics of Energy Efficiency. Encyclopedia of Energy Vol. 2: 79-89. 2004.

- **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.

2.1.7.1 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 Report[31], more than half of homeowners (54%) believe that the higher upfront costs present a barrier to energy efficiency 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.[32] Amongst homeowners who made an energy upgrade and used financing, nearly three-quarters using financing indicated that the financing allowed them to do a larger project or purchase higher quality equipment than what they would have done on their own[33]. For the non-residential sector, 83% of on bill financing (OBF) loans were for projects exceeding 10% energy savings.[34]

Financing may also reduce the "hassle factor" barrier that may affect a consumer's willingness to take on an energy efficiency 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[35].
For non-residential customers, qualified customers can access zero-percent 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 creditworthiness[36]. 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 zero percent financing over rebates (34%)[37], PG&E is testing an OBF alternative pathway that will be paired with metered energy data instead of an incentive[38]. Because the incentive applications are where most problems occur

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[31] PY2014 Finance Residential Market Baseline Study Report. Opinion Dynamics Corporation and Dunsky Energy Consulting. March 2016

[32] Southwest Energy Efficiency Project. Energy Efficiency Finance Options and Roles for Utilities. October 2011.

[33] PY2014 Finance Residential Market Baseline Study Report. Opinion Dynamics Corporation and Dunsky Energy Consulting. March 2016

[34] 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.

[35] PY2014 Finance Residential Market Baseline Study Report. Opinion Dynamics Corporation and Dunsky Energy Consulting. March 2016

[36] Financing Energy Improvements on Utility Bills. Technical Appendix Case Studies. State and Local Energy Efficiency Action Network (SEE Action). May 2014.

[37] California 2010-2012 On-Bill Financing Process Evaluation and Market Assessment (CALMAC ID CPU0056.01),

[38] Commercial customers can receive up to a $100,000 loan for five years, and government can receive up to a $250,000 loan for

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 energy efficiency programs.[39]

2.1.7.2 Impact of Financing on Consumer Economics

Financing allows consumers to use private capital to fund energy efficiency projects; borrowers avoid the up-front 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.[40]

To discount future payments, we apply the annual consumer discount rate (*i*) per Equation 2-9, where *n* is the number of years:

Equation 2-9. Present Value Equation

$$Present\ Value\ = Future\ Value\ \times (1 + i)^{-n}$$

We can evaluate the present value of an energy efficiency measure over the useful life of the equipment by comparing the net present value of the hypothetical costs of the equipment and energy. For example, Table 2-4 shows the present value cost of a base efficiency technology ($1000) purchased in year 0, followed by energy costs for that unit of $200 annually for ten 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 $1250 to the consumer up-front after a 50% rebate on the incremental cost of the efficient technology whose original cost was $1500 (i.e., $1500 – [($1500-$1000) x 50%] = $1250). 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 $1250 with the utility incentive. Assuming a consumer uses an energy efficiency loan at 4% for ten years, the equipment and financing costs are spread over ten 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.

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ten years. The alternative path will leverage existing infrastructure as well as the existing on bill financing program's revolving loan fund.

[39] 2010-2012 CA IOU On-bill Financing Process Evaluation and Market Assessment. May 2012.

[40] OMB Circular A-94. Available at: https://www.wbdg.org/FFC/FED/OMB/OMB-Circular-A94.pdf

Table 2-4. 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
Net Present Value 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
Net Present Value 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
Net Present Value	**$1,992**										

The modified cash flows feed into the calculation of consumer willingness (described earlier in 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.

2.2 Calibrating Rebated Technologies and Whole Building Approaches

SB 350 directed the CPUC to adopt goals based on energy efficiency potential studies that are not restricted by previous levels of utility energy efficiency savings. However, this does not mean that a potential study model shouldn't 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 model results with a level of comfort that simulated results are reasonable. 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; and
- 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 PG model is calibrated by reviewing portfolio data from 2013 through 2015 to assess how the market has reacted to program offerings in the past. For more details on the necessity of calibration, the data basis of calibration, effects of calibration, and interpreting calibration please see Appendix A.

2.3 Scenarios

In the recent past (2013 and 2015), the PG studies produced a single forecast of energy efficiency potential for the purposes of informing IOU goals. The forecast was calibrated to historic program activity. In these past studies, alternate scenarios were only considered in the Additional Achievable Energy Efficiency (AAEE) forecast used by the California Energy Commission. The AAEE scenarios were developed after the CPUC had established goals and were primarily driven by the needs of the CEC. The 2018 PG study considers multiple scenarios to inform the goal setting process.

SB 350 directed the CPUC to adopt goals based on energy efficiency potential studies that are not restricted by previous levels of utility energy efficiency savings. Commission staff proposed to meet this direction by exploring scenarios reflecting alternative future outcomes based on variables that can be controlled by policy decisions or program influence. 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. On the other hand, “externally influenced” variables were not considered in scenarios that inform the goals. External variables are those that CPUC and IOUs collectively have no control over. A list of example internally and externally influenced variables can be found in Table 2-5 below.

Table 2-5. Variables Affecting Energy Efficiency Potential

Internally Influenced	Externally Influenced
• Cost-effectiveness (C-E) test • C-E measure screening threshold • Incentive levels • Marketing & Outreach • Behavior, Retro commissioning & Operational (BROs) customer enrollment over time • IOU financing programs	• Building stock forecast • Retail energy price forecast • Measure-level input uncertainties (unit energy savings, unit costs, densities) • Non-IOU financing programs

Additional details on each of the internally influenced variables can be found in the study team's presentation to the Demand Analysis Working Group (DAWG) on December 12, 2016.[41]

2.3.1 Stakeholder Input

Stakeholders and members of the DAWG were given the opportunity to provide informal feedback to the team on the development of scenarios including which variables to consider and the range of variables. Table 2-6 contains a summary of relevant stakeholder feedback received from the December DAWG meeting.

Table 2-6. Stakeholder Feedback

Stakeholder Comments	Additional Context from Navigant
Cost Effectiveness Test	
• **PG&E:** Screening measures based on different cost-effectiveness tests is acceptable "so long as the goals assigned to the IOUs are aligned with the policy that the IOUs will have to follow when operating their portfolios." • **NRDC:** Supports assessing the potential using the PAC as well as the SCT • **SDG&E:** Supports creating scenarios around prospective changes in the C-E tests given that the CPUC is actively exploring such tests. • **TURN:** Suggests portfolio cost-effectiveness should be subject to a 10-year lifecycle average measure mix. • **SCE:** Encourages investigating alternative C-E tests, and assessing the impacts of changes on EE programs ability to capture savings.	• TURN's comment is a broader policy issue that Navigant does not plan to address in these scenarios. • Factors impacting the SCT test (discount rate, cost of carbon) may be informed by the other CPUC proceedings as appropriate. Methods to determine some factors, like health and air quality impacts are yet to be defined.
C-E Screening Threshold	
• **PGE:** Current thresholds of TRC in the model (0.85 for conventional technologies, 0.5 for emerging technologies) are appropriate. • **SoCalGas:** Prefers using a "1.0 TRC scenario as a benchmark" • **SCE:** Prefers using a TRC threshold of 0.85 with no exception for new technologies or approaches (i.e. including emerging technologies). SCE does encourage exploring "what if" scenarios around thresholds to guide possible policy changes.	• The assumption of 0.85 has been used for several iterations of the study and is also reflective of the history of measures with TRC < 1 being included in programs
Incentive Levels	
• **PG&E:** Suggests it's reasonable to use tiered incentives with a cap at 50% as was previously used in the AB802 Technical Analysis.[42] Suggests it would be reasonable for a high scenario to use up to a 75% cap and a low scenario to use as low as a 25% cap.	• Scenarios will explore higher levels of rebates but not lower.
Marketing & Outreach	

[41] Slides available at: http://demandanalysisworkinggroup.org/event/energy-savings-pup-cpuc-2018-beyond-ee-potential-goals-study-model-calibration-and-forecasting-scenarios/?instance_id=445

[42] Navigant. *AB802 Technical Analysis - Potential Savings Analysis*. Prepared for the CPUC. March 2016.

Stakeholder Comments	Additional Context from Navigant
• **Jeanne Clinton:** Suggests having scenarios on different levels of penetration, to reflect different levels of "market effectiveness and/or payment facilities" to better inform program design and market strategy. • **NRDC:** Suggests an additional scenario that assesses the energy savings potential based on various delivery channels (e.g., upstream, midstream, downstream) • **SCE:** Advocating for explicitly identifying barriers to EE program adoption when developing Scenarios.	• The model does not forecast the explicit impact of specific program design or delivery mechanisms or barriers to specific technologies but rather the overall effect of removal of barriers that drive more participants to programs.
Behavior, Retro-commissioning & Operational (BROs) Enrollment	
• **PG&E:** Suggests assuming current levels of participation for the reference forecast is acceptable, as well as reasonable upper and lower ranges around current levels. • **SCE:** Suggests including scenarios around increased savings from behavior and operational efficiency programs. • **SDG&E:** "It would be useful to see scenarios built around holistic approaches/program designs that develop potential long-term energy road maps for customers, in addition to looking at just individual technologies or end uses. An example would be Strategic Energy Management programs."	• Scenarios will explore reasonable upper bounds but no lower than current levels. • Navigant held a follow-up workshop on BROs that included discussion of scenarios. Additional discussion can be found in section 3.8.
IOU Financing Programs[43]	
• **PG&E:** IOU activities (to date) are not driving the energy efficiency financing industry though there is a role for IOUs to play in the future. PG&E further commented that most energy efficiency projects "will be financed – however PG&E doesn't think it is appropriate to assume this financing will use [IOU] EE financing tools. Traditional financing tools are more likely to be the financing source (e.g., bonds … mortgages…). PG&E would expect to see greater participation in EE financing tools as goals increase. However, the financing schemes that are put in place are unlikely to change much under different goal scenarios. So PG&E believes that incentive level is the primary driver of EE financing investments." • **SoCalGas:** Suggests any assumptions about financing programs "should be realistic because of the slow start and likely niche operations" of IOU financing programs. • **SDG&E:** Supports different scenarios considering different financing levels/schemes though also comments that IOU financing pilots are not deployed and cannot provide complete information.	• Since the last PG study there have been no new completed impact evaluations of financing programs to better inform our analysis. • Note: the 2015 PG study excluded financing from the results being used to inform goals
Additional Comments	
• **PG&E:** Suggests overall scenarios should focus on three variables: cost-effectiveness, awareness, and incentive level. • **SDG&E:** Suggests various scenarios and sensitivity analysis around avoided costs.	• Avoided costs are an externally influenced variable and is out of scope of scenario analysis.

43 Financing impacts are modeled as reductions in consumer iDR and change in customer payment structure, building off work done in the 2015 Potential and Goals Study.

2.3.2 Final Scenarios

The team worked with Commission staff to develop scenarios for consideration in the goal setting process. Each of the internally influenced variables in Table 2-7 is expected to have an impact on the forecast of energy efficiency potential. The combined impact of these variables represents a scenario.

Commission staff took the following into consideration when directing Navigant on the final scenarios

- Commission staff followed closely the developments in the IDER proceeding. This informed the alternative cost-effective tests to consider.
- On February 2017, Commission staff released a Societal Cost Test (SCT) white paper with recommendations for parameters to support a SCT as well as modifications to currently used TRC and PAC.
- On April 2017, Commission staff proposed a GHG adder curve as an interim value that could inform goal setting. The interim GHG adder proposal followed the methods proposed in the SCT staff white paper. The GHG adder curve was developed based on draft runs of the RESOLVE model in the Integrated Resources Proceeding (IRP).
- In the comments to the staff proposed interim GHG adder, the joint IOUs proposed an alternative GHG adder curve based on the Allowance Price Containment Reserve (APCR)[44]. This curve is an extrapolation of preliminary values released by the ARB during the development of the California Air Resources Board AB 32 Scoping Plan Update. Although the proposed allowance prices are not final and are subject to change, Commission staff believes they are a reasonable alternative to the staff proposal and will give stakeholders the chance to see how market potential changes when using alternative GHG adder values.

Commission staff's intent was to keep the number of scenarios manageable but still provide a range of alternatives to bound market potential. Therefore, five scenarios in total were proposed and are listed in Table 2-7.

Table 2-7. Final Scenarios for Energy Efficiency Potential – Summary

Scenario	Cost Effectiveness Screen	Program Engagement
1: TRC | Reference	TRC test using 2016 Avoided Costs	Reference
2: mTRC (GHG Adder #1) | Reference	TRC test using 2016 Avoided Costs + IOU proposed GHG Adder	Reference
3: mTRC (GHG Adder #2) | Reference	TRC test using 2016 Avoided Costs + Commission staff proposed GHG Adder	Reference
4: PAC | Reference	PAC test using 2016 Avoided Costs	Reference
5: PAC | Aggressive	PAC test using 2016 Avoided Costs	Aggressive

[44] Joint Opening GHG Adder Comments, page 6 (http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M185/K576/185576217.PDF)
The curve is an extrapolation of the prices on ARB Staff Report, "Initial Statement of Reasons," Appendix C, August 2, 2016, Table 5. Available at: https://www.arb.ca.gov/regact/2016/capandtrade16/appc.pdf.

The TRC | Reference scenario represents “business as usual” and the continuation of current policies. Three of the alternate scenarios continue to assume similar program design but apply different cost effectiveness tests and avoided costs. The final scenario (PAC | Aggressive) is meant to show an upper bound of the combination of program engagement and cost-effectiveness screens. Table 2-8 below lists more detail for regarding Program Engagement.

Table 2-8. Reference vs. Aggressive Programs

Variable	Reference	Aggressive
Incentive levels	$/kWh $/Therm Capped at 50% of incremental Cost	$/kWh $/Therm Capped at 75% of incremental Cost
Marketing & Outreach	(default calibrated value)	Increased marketing strength
BROs	Continued offering of existing BROs interventions and planned new interventions based on policy directions	Additional BROs interventions that had limited verified data though show promise for possible savings
IOU financing programs	No savings claimed from financing programs[45]	IOU financing programs broadly available to Residential and Commercial customers

[45] Consistent with the 2015 Potential and Goals Study. Financing was modeled in the 2015 study but it did not inform the goals or AAEE forecast.

3. DATA SOURCES

The data sources relied upon in the 2018 PG study are vast and varied. Throughout the study, the Navigant team sought to rely upon 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 chapter 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. Navigant reviewed the data source for each of these inputs to ensure that the most recent data is utilized for the 2018 PG Model update. Table provides an overview of all the global inputs within the 2018 model and their data source. This section discusses each item in Table 3-1 in further detail in the sub-sections that follow.

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

Global Input *(description)*	Data Source for Update
Retail Rates *($/kWh, $/therm)*	CEC - *2016 Integrated Energy Policy Report (IEPR) Update and Demand Forecast Forms.* Adopted Feb. 2017. Excel Demand Forecast Forms available at: *http://www.energy.ca.gov/2016_energypolicy/documents/*
Sales Forecasts *(GWh, MW, and MM Therms)*	
Building Stocks *(households, floor space, consumption)*	CPUC – *California Energy Consumption Database (ECDMS).* Accessed: Apr. 2017
Avoided Costs *(Avoided energy and capacity costs)*	CPUC – *Cost Effectiveness Tool.* Accessed: Mar. 2017
Historic Program Accomplishments *(Used for calibration)*	CPUC – Energy Efficiency Full Program Cycle (2013-2015) Data. Download at: *http://eestats.cpuc.ca.gov/Views/EEDataShelf.aspx*
Non-Incentive Program Costs	

3.1.1 Retail Rates and Sales Forecasts

The CEC's Integrated Energy Policy Report (IEPR), which includes a forecast that is updated annually, is the source for retail rates and sales forecasts in the 2018 Study. The team used the 2016 IEPR for electric rates and forecasts and the 2015 IEPR for gas rates and forecasts. This was because only electric rates and forecasts were updated in the 2016 IEPR.

Navigant revised the retail rates and sales forecast based on information from the recently released IEPR 2016, published by the CEC in February 2017.

Sales forecasts in IEPR are shown by CEC's eight planning areas, which differs slightly from the IOU service territory area. Some of the CEC planning areas include the territories of small POUs in California. Therefore, an adjustment is needed. Using data on service territory and planning area sales for 2015, Navigant 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 2015 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 SDG&E service territory so this is no need to calculate an adjustment ratio for SDG&E.

Table 3-2. 2016 IEPR Electric Service Territory to Planning Area Adjustment Ratios

	Residential	Commercial	Industrial	Mining	Agriculture	Streetlights
PG&E	97.0%	89.4%	88.4%	96.2%	97.0%	87.7%
SCE	92.6%	90.2%	89.2%	94.1%	58.8%	90.3%

Source: California Energy Commission, 2017.

Most POUs in California do not offer any gas service (currently 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 2013-2014 data from the CEC's Energy Consumption Database (ECDMS), shown in Table 3-3.[46]

Table 3-3. 2016 IEPR Gas Service Territory to Planning Area Adjustment Ratios

	Residential	Commercial	Industrial	Mining	Agriculture	Streetlights
PG&E	100.0%	98.1%	99.3%	99.3%	99.5%	NA
SCG	100.0%	97.0%	100.0%	10.3%	97.9%	NA

Source: California Energy Commission, 2017.

While most of the adjustment ratios are close to or at 100%, SCG mining is 10.3% based on service territory sales found in 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 additionally 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 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 streetlighting stocks are the number of pumps and streetlights respectively. The residential, commercial, industrial and agriculture building stock metrics are derived from the CEC's IEPR.

[46] California Energy Consumption Database. Accessed April 2017: http://ecdms.energy.ca.gov/

The model requires building stocks by sector, scenario, and utility for the time frame 2013-2030. IEPR 2016 organizes building stock data into the 8 electric planning areas determined by the CEC. To translate these IEPR results to the PG model and split them by utility, Navigant worked with CEC to map CEC planning areas to the IOU service territories in Table 3-4.

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

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

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 our 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 is available for download on this website. This data set includes ex ante and evaluated program savings, expenditures, cost-effectiveness, and emissions for energy efficiency programs statewide. For the 2017 PG study, Navigant used this data set to compute portfolio net and gross savings for each sector and utility.

Table 3-5 provides the 2013-2015 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 and retro-commissioning fall under the definition of the BROs subtask and were removed to prevent double-counting savings. Savings labeled “Other” were also removed.

Table 3-5. 2013-2015 IOU-reported Portfolio Gross Program Savings

IOU	Spending ($MM)		Energy Savings (GWh)		Gas Savings (MM Therms)	
	RES	COM	RES	COM	RES	COM
PG&E	282.50	520.96	758.46	1,120.47	8.8	27.6
SCE	299.59	503.66	892.17	1,291.51	NA	NA
SCG	77.08	36.16	NA	NA	12.7	17.5
SDG&E	70.69	110.08	175.57	295.18	-1.0	3.5

Source: CPUC – Energy Efficiency Full Program Cycle (2013-2015) Data

Additional discussion of the calibration process can be found in 5.Appendix A.

3.1.4 Non-Incentive Program Costs

Non-incentive program costs also come from the 2013-2015 Full Program Cycle Data on the CPUC’s EEStats portal. For the PG Model, Navigant 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 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 streetlighting 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	$0.12	$0.15	$0.08	$3.55	$4.53	$2.38
SCE	$0.16	$0.18	$0.18	NA	NA	NA
SCG	NA	NA	NA	$2.14	$1.15	$0.72
SDG&E	$0.12	$0.07	$0.06	$3.40	$1.92	$1.88

Source: CPUC – Energy Efficiency Full Program Cycle (2013-2015) Data

3.1.5 Avoided Costs

Avoided costs place an economic value on the amount of energy and greenhouse gas 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, Navigant used the Cost-effectiveness Tool (CET), a calculator commissioned by the CPUC. Post-processing of the CET calculator data resulted in a dataset that displays total avoided costs for 2016-2046 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 Navigant 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.

Using the original data obtained in the CET calculator, Navigant created a baseline projection of avoided costs that is to be used for the calculation of the Total Resource Cost test. However, in considering the modified TRC test the team needed to update the cost per ton of carbon. Two different GHG adders were used in this analysis.

In April 2017, the CPUC issued a draft statement on an interim greenhouse gas adder for consideration in alternate cost effectiveness tests. This adder is an incremental cost of carbon forecast that projects the cost from $0 per ton beginning in 2017 to $250 per ton in 2030.[47] Navigant refers to this data set as GHG Adder #2 in its scenario analysis as is the larger of the two adders. In the comments to the staff proposed interim GHG adder, the joint IOUs proposed an alternative GHG adder curve based on the draft Allowance Price Containment Reserve (APCR)[48]. This curve is an extrapolation of preliminary values released by the ARB during the development of the California Air Resources Board AB 32 Scoping Plan Update. Navigant refers to this data set as GHG Adder #1 as it is the lower of the two adders. Both adders are detailed in Table 3-7.

[47] CPUC Rulemaking 14-10-003. Downloadable from http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M182/K363/182363230.PDF

[48] Joint Opening GHG Adder Comments, page 6 (http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M185/K576/185576217.PDF) The curve is an extrapolation of the prices on ARB Staff Report, "Initial Statement of Reasons," Appendix C, August 2, 2016, Table 5. Available at: https://www.arb.ca.gov/regact/2016/capandtrade16/appc.pdf.

Table 3-7. Costs of Carbon, 2016-2046[49]

Year	Baseline Carbon Cost (nominal $/ton)	GHG Adder #1 (real 2016 $/ton)	Carbon Cost #1 (Baseline + Adder #1) (nominal $/ton)	GHG Adder #2 (real 2016 $/ton)	Carbon Cost #2 (Baseline + Adder #2) (nominal $/ton)
2016	$12	$47	$59	$0	$12
2017	$13	$50	$63	$0	$13
2018	$14	$55	$69	$19	$34
2019	$15	$59	$74	$38	$56
2020	$25	$55	$80	$58	$87
2021	$27	$59	$86	$77	$112
2022	$29	$60	$88	$96	$137
2023	$31	$61	$91	$115	$163
2024	$33	$61	$94	$135	$191
2025	$36	$62	$97	$154	$220
2026	$38	$62	$100	$173	$249
2027	$41	$62	$104	$192	$280
2028	$45	$63	$107	$212	$313
2029	$48	$63	$111	$231	$347
2030	$52	$63	$115	$250	$382
2031	$55	$64	$119	$250	$391
2032	$58	$63	$121	$250	$402
2033	$62	$62	$123	$250	$412
2034	$65	$61	$126	$250	$422
2035	$68	$60	$128	$250	$433
2036	$72	$59	$131	$250	$443
2037	$75	$58	$134	$250	$454
2038	$79	$58	$136	$250	$465
2039	$82	$57	$139	$250	$476
2040	$85	$56	$142	$250	$487
2041	$89	$56	$145	$250	$499
2042	$92	$55	$147	$250	$510
2043	$96	$55	$150	$250	$522
2044	$99	$55	$153	$250	$534
2045	$102	$54	$157	$250	$546
2046	$106	$54	$160	$250	$558

[49] The forecast assumes a 2% inflation rate when converting real 2016 dollars into nominal cost.

3.2 Residential and Commercial Technology Characterization

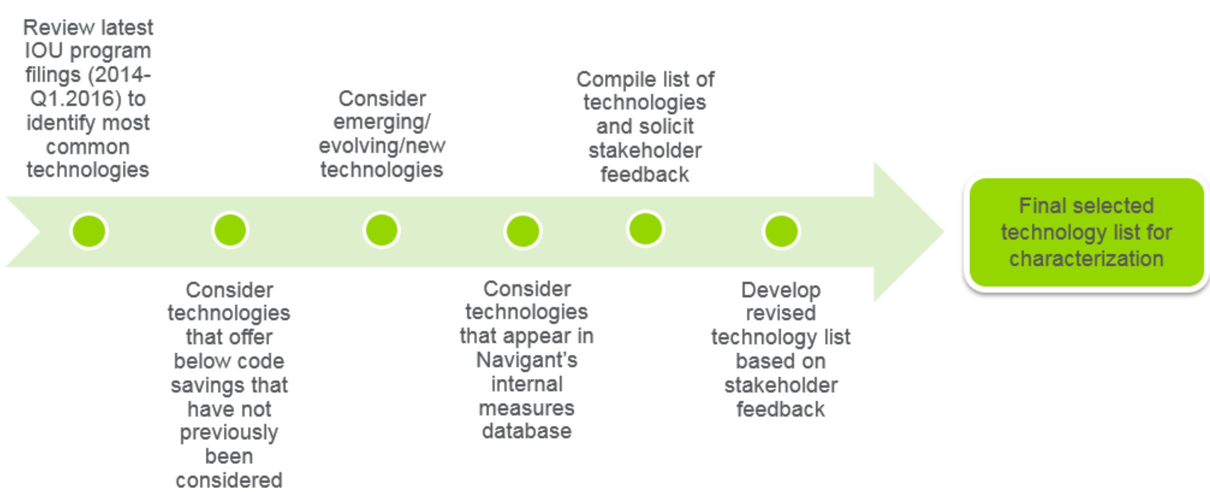
The technology characterization step in the potential study develops the essential inputs that are used in the PG model to calculate potential. This section provides an overview of the technology selection process for residential and commercial sectors, describes the fields along which technologies are 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.

The 2018 study departs from the 2015 Study in terms of measure characterization. The 2015 study classified measures defined by a base technology upgrading to an efficient level technology (e.g. SEER 13 to SEER 15 and SEER 13 to SEER 18 are **two** different measures). The 2018 study uses a technology-based characterization, which characterizes the individual technologies (e.g. SEER 13, 15 and 18 are **three** different technologies). This new method allows the model to better track stock flow between technology levels (as discussed earlier in 2.1.1.2.

3.2.1 Technology Selection Process

The first step under technology characterization is to select and develop a list of representative technologies. The selection process is necessary to identify high impact technologies with significant savings opportunities across multiple end uses, referred to as "representative" technologies. As part of this, the Navigant team reviewed multiple databases and information sources and followed a systematic process for selection of the "representative" technologies, briefly described below, and represented in Figure 3-1 below.

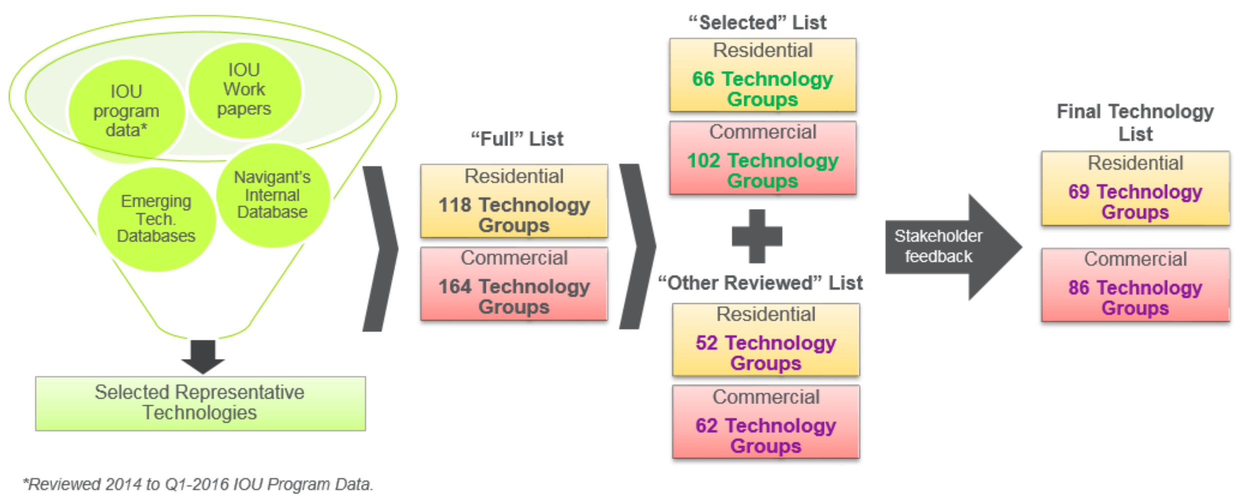
Figure 3-1. Res/Com Technology Selection Process



As depicted in Figure 3-1, the technology selection process involved multiple steps to arrive at the list of selected technologies. It involved review and inclusion of technologies from the California IOUs recent program databases (2014 to Q1.2016) and approved utility workpapers, consideration of technologies that provide below-code savings opportunities not considered previously, review and consideration of emerging technologies, and inclusion of technologies from Navigant's internal technology databases used for other utility studies. Navigant presented an initial list of compiled technologies for stakeholder review and feedback (in August 2016), addressed stakeholder comments and developed a final list of selected technologies for characterization.

Figure 3-2 below presents additional details associated with these steps.

Figure 3-2. Res/Com Technology List Development Process



The first step in the technology selection process included a review of multiple information/data sources, described earlier, to develop a comprehensive and universal list of technology groups for consideration in the study (referred to as the "Full" list in Figure 3-2). Note that a *"technology group",* defined and referred to earlier in Section 2.1 of the report, 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 e.g., residential ACs with different efficiency levels (ranging from SEER 10 to SEER 21) are considered a single technology group termed "Residential Air Conditioners" under residential HVAC. The "full" list was developed based on a review of different sources, which primarily include available databases in EEstats[50], program savings data from California IOUs[51], utility work papers, emerging technology databases, and Navigant's internal technology database of energy efficient technologies outside of this study.

The next step after developing the "full" list of technology groups was to parse it into two sets, a "selected" list and an "other reviewed" list, as depicted in Figure 3-2. The "selected" list at this stage included representative technology groups from the California IOUs' program portfolios that provide bulk of the savings[52], new below-code technologies not considered previously, refreshed list of emerging

[50] EEstats database downloadable at http://eestats.cpuc.ca.gov/Views/EEDataPortal.aspx

[51] Navigant obtained database of IOU programs with savings and cost information from 2013 to Q1. 2016 from Itron.

[52] Navigant reviewed EEStats and IOU program data to determine the share in savings from each technology group by enduse for the residential and commercial sectors, and included all technology groups that constituted 98% of the total savings by enduse for these two sectors.

technologies, and relevant technologies included through Navigant's benchmarking with other similar potential studies. Technology groups not included in the "selected" list were in the "other Reviewed" list.

Navigant presented this list of "selected" and "other reviewed" technology groups for stakeholder review and feedback.[53] From stakeholder comments, the team developed a **"**final**"** list of technology groups that addressed stakeholder comments. This final list served as the starting point for developing the full list of individual technologies under each technology group. As discussed earlier in section 2.1.1.2, the individual technologies in each technology group represent "average below code", "code" and "efficient" technologies that compete for stock replacement. Table 3-8 below shows the number of technology groups and individual technologies characterized in the study, by end use for residential and commercial sectors. This includes technologies included under both fuel types, electric and gas.[54]

[53] Navigant described the approach for technology selection and presented the list of "selected" and "other reviewed" technologies during a DAWG workshop held on August 29, 2016.

[54] Please refer to the MICS database for additional details.

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

Sector	End Use	Technology Group Examples[55]	Number of Technology Groups	Number of Individual Technologies[56]
Residential	Appliances/Plug Loads	Refrigerators, Pool Pumps, Clothes Dryers.	13	42
	Building Envelope	Weatherization, Attic Duct Insulation, Windows.	13	39
	HVAC	Air Conditioners, Heat Pumps, Ceiling Fans.	16	47
	Lighting	Indoor Screw-in Lamps, Specialty Lamps, Linear Fixtures.	13	50
	Water Heating	Electric Water Heaters, Faucet Aerators, Showerhead.	9	23
	Total		**64**	**201**
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.	23	80
	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		**78**	**244**

[55] The complete list of technology groups is presented in the MICS database.

[56] Note that the technology list does not include "Whole Building Packages" and BROs Interventions The approach used for selection and characterization of these measures are discussed in separate sections of this report. Please refer to the MICS database for a complete list of technologies included in the study.

3.2.2 Comparison with Measure Characterization in the 2015 Study

The technology-based characterization allows greater flexibility in characterization, this combined with our holistic refresh of the technology list, expands the number of efficient technologies included in the 2018 study relative to the 2015 study. This comparison is shown in Table 3-9. Several notable changes can be observed form the table:

- Increase in the number of HVAC technologies
- Increase in the number of building envelop technologies
- Increase in the number of Commercial Refrigeration technologies
- Addition of a "Data Center" end use and technologies
- Consolidation of "Service" and "Process Heat" end uses into HVAC

Table 3-9. Comparison of Efficient Residential and Commercial Technologies in 2015 and 2018 PG Study

Sector	End Use	Number of Efficient Technologies in 2015 Study	Number of Efficient Technologies in 2018 Study
Residential	Appliances/Plug Loads	18	22
	Building Envelope	3	14
	HVAC	12	26
	Lighting	29	25
	Water Heating	6	12
	Total	**68**	**99**
Commercial	Appliances/Plug Loads	4	22
	Building Envelope	3	7
	Com. Refrigeration	5	10
	Data Center	N/A	5
	Food Service	7	7
	HVAC	25	44
	Lighting	27	26
	ProcHeat	1	N/A
	Service	4	N/A
	Water Heating	9	7
	Total	**85**	**136**

The technology-based characterization allows for the inclusion of below-code technologies (and thus to-code savings). In the new technology list, Navigant defined the average below code efficiency level for technology groups where appropriate. Such technologies are flagged as "Accelerated Replacement" and are summarized in Table 3-10 below.

Table 3-10. Residential and Commercial Accelerated Replacement Technology Groups

Sector	End Use	Number of Technology Groups Characterized as Accelerated Replacement
Residential	Building Envelope	2
	HVAC	6
	Lighting	2
	Total	**10**
	Data Center	1
	HVAC	9
	Water Heating	3
	Total	**13**

3.3 Technology Characterization

Characterization of the selected technologies involves developing various inputs for each technology that are necessary for calculation of potential. Table 3-11 below summarizes the key items for characterization of technologies with brief descriptions.

Table 3-11. Key Fields for Measure Characterization with Brief Descriptions

Items	Brief Description
Technology Description	Specifies the following for each technology: • Sector • End Use • Fuel Type • Climate Zone • Segment/Building Type • Replacement type
Energy Use	Specifies the following for each technology: • Energy use (electric and gas) • Coincident Peak Demand • Interactive Effects
Technology Costs	Specifies the following for each technology: • Equipment Cost • Repair Cost (for accelerated replacement technologies). • Installation Cost
Market Information	Specifies the following for each technology: • Applicability by Segment/Building Type • Density associated with the Technology Group • Saturation for Individual Technologies
Other Items	Includes the following: • Technology lifetime (EUL and RUL), • Net-to-Gross (NTG) ratio

The following sub-sections 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.

3.3.1 Energy Use

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

This study utilizes the findings from the CPUC AB802 Technical Analysis study to define below-code baseline (referred to as "average below code") vs. defining code technology as the baseline, which is common practice for many potential studies (including prior CPUC potential studies). The below-code baseline of a given measure is the average efficiency level of older units that are not up to code and have not been replaced. These units have the option of being upgraded to the code/standard or to the efficient or above-code efficiency level.

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

Table 3-12 below lists the data sources for energy use (in hierarchical order) with brief descriptions of the sources.

Table 3-12. Hierarchy of Data Sources for Energy Use Information

Priority	Energy Consumption Source Name	Description	Author	Year
1	DEER (Database of Energy Efficient Resources)	Navigant used information from 2017/2018 DEER updates for obtaining energy use and coincident peal demand for technologies, wherever available. Lighting energy use was calculated using the lighting calculator tool available at DEER.	CPUC	2016
2	Non-DEER Ex Ante Database	Navigant referred to the Non-DEER ex ante database, available from Commission staff, for characterizing 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	CMUA TRM	Navigant referred to the CMUA TRM for energy use information for applicable technologies.	Cal TF	2015
5	CA 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 EEStats database[57] and 2014-Q12016 program savings[58] database from CA IOUs, in case energy use information was not available from the above-listed sources.	CPUC, IOUs	2014-2016
7	Non-California source examples: ○ Regional Technical Forum (RTF) Database	In cases where CA-specific sources were not available for energy use information, Navigant referred to the following sources: • Measure-level savings data from evaluated programs in the Pacific Northwest region, available through the RTF.	Northwest Power and Conservation Council (NPCC)	2015
	○ Navigant Potential Study Database	• Navigant's archive of characterized measure savings from potential studies and projects with other utilities.	Navigant	2015-2016

[57] http://eestats.cpuc.ca.gov/Views/EEDataPortal.aspx

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

3.3.2 Technology Costs

The measure characterization database requires specification of equipment costs, labor costs for installation and repair costs for “accelerated replacement” 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 earlier under energy use. Table 3-13 below summarizes the data sources used for technology costs.

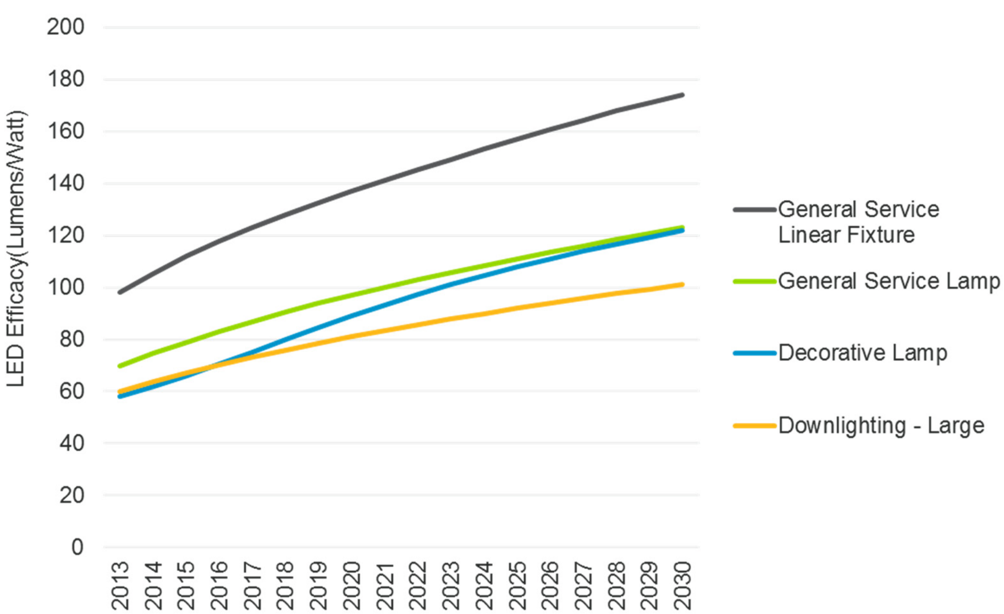
Table 3-13. Hierarchy of Data Sources for Technology Cost Information

Priority	Cost Source Name	Description	Author	Year
1	CA Measure Cost Study	This served as the primary surce of information for equipment and installation costs.	Itron	2012
2	DEER	Navigant used information from 2017/2018 DEER updates for obtaining equipment and labor costs for technologies, wherever available.	CPUC	2016
3	IOU Workpaper [with CPUC Disposition]	Navigant obtained equipment and labor costs from **approved CA IOU workpapers**, in cases where the Navigant team referred to these workpapers for obtaining energy use information.	Calfornia 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	CA IOU Emerging Technology Reports	Navigant obtained cost information on emerging technologies from ETCC technology reports, wherever available.	Emerging Technology Coordinating Council (ETCC); IOUs	Various

Priority	Cost Source Name	Description	Author	Year
6	Non-California source examples: ○ Energy Savings Forecast of Solid-State Lighting in General Illumination Applications[59] ○ Navigant Potential Study Database	For lighting technologies, Navigant referred to a DOE report authored by Navigant for LED cost data (see discussion following table) In cases where no California-specific source was available for costs, Navigant referred to the company's internal database of energy efficient technologies for available cost information.	DOE Navigant	2016 2015-2016

Navigant referred to forecast from the DOE to obtain LED costs.[60] This was done to incorporate cost projections into the model while maintaining consistency across years. Navigant used efficacy (lm/W) and price per kilo-lumen ($/klm) projections to determine current and future costs for LEDs. Figure 3-3 and Figure 3-4 below graphs the projected efficacy and costs of different lamp types of LEDs, respectively, through 2030.

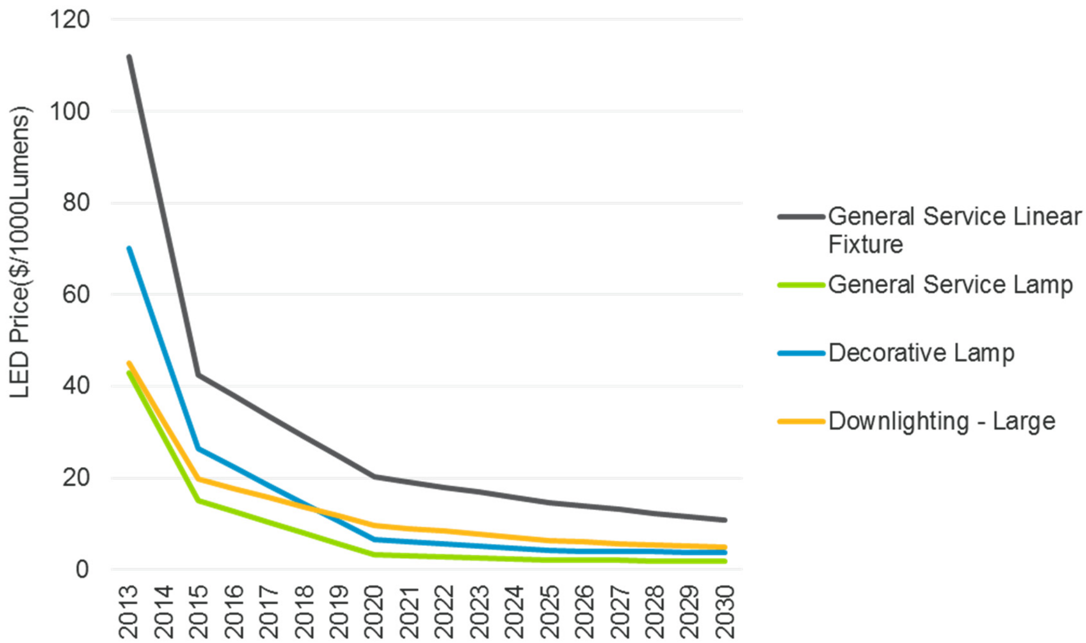
Figure 3-3. Projected LED Technology Improvements, 2013-2030



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

60 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 3-4. Projected LED Cost Reduction Profiles, 2013-2030



3.3.3 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 sq. ft. 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/1000 square feet, tons of cooling/1000 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 3-14 below shows the densities and saturations for residential refrigerators in single-family homes in PG&E's service territory.

Table 3-14. 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 change overs time with population growth and stock turnover as more “below-code” stock gets replaced with “at-code” and “higher efficiency” stock.

Table 3-15 lists the resources used to calculate density and saturation for the residential and commercial sector in 2017, in order of priority. Navigant 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 3-15. 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	2013
3	Residential Appliance Saturation Study (RASS)[61]	Residential end-use saturations for 24,000 households in California.	DNV GL (formerly KEMA)	2009
4	Non-California source examples: ○ 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
	○ Res. Energy Consumption Survey (RECS) ○ Comm. Bldg. Energy Cons. Survey (CBECS)	RECS and CBECS are surveys of residential and commercial building stock in the United States by region. Used West regional data only.	U.S. Dept. of Energy	2009
	○ Energy Star Shipment Database	Unit shipment data of Energy Star-certified products collected to evaluate market penetration and performance	EPA	2003-2016

In addition to the density and saturation values, measure characterization requires specification of 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.

3.3.4 MICS Database

The MICS database consolidates the information from the measure characterization effort and in an Excel spreadsheet that serves as an input to the potential 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.[62]

3.4 Agriculture, Industrial, Mining, and Street-lighting (AIMS) Technology Characterization

The 2018 PG study updated the Agriculture, Industrial, Mining, and Street Lighting (AIMS) sectors, with a heavy focus on the Agriculture and Industrial sector and limited focus on the Mining and Street lighting

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

[62] http://www.cpuc.ca.gov/General.aspx?id=6442452619

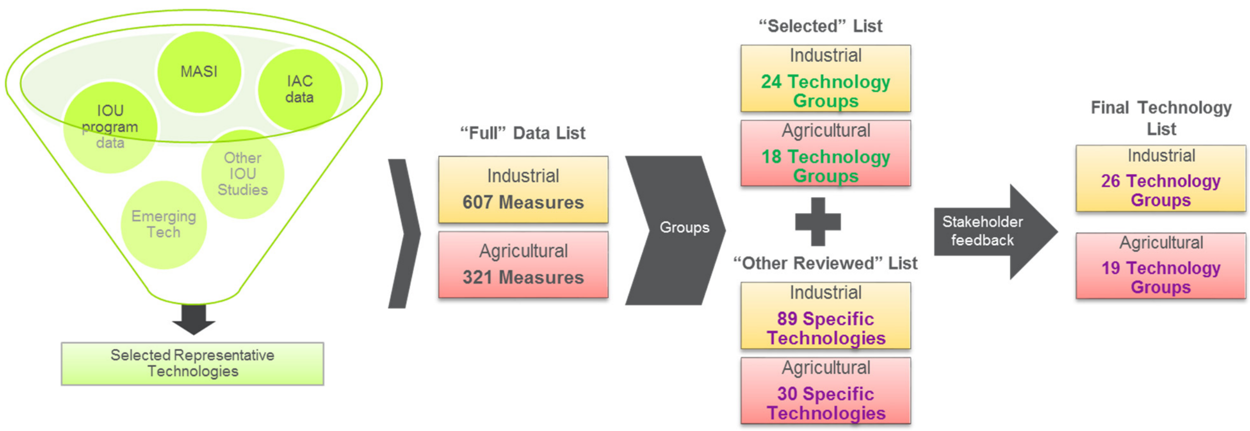
sectors. The Navigant team's approach to each sector's data sources varied. The primary effort for Agriculture and Industrial focused on historical program data to directly relate measures developed for the potential model to IOU program activities. The data approaches to Mining and Street Lighting remain largely consistent with the 2015 PG study, but Navigant reviewed and updated the existing data with new and current sources. The following sections provide additional details about the development of data for the four AIMS sectors. Additional detail on the industrial and agriculture subsectors and measures can be found in Appendix D.

3.4.1 Agriculture and Industrial Sectors

Navigant identified over 900 records[63] in the 2013 to 2015 Energy Efficiency Statistics (EEStats) 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.

The Navigant team presented the list of initial representative technologies to stakeholders during the DAWG meeting in August 2016, 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 EEStats data and recommended a few areas of improvement, including expanding the lighting end-use to cover specific technologies (e.g., LEDs and lighting controls). Figure 3-5 illustrates this technology list development process.

Figure 3-5. Industrial and Agriculture Technology List Development Process



The Navigant team then segmented the final technology list into three categories:

- Discrete **identified deemed** measures, readily defined and forecasted using the diffusion model using deemed savings estimates
- Discrete **identified custom** measures, readily defined and forecasted using the diffusion model using custom savings estimates

[63] Navigant defined a record as a unique EEStats program identification or ProgramID field, e.g., PGE21021.

- **Generic custom** measures included in projects unique to various subsectors that cannot be readily defined at the measure level or forecasted using a diffusion model. Navigant describes the methodology used to characterize these generic custom measures in section 3.5.

3.4.1.1 Agricultural and Industrial Identified Technologies

For the 2018 study, Navigant characterized 19 technology groups for the Agriculture sector, and 26 for the Industrial sector, representing the identified deemed and identified custom measures for the diffusion model (summarized in Table 3-16). Most of these are sourced from the EEStats technologies with other sources informing the development of four technologies, two each for Industrial and Agriculture. 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.

Table 3-16. Final List of Technology Groups and Individual Technologies

Sector	End Use	Technology Group Examples[64]	Number of Technology Groups	Number of Individual Technologies[65]
Agriculture	Machine Drives	Motors, Pumps, Air Compressor Equipment	3	33
	Irrigation Drives	Crop Irrigation, Water Pumping	3	10
	Lighting	Indoor LED Fixtures, Specialty Lamps, Linear Fixtures.	5	92
	HVAC	Air Conditioners, Heat Pumps, Ventilation	1	16
	Process Heating	Greenhouses, Post-Harvest Processing, Drying	3	48
	Process Refrigeration	Milk Cooling, Wine Cooling	3	61
	Other	System Controls and Optimizations	1	9
	Total		**19**	**269**
Industrial	Machine Drives	Motors, Pumps, Air Compressor Equipment	11	145
	Lighting	Indoor LED Fixtures, Specialty Lamps, Linear Fixtures.	3	206
	HVAC	Air Conditioners, Heat Pumps, Ventilation, VAV Systems	5	82
	Process Heating	Boilers, Steam Traps, Insulation, Furnace/Ovens	4	56
	Process Refrigeration	Refrigerators, Refrigeration Controls	1	20
	Other	System Controls and Optimizations	2	6
	Total		**26**	**515**

The Industrial and Agriculture sectors of this 2018 study are informed by 515 individual technologies sourced from EEStats (as listed in Table 3-16). For comparison, the 2015 study was informed by 167 supply curves defining a specific combination of subsector, end-use, measure type, and fuel. As a result,

[64] The complete list of technology groups is presented in the MICS database.

[65] Note that the technology list does not include “Emerging Technologies,” “Interventions (BROS),” or “Generic Custom” technologies. The approach used for selection and characterization of the non-diffusion measures are discussed in separate sections of this report. Please refer to the MICS database for a complete list of technologies included in the study.

the 2018 study has more granular disaggregation of savings opportunities.

3.4.1.2 Technology Characterization

The PG diffusion model required the characterization of a number of technology-level inputs including, unit energy savings, unit costs, and the saturation or density of efficient versions of each technology currently existing in the marketplace. The team mined a number of 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 investor-owned utilities. The team also relied on the Database for Energy Efficiency Resources (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).[66]

Navigant closely reviewed the data sources for agricultural technologies and aggregated common technology details for each input to the diffusion model, including energy savings, costs, effective useful life (EUL), and densities. 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, Navigant utilized other peer group jurisdictions and substituted in California specific variables where possible (e.g., for post-harvest process grain dryers, Navigant reviewed the Wisconsin TRM but substituted California specific data for operating hours, moisture content, and other general drying conditions).[67]

For the industrial technologies, the team used a mix of data sources to characterize the inputs to the diffusion model.

Energy Savings. The 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 is comprised of 24 universities which 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,[68] the specific energy savings the site can expect by 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 identified deemed or identified custom

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[66] https://energy.gov/eere/amo/industrial-assessment-centers-iacs

[67] 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.

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

industrial technologies created from the EEStats database. The team then used NAICS coding to sum the energy savings estimates for each technology to the entire industrial sector level 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.[69] 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 a few industrial technologies. The technologies not included in IAC, but identified in EEStats, were LED Lighting, Injection Molding, and Wastewater Aerators.

Lighting End Use: Navigant leveraged commercial sector data for all industrial and agriculture lighting measures. To account for differences in lighting characteristics between commercial, industrial, and agriculture sectors, the team applied a 50 percent technical suitability factor to the industrial and agriculture savings results for lighting controls.[70]

Injection Molding and Wastewater Aerators: Southern California Edison (SCE) provided work paper data regarding actual savings estimates from the installation of these two technologies, which the team used to estimate sector level savings percentages.

Costs. Navigant primarily used the EEStats database to calculate the incremental cost per unit energy savings for technologies included in the industrial and agriculture analysis.[71] The team multiplied the incremental cost per unit by the technology energy savings to estimate technology costs.

EUL and NTG. Navigant used the EEStats database to calculate the EUL and net-to-gross (NTG) ratios for all technologies included in the industrial technology list.

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 their 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

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[69] 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.

[70] The 50% suitability factor identifies the amount of lighting that is available for controls. Based on professional judgement, Navigant assumes that half25% of industrial and agriculture lighting cannot be controlled due to various operational considerations.

[71] The costs in EEStats include labor to represent the full incremental cost of implementation. 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.

receiving a recommendation for a technology).[72] 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.

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

3.4.2 Mining Sector

The PG Model and the updates for the 2018 effort rely on the mining sector inputs established in previous studies.[73] Navigant 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.[74] 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.[75]

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 saturations of efficient equipment.

3.4.3 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.[76] 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.[77] The PG Model outputs reflect potential energy savings associated only with customer-owned lamps (LS-2 rate schedule). However, Navigant gathered data on IOU-own lamps (LS-1 rate schedule) to aid with data vetting and quality control.

The IOU street lighting inventories inform several model inputs including equipment stocks, densities, and saturations of efficient equipment. Finally, Navigant 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.[78]

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[72] 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 they already have the efficient version of the recommendation installed).

[73] http://www.cpuc.ca.gov/General.aspx?id=2013

[74] http://www.conservation.ca.gov/dog

[75] http://www.conservation.ca.gov/dog/pubs_stats/annual_reports/Pages/annual_reports.aspx

[76] http://www.cpuc.ca.gov/General.aspx?id=2013

[77] Example from SCE: https://www.sce.com/NR/sc3/tm2/pdf/ce37-12.pdf

[78] 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

3.5 Industrial and Agriculture Custom Technologies Data Sources

This section describes the data sources used to characterize the custom and emerging technologies for the Industrial and Agriculture sectors.

3.5.1 Generic Custom Measures

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 report IOU tracking data and they present several challenges within a potential forecast, including:

- 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 with little to no engineering details, market parameters, or work papers

Generic custom measures make-up a significant portion of the energy efficiency program portfolio. Based on an analysis portfolio level EEStats data for the 2013 and 2014 portfolio, generic custom accounted for 36% of industrial savings and 58% of agricultural sector savings.

The 2018 potential model treats generic custom measures as a specific measure class. Table 3-17 provides the inputs for electricity and natural gas for these measures. Navigant 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 does provide separate UES estimates for the industrial and agricultural market sectors. The team calculated the EUL for these measures at 15 years since they tend to be larger capital investments with long operating lives. Costs for electricity and natural gas savings are $0.33 /kWh and $2.25/therm. Navigant applied cost and EUL values consistently across market segments within the industrial and agricultural sectors and across utilities.

Table 3-17. Generic Custom Measures - Key Assumptions

Sector	Type	EUL years	Savings Range		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
AIMS	Generic Custom	15	0.16% (Ind) 0.28% (Ag)	0.17% (Ind) 1.19% (Ag)	$0.33	$2.25	0.000195

Source: Navigant team analysis

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. Because the forecasting approach assumes generic custom measures will produce a static level of savings each year, penetration rates are meant to ultimately reflect current savings levels and do not vary over the forecast period. Penetration rates were held constant over the forecast horizon because industrial facilities continually upgrade equipment and processes and it is likely that generic custom measures will be installed at the same rate as past program activity.

Savings from generic custom measures are based on an analysis of portfolio level savings from data available through the California EEStats portal[79] for programs operating from 2006 through 2015. Over this period, generic custom measures contributed 42% of industrial and 62% of agricultural sector net electricity savings, with similar percentage contributions for natural gas. Navigant based the savings values in the 2018 PG model on an analysis of generic custom measures savings in EEStats for the 2013 and 2014 program years. Data for these program years provided the level of detail necessary to separate generic custom measures from savings attributable to deemed measures, or other custom measures that could be defined and modelled using a diffusion approach.

Using historic savings values defined by the analysis of EEStats data and sector level consumption forecasts provided by CEC, the team determined that generic custom measures would save roughly 0.16% and 0.17% of annual Industrial sector electricity and natural gas usage, respectively. Using a similar methodology, Navigant forecasted savings from generic custom measures in the Agricultural sector at 0.28% of annual electricity consumption, and 1.19% of annual gas usage. These percentages are used in both the reference or aggressive cases and remain constant throughout the forecast horizon. 5.Appendix F provides addition details on the generic custom analysis and forecast methodology.

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. They are estimated at $0.33/kWh and $2.25/therm, and they are applied consistently across sectors and utilities through the 2018 study forecast horizon.

3.5.2 Emerging AIMS Technologies

New emerging technologies (ET) to reduce energy use and energy demand are continually being introduced in the California marketplace. For the 2018 study, Navigant initially identified approximately 1,500 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 169 emerging technology processes[80] for final consideration within the model. For a summary of the ET literature reviewed, and details on screening process and how this was used to define sub-sector potential, see Appendix F.

Table 3-18 summarizes the resulting savings and cost factors. Navigant applied segment-specific electric and gas savings, as well as costs, EUL, and the kW/kWh savings ratio consistently across all utilities.

Table 3-18. Emerging Technologies - Key Assumptions

Sector	Type	EUL years	Savings Range (Percent of Building Energy Consumption)		Cost		kW/kWh Savings Ratio
			kWh	Therm	kWh	Therm	
AIMS	Emerging Technologies	15	0.18% - 4.8%	0.44% - 9.5%	$0.42	$2.83	0.000195

Emerging technologies apply to different industrial and agricultural sectors in varying degrees. However, because Navigant conducted sector-specific technology applicability calculations during the screening process, the team assigned each sector a 100% eligibility factor for modeling purposes. This was

[79] http://eestats.cpuc.ca.gov/Default.aspx

[80] The emerging “technologies” represent a process for reducing energy consumption and not necessarily a specific technology.

possible because the forecasted savings for that sector are derived only from those technologies that are relevant to the end uses within that respective industrial or agricultural sector.

Electric savings range from 0.18% to 4.8%, with an average of 1.74%. Natural gas savings range from 0.44% to 9.5%, with an average of 3.99%.

The model uses a universal EUL of 15 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 same value used for SEM, and it based on an analysis of several third-party SEM programs operating in California during the 2014-2015 portfolio cycle. Actual ET-specific EULs and kW/kWh are presently unknown and can be refined during future ET market studies as additional information becomes available.

Adoption of future ETs will vary by technology. Some ETs will gain widespread customer acceptance and capture broad market share based on price, energy savings, and other customer-driven factors, while other ETs will see a more limited adoption. Although Navigant 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 ETs. As such, penetration forecasts for both the industrial and agricultural sectors begin with a saturation level of 1% for the reference case and follow a compound annual growth rate of 2.95%, yielding a target saturation of 21.17% by 2030. The 2030 target saturation of the portfolio of AIMS relevant ETs of approximately 20% 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.

Navigant estimated costs for electricity and natural gas ET 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 derives UES values and costs for ET measure can be found in Appendix F.

3.6 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 2018 Study models whole building initiatives via the technology levels indicated in Table 3-19. As described in section 2.1.1.2, the technology levels within the technology group include existing baseline, code baseline, and the efficient result of a whole building initiative.

Table 3-19. 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
	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, 2017.

The Navigant team presented measures and methodology overviews at the Demand Analysis Working Group (DAWG) Meeting on November 4, 2016 and requested additional data sources of stakeholders. No additional data sources were provided to support this analysis. The following sections discuss the technology levels used in the 2018 Study. The final values for savings, cost, measure life, and other key model inputs can be found in the MICS spreadsheet.

3.6.1 New Construction

The 2018 Study refines results to represent 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. Though analysis is ongoing, communications with the CEC indicate that 10 percent energy savings are expected for 2019 Title 24 over 2016 Title 24.

3.6.1.1 Commercial

Table 3-20 provides the sources for the characterization of commercial new construction whole building initiatives. These represent the best and usable data sets 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 3-20. 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 T24
	Incremental Cost of ZNE over 2013 Title 24	Calculated using the following: New Building Institute, Getting to Zero 2012 Status Update: A First Look at the Costs and Features of Zero Energy Commercial Buildings: 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	California Energy Commission, 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 California Energy Commission, January, 2017.
	Incremental Energy Savings of ZNE over 2013 Title 24	ARUP, The Technical Feasibility of Zero Net Energy Buildings in California, December, 2012.

3.6.1.2 Residential

Table 3-21 provides the sources for energy consumption and cost data. By using the percent savings values rather than absolute energy consumption reported by different sources, the 2018 Study accounts for inconsistencies in simulation assumptions across data sources. This results in lower electricity consumption and higher natural gas consumption in comparison to the 2015 Study.

Table 3-21. Residential 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 T24
	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	California Energy Commission, 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	California Energy Commission, CBECC-Res 2013 Std. Design Results, 2015.
	2016 Title 24 Energy Consumption	California Energy Commission, CBECC-Res 2016 Std. Design Results, January, 2017.
	Incremental Energy Savings of 2019 Title 24 over 2016 Title 24	Communications with the California Energy Commission, January, 2017.
	Incremental Energy Savings of ZNE over 2013 Title 24	ARUP, The Technical Feasibility of Zero Net Energy Buildings in California, December, 2012.

3.6.2 Retrofit

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

3.6.2.1 Commercial

In the 2015 Study, bundles of electric and gas measures were assembled from the MICS to represent the weighted average installation of measures by a typical participant. This 2018 Study moves away from this bottom-up approach, and instead uses a top-down approach with a goal of saving 15 percent of consumption at the whole building level. This target was selected in response to feedback collected at the November DAWG Meeting 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 reflect deeper energy savings from multi-measure approaches.[81]

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.[82] Figure 3-6 uses the example of colleges in PG&E's territory to demonstrate the calculations conducted for each building type to ensure feasibility of the 15% savings target. After defining the total savings target, these savings are distributed among the end uses listed above. The distribution was derived by starting with the percent savings exhibited by each end use in the 2013-2015 California energy efficiency portfolio. These had to be modified in an iterative process using the following parameters to ensure that reasonable savings were expected from each end use: Navigant kept savings at or below 50% for lighting and at or below 20% on all other end-uses with minimal exceptions.

Figure 3-6. Whole Building Retrofit Savings Calculation and Viability Check

How much energy does each end use consume?	
End Use	Energy Intensity
Ext. Lighting	0.77 kWh/sf
…	…
Total	**11.87 kWh/sf**

Total Savings Target =
Total Energy Intensity x 15% =
1.78 kWh/sf

Where should savings come from?		How much savings should come from each end use?		Is that an achievable percent savings at each end use?	
End Use	Targeted Savings Distribution	x Total Savings Target	Targeted Savings	÷ Energy Intensity	Check
Ext. Lighting	16%		0.28 kWh/sf		✓ 37%
…	…		…		…
Total	**100%**		**1.78 kWh/sf**		**Criteria:** Lighting: <50% Other: <20%

Costs were applied to these energy savings using an average unit energy savings ($/kWh or $/therm) associated with each end use across the 2013-2015 California energy efficiency portfolio. The data

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

[82] With the exception of gas savings at dual fuel utilities for the following building types: office, retail, school, and health

sources listed in Table 3-22 were used for this analysis. This approach yields increased demand savings and comparable energy savings to the 2015 Study analysis.

Table 3-22. Commercial Retrofit Whole Building Data Sources

Data Items	Data Sources
Energy Intensity by End-Use and Building Type	California Energy Commission, California Commercial End-Use Survey, March, 2006.
Floorspace	California Energy Commission, 2016 Integrated Energy Policy Report.
Costs	California Public Utilities Commission, California Energy Efficiency Statistics, 2013-2015 Program Cycle.

3.6.2.2 Residential

Table 3-23 provides the sources of data used in characterizing the Energy Upgrade California program. Costs were applied to the energy savings using an average unit energy savings ($/kWh or $/therm) as derived from the program metrics reported by all Energy Upgrade California IOU programs. The 2018 Study results indicate higher multifamily costs than the 2015 Study as well as higher energy savings.

Table 3-23. Residential Retrofit Whole Building Data Updates

Data Items	Data Sources
Single Family Savings	DNV GL, Focused Impact Evaluation of the 2013-2014 Home Upgrade Program, CALMAC ID: CPU0118.01. http://www.calmac.org/publications/CPUC_HUP_Focused_Evaluation-FINAL_05-03-16atr.pdf
Multifamily Savings	Apex Analytics, Draft Results of 2015 Impact Evaluation.
Costs	California Public Utilities Commission, California Energy Efficiency Statistics, 2013-2015 Program Cycle.

3.7 Codes and Standards

C&S modeled in the PG study use data from multiple sources. For evaluated C&S the 2018 PG Model uses ISSM[83] as its data source. For certain unevaluated C&S, the 2018 PG model uses data provided by PG&E[84]. For all other C&S, the 2018 PG Model uses data from the 2015 Potential and Goals Study[85] or additional assumptions made by Navigant.

Table 3-24 lists the number and type of codes and standards 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) are listed in Appendix E.

[83] Cadmus and DNV GL. *Integrated Standards Savings Model (ISSM)*. 2017.

[84] Julie Liberzon. PG&E. January 3, 2017. Personal email communication in response to CPUC data request.

[85] Navigant Consulting, Inc. *Energy Efficiency Potential and Goals Study for 2015 and Beyond*. September 2015.

Table 3-24. 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
2015-2016 Title 20	14 appliance standards	PG&E
Future Title 20	15 appliance standards	PG&E, 2015 Model, Navigant Estimates
Federal	50 appliance standards	ISSM, PG&E, 2015 Model
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	PG&E
Future Title 24	5 building codes	Navigant Estimates

Sources: Cadmus and DNV GL. Integrated Standards Savings Model (ISSM). 2017.; Julie Liberzon. PG&E. January 3, 2017. Personal email communication in response to CPUC data request.

The 2018 study made several adjustments to the data obtained:

- An uncertainty factor of 80% was applied to all unevaluated C&S.
- IOUs provided claims for "T20 LED Quality" standards. This is a voluntary standard and thus was removed from the forecast to err on the side of conservatism.
- Per guidance from Cadmus, several 2013 Title 24 codes were removed from the analysis because their savings were already included in Whole Building codes[86].

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[87]. "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 2018 PG study uses bounded values from ISSM.

The 2018 study re-evaluated the percentage of C&S savings that occurs in new construction vs. building retrofits. The 2015 study assumed new construction percentages of 0-2% for appliance standards and 100% for building codes. The 2018 study, on the other hand, used new construction percentages for 2005 and 2008 Title 24 evaluated measures from the 2010-2012 impact evaluation report[88]. For 2013 Title 24, each evaluated code name specified whether it was for new construction. For Title 20 and federal standards, the 2018 study calculated new construction percentages based on the average new

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

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

[88] Cadmus, Energy Services Division and DNV GL. Statewide Codes and Standards Program Appendices to Impact Evaluation Report for Program Years 2010-2012. August 2014.

construction rate for each standard's sector and the retrofit lifetimes for each standard, as shown in Equation 3-1.

Equation 3-1. C&S New Construction Percentage

$$New\ Construction\ Percentage = \frac{Sector\ Population\ Annual\ Growth\ Rate}{{}^{1}\!/_{Measure\ EUL}}$$

The 2018 study determined new energy savings estimates for future Title 24 codes in 2019. The 2018 study has unit energy savings (UES) inputs for 2013 and 2016 Title 24 from ISSM and PG&E data sources. The 2018 study also had whole building energy use values for 2013, 2016, and 2019 Title 24 (discussed in further detail in section 3.6.1). The team therefore used UES values and ratios of consumption values to estimate 2019 Title 24 UES for C&S analysis using Equation 3-2.

Equation 3-2. 2019 Unit Energy Savings

$$2019\ UES = \frac{(1 - 2016\%savings) \times (2019\%savings)}{(2016\%savings)} x\ 2016\ UES$$

Where

2019%savings = expected percent savings of a 2019 T24-compliant relative to a 2016 T24-compliant building

2016%savings = expected percent savings of a 2016 T24-compliant relative to a 2013 T24-compliant building

Table 3-25 shows the savings percentages used in Equation 3-2.

Table 3-25. 2016 and 2019 Savings Percentages

Building Type	Impact Type	Year	Savings Percentage
Residential Multi Family	Electric Energy (kWh/year)	2016	34.5%
Residential Multi Family	Electric Energy (kWh/year)	2019	10%
Residential Multi Family	Electric Demand (kW)	2016	27.3%
Residential Multi Family	Electric Demand (kW)	2019	10%
Residential Multi Family	Gas Energy (Therms/year)	2016	31.2%
Residential Multi Family	Gas Energy (Therms/year)	2019	10%
Residential Single Family	Electric Energy (kWh/year)	2016	14.1%
Residential Single Family	Electric Energy (kWh/year)	2019	31.8%
Residential Single Family	Electric Demand (kW)	2016	11.7%
Residential Single Family	Electric Demand (kW)	2019	32.9%
Residential Single Family	Gas Energy (Therms/year)	2016	12.4%
Residential Single Family	Gas Energy (Therms/year)	2019	32.5%
Commercial	Electric Energy (kWh/year)	2016	4.6%
Commercial	Electric Energy (kWh/year)	2019	10%
Commercial	Electric Demand (kW)	2016	4.4%
Commercial	Electric Demand (kW)	2019	10%
Commercial	Gas Energy (Therms/year)	2016	4.6%
Commercial	Gas Energy (Therms/year)	2019	10%

Source: Navigant analysis.

Title 24 codes beyond 2019 (for example, the 2022, 2025, and 2028 cycles) were not considered in the 2018 study forecast due to the highly uncertain nature of their savings. While California has a goal of all new commercial construction to be ZNE by 2030, the regulatory path towards requiring this by 2030 is uncertain. The 2015 study included a preliminary estimate of the savings from 2022 T24 using a similar process to Equation 3-2 above. However, that estimate was ultimately excluded from the goal setting process. The updated assumptions used for 2019 T24 made in this study would necessarily change what remaining savings can be obtained from 2022 T24. However, CEC staff were unable to provide guidance on what savings may remain for 2022 T24.

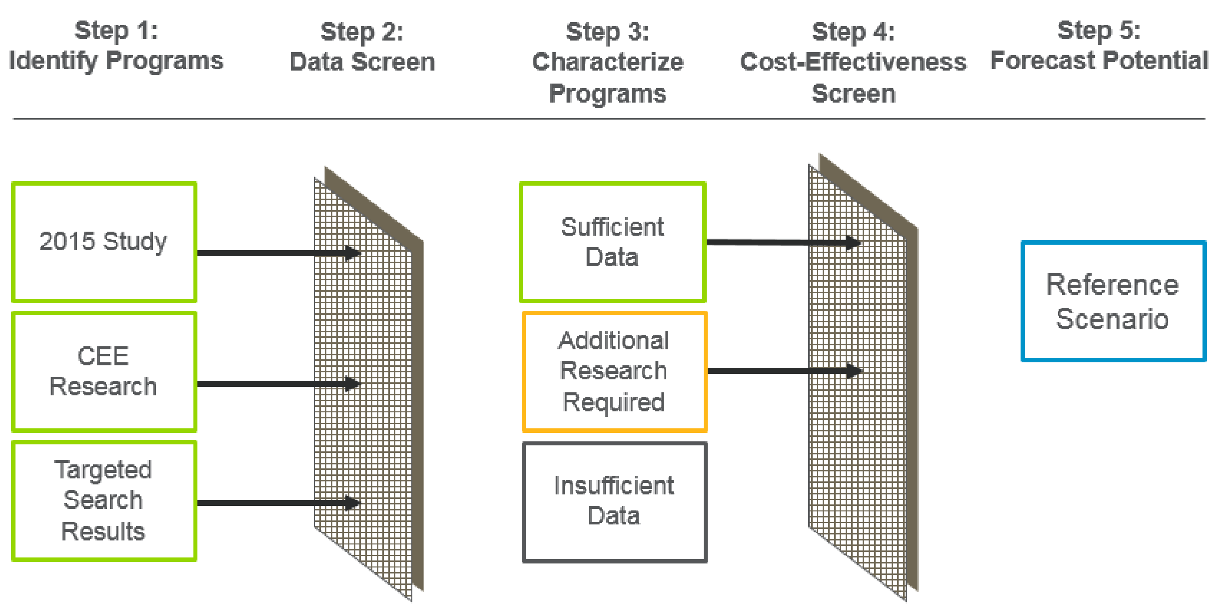
The 2015 study applied a reduction factor to the number of units for 2013 and later Title 24 to account for the recession. The 2018 study removed the reduction factors after confirming with Cadmus that the 2013 Title 24 ISSM analysis[89] already accounted for the recession.

[89] Cadmus and DNV GL. Integrated Standards Savings Model (ISSM). 2017.

3.8 Behavior, Retrocommissioning, and Operational (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, we cast the net wide in consideration of interventions and coordinate with stakeholder through the Demand Analysis Working Group. Figure 3-7 illustrates the five-step selection process used to determine intervention types to include in the reference case scenario.

Figure 3-7. Selection Process for Residential and Commercial BROs Energy Efficiency 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 our existing knowledge base drawn from the 2015 study and the AB802 TA with additional findings from numerous Navigant 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, we sought out formal evaluation findings wherever possible—particularly evaluations of programs run by the four California investor owned utilities—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 were 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 were more often scarce. So, in some cases we extrapolated or estimated based on a limited number of data points.

Penetration rates were calculated based on relevant EM&V reported program participation rates for current California IOU program offerings and reported participation in programs in other states.

We modeled an EUL of one year for residential programs. Commercial programs used a two or three year EUL, per CPUC Decision 16-08-019, unless evidence supported a longer duration.

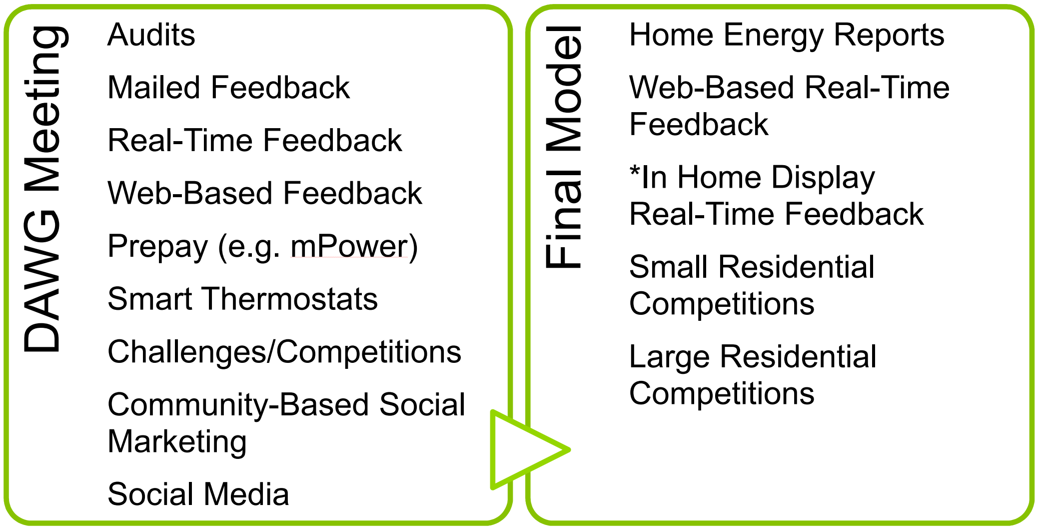
Specific modelling inputs for each intervention type are discuss in detail in Appendix C.

Step 4. Cost Effectiveness Screen. The cost-effectiveness screen used the total resource cost (TRC) test – the most conservative of the cost-effectiveness tests used in the 2018 Study – and the latest CPUC-approved avoided costs for each utility. This screen was used to eliminate measures 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 upon program operations and whether participation is utility driven (opt-out) or customer driven (opt-in). The forecasted penetration rates were adjusted to represent a reference and an aggressive scenario.

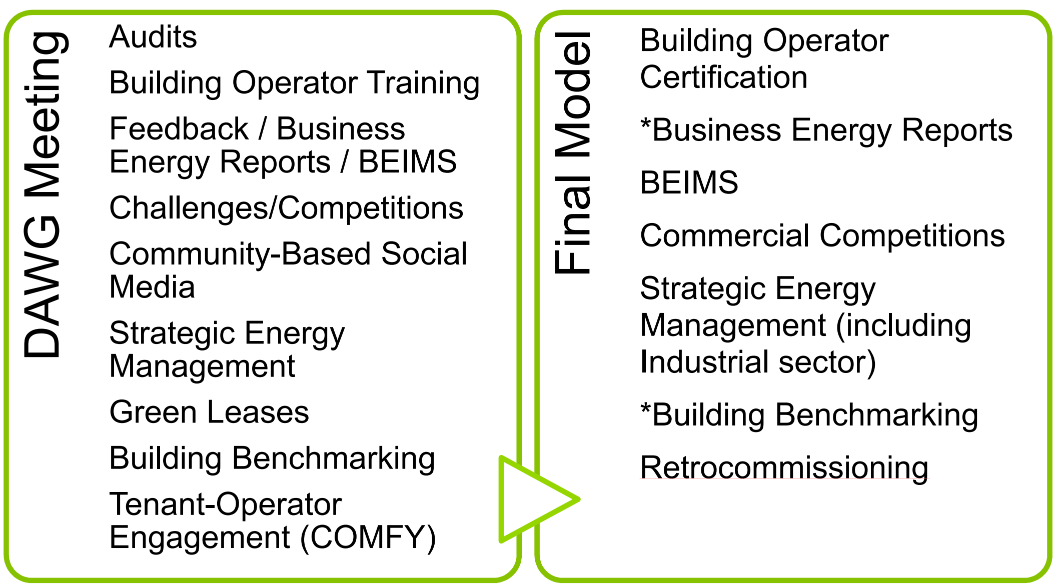
The results of Step 1 were presented at the DAWG meeting held in San Francisco on November 4, 2016. Feedback from stakeholders on these interventions was requested during the meeting, but none was subsequently submitted. Several of the originally-considered behavior intervention types were eliminated after completing the five-step selection process due to insufficient data. Thus, the 2018 Study ultimately includes the programs shown in Figure 3-8 and Figure 3-9. A more detailed description of each of the final intervention types follows in Table 3-26.

Figure 3-8. Residential BROs



*Note: Removed from the reference case scenario due to low cost effectiveness.

Figure 3-9. Commercial BROs



*Note: Removed from the reference case scenario due to high uncertainty.

Table 3-26. Behavioral Intervention Summary Table

Sector	Type of Behavioral Intervention	Brief Description	EUL (years)
RES	Home Energy Reports (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 energy efficiency, and occasionally messaging about rewards or incentives.	1
RES	Web-Based Real Time Feedback (Web RTF)	Real time information and feedback about household energy use provided via websites or mobile apps	1
RES	In-Home Display Real Time Feedback (IHD RTF)	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
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 business to provide feedback about their business's energy use, including normative comparisons to similar businesses, tips for improving energy efficiency, 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 upon energy consumption. It also often includes goal setting and rewards in the form of recognition.	2
COM/IND/AG	Strategic Energy Management (SEM)	Strategic Energy Management 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

Sector	Type of Behavioral Intervention	Brief Description	EUL (years)
COM	Building Energy Information Management Systems (BEIMS)	Building Energy Information Management Systems 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 Stakeholder Input

Stakeholders and members of the DAWG were given the opportunity to provide informal feedback to the team following a webinar presentation of draft results on April 20, 2017. Navigant also made revisions based on feedback received following the June 2017 draft release and August 2017 final release. Table 3-27 contains a high-level summary of relevant stakeholder feedback received and Navigant responses.

Table 3-27. Stakeholder Feedback

Stakeholder Comments	Additional Context from Navigant
General	
• Reduce near-term potential to reflect uncertainty. • Provide a high-level assessment of data quality and recommendations for further research to improve estimates of potential. • Explicitly address potential double-counting of savings among interventions in the same sector. • Reflect the non-linear scaling of costs.	• Table 3-28 provides a high-level assessment of data quality, and the general recommendation is to focus future research on initiatives with high potential savings, but a low level of data rigor. • The methodology employed in this study does not account for non-linear cost scaling as sufficient data was not available.

Stakeholder Comments	Additional Context from Navigant
Residential Programs	
• IOUs contributed additional data that helped tailor the analysis of each residential program. • Concern was raised that savings forecasted in this study may already have been claimed as part of the rollout of Smart Meters. • Concerns were expressed that the penetration of web-based real-time feedback was not representative of an opt-in program. • Concerns were raised by SCG regarding the ability to ramp up HERs programs from existing pilots	• Double counting in the residential sector was determined not to affect the achievable savings because the programs target different behavior changes. • As the utilities have not decreased their claimed savings as a result of Smart Meters to-date, no such reduction was included in this modeling effort. • The penetration of web-based real-time feedback was adjusted to reflect more conservative estimates. • Forecast reflects a 3-year ramp period for SCG HERS programs starting in 2018
Commercial Programs	
• IOUs contributed additional data that helped tailor the analysis of several commercial programs. • Commercial Competitions drew heavy criticism for its high forecasted potential and low data rigor. • It was suggested that unit energy savings for BEIMS increase over time to reflect improvements to data analytics and software algorithms (e.g., machine learning). • The potential for claimed savings from Building Benchmarking was questioned in light of related government requirements. • A CPUC decision allows for recommissioning after 5 years.	• Double counting concerns were addressed by adjusting the penetration of recommissioning after all other revisions were made. All other penetration is considered independent. • Business Energy Reports were removed from the reference scenario. • Penetration of BOC, BEIMS, and Retrocommissioning was delayed until 2018 for SoCalGas. • The savings associated with Commercial Competitions was lowered to reflect IOU analysis presented. • Energy savings of BEIMS was not increased over time due to a lack of data and to maintain a conservative forecast. • Building Benchmarking was removed from the reference scenario. • Recommissioning was added to the characterization of the Retrocommissioning program.

3.8.2 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 3-28 provides a snapshot of the quality of data collected for this study. Across the board, demand savings data is often very 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.

We recommend 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: strategic energy management, building benchmarking, competitions, web based feedback, and in-home real time feedback.

Table 3-28. Qualitative Assessment of Data Quality

Sector	Program	Savings			Cost	Applicability	Participation Rate	Penetration Forecast
		kWh	therms	kW				
Res	Home Energy Reports	Green	Green	Green	Green	Yellow	Green	Green
	Web-Based Real-Time Feedback	Yellow	Yellow	Red	Yellow	Green	Red	Red
	In Home Display Real-Time Feedback	Yellow	Yellow	Red	Green	Green	Green	Green
	Small Residential Competitions	Yellow	Yellow	Red	Yellow	Green	Yellow	Red
	Large Residential Competitions	Green	Yellow	Red	Yellow	Green	Green	Red
Com	Building Operator Certification	Green	Green	Red	Red	Green	Red	Red
	Business Energy Reports	Green	Green	Red	Red	Green	Red	Red
	BEIMS	Green	Green	Green	Green	Green	Green	Red
	Commercial Competitions	Green	Green	Red	Yellow	Red	Green	Red
	Strategic Energy Management	Yellow	Red	Red	Red	Green	Red	Red
	Building Benchmarking	Yellow	Yellow	Red	Green	Green	Red	Red
	Retrocommissioning	Green	Green	Green	Green	Green	Green	Red
Legend								
Green	California program data and its derivatives, IOU feedback to Webinar on April 20, or detailed analysis							
Yellow	Aggregated reports and non-verified savings reported by utilities outside of California							
Red	Assumed equivalence to similar programs and other forms of professional judgement							

3.9 Low Income Programs

Data for Low Income Programs was primarily obtained from the IOUs via a formal data request. The first round of data provided by the IOUs was summarized by Navigant in a public workshop through the Demand Analysis Working Group on April 28, 2017. The workshop noted several minor gaps in data received. Discussion during and after the workshop releveled that additional information was available from the IOUs to fill these gaps. The final data provided by the IOUs is reflected in this report and can be found in Appendix G.

3.9.1 Households Treated

The IOUs provided planned household participation for first time treatment and retreatment in their Low Income Programs. The primary eligibility criteria for ESAP first time participants are that they must live in a house, mobile home or apartment that is at least five years old and must meet income guidelines which are the same as those for the California Alternative Rates for Energy (CARE) program. Decision 16-11-022 also defines various criteria for retreatment eligibility. Based on these criteria, California's four IOUs forecasted ESAP eligibility and participation at the household (HH) level including:

- Installation forecasts by HH type for single family, multifamily, and manufactured homes
- First time HH installation forecasts for program years 2017 through 2020
- Retreatment HH installation forecasts for program years 2017 through 2030

All IOUs provided HH type forecast for first and retreatment households, though only SCG and SDG&E provided guidance on HH retreatment forecasts from 2017 to 2030, as allowed by the Decision. PG&E and SCE only provided retreatment HH forecasts for 2017 through 2020, and the 2018 PG model therefor forecasts retreatment HH for PG&E and SCE using the assumption that participation rate holds constant from 2020 through 2030 (similar to was SCG and SDG&E assume).

3.9.2 Unit Energy Savings

Consistent with Navigant's past forecasts of low income sector potential, the forecast is based on a unit energy savings (UES) that is defined at the household level. Throughout April and May of 2017 the CPUC Energy Division and Navigant Consulting Inc. engaged California's four IOUs in several data requests to provide the UES estimates for KWh, KW, and Therms used in the 2018 PG model, including:

- UES values for first time installations by HH type for single family, multifamily, and manufactured homes
- UES value for retreatment installations by HH type for single family, multifamily, and manufactured homes

All IOUs provided UES estimates by HH type for first time and treatment installations. PG&E, SDG&E, and SCG also provided estimated useful life (EUL) values by HH type which ranged between 8 and 14 years. SCE declined to provide an EUL estimated and the 2018 PG model uses an average of EUL estimated provided by the other IOUs, ranging between 10.8 and 11.9 years, depending on the household type and treatment. All IOUs concurred with the CPUC-ED and Navigant guidance that a net-to-gross of 1.0 is appropriate for the low-income sector forecast.

3.10 Energy Efficiency Financing

The CPUC has recognized financing as an energy efficiency resource program.[90] 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*.*

3.10.1 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 lenders[91].

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[90] CPUC Decision 12-05-2015, May 8, 2012 and Decision Approving 2013-14 Energy Efficiency Programs and Budgets, October 9, 2012

[91] REEL Lenders Chart. Available at: http://www.thecheef.com/lender-chart

Table 3-29. 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.*

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 Residential Energy Efficiency Loan (REEL) Program. Based on this information, Navigant assumed an interest rate of 6% for residential energy efficiency loans in the cash flow model.

Loan term

The loan term is the length of time of the loan agreement. REEL Program loans offer terms up to 15 years[92]. 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.

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 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 seven percent for benefit-cost analysis, and the U.S. Department of Energy (DOE) uses 3 percent and 7 percent in the analyses for residential appliance standards.[93] Other government organizes 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 energy efficiency and found that “a simple

[92] Ibid.

[93] For example, see: http://www.gao.gov/assets/690/682586.pdf

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".[94] Based on these considerations, Navigant used a consumer discount rate of seven percent for the financing model.

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 multi-family sector in the 2013 and 2015 Potential Studies, Navigant estimated multi-family sector eligibility to be 5% based on the proportion of the segment that is affordable housing.[95]

In summary, the Navigant team used the following inputs for the residential cash flow model:

Table 3-30. 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

Navigant analysis of the Regional Finance Program Attribution and Cost-effectiveness Study: Evaluation Plan

3.10.2 Commercial Inputs

Interest rate

Non-residential customers can access zero-percent financing through the statewide OBF program. The projects are designed to be bill neutral, such that the monthly payment is less than

[94] 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.

[95] 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.

the projected energy savings.[96] 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.

Loan term

The OBF program offers zero-percent financing for loans up to five years for the small and large commercial sector, and up to ten years for the government sector. Given that our model doesn't distinguish between the commercial and government sector, we apply a single assumption for the commercial sector.

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:

Table 3-31. Key Inputs to Commercial and Industrial (C&I) Financing Cash Flow Model

Model Input	Assumption	Source
Interest Rate	0%	California on-bill financing (OBF) program terms
Loan Term	5 years	California on-bill financing (OBF) program terms
Discount Rate	5.8%	2016 LBNL Commercial Discount Rate Estimation for Efficiency Standards

[96] SEEaction OBF report, Appendix A https://www4.eere.energy.gov/seeaction/system/files/documents/publications/chapters/onbill_financing_appendix.pdf

4. 2018 STUDY RESULTS

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 our potential study, and not to establish goals as 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 our study.

Graphs in this section focus on electric and gas savings. Peak demand savings are not illustrated though 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 4-1 through Table 4-3 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 parameter discussed earlier in section 2.3.2. Additional discussion of the variation in rebate program savings by scenario can be found in 4.1.3
- BROs savings vary only in terms of Reference vs. Aggressive. Thus, four of the five scenarios have the same forecast of BROs savings. Additional discussion of the variation in BROs savings by scenario can be found in 4.1.4.
- Codes and Standards and Low Income Savings do not vary by scenario.

Total savings are dominated 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 4-1. Statewide Net Incremental Electric Savings by Scenario

Electric Energy (GWh/year)													
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
TRC | Reference													
Equipment Rebates	622	671	644	712	727	744	778	798	814	820	828	830	830
BROs	213	270	302	338	363	388	414	451	482	514	547	582	613
Low Income	57	57	57	33	33	33	33	33	33	33	33	33	33
Incentive Programs (Subtotal)	893	999	1,003	1,082	1,123	1,165	1,225	1,282	1,329	1,367	1,408	1,445	1,476
C&S*	1,212	1,257	1,266	1,304	1,269	1,406	1,347	1,299	1,218	1,173	1,067	966	864
Total	**2,104**	**2,256**	**2,269**	**2,386**	**2,392**	**2,572**	**2,572**	**2,581**	**2,547**	**2,540**	**2,475**	**2,411**	**2,340**
mTRC (GHG adder 1) | Reference													
Equipment Rebates	663	729	703	772	781	797	838	849	848	850	855	855	853
BROs	213	270	302	338	363	388	414	451	482	514	547	582	613
Low Income	57	57	57	33	33	33	33	33	33	33	33	33	33
Incentive Programs (Subtotal)	933	1,056	1,061	1,143	1,177	1,218	1,284	1,333	1,363	1,397	1,435	1,470	1,498
C&S*	1,212	1,257	1,266	1,304	1,269	1,406	1,347	1,299	1,218	1,173	1,067	966	864
Total	**2,145**	**2,314**	**2,328**	**2,447**	**2,446**	**2,624**	**2,632**	**2,632**	**2,581**	**2,571**	**2,502**	**2,435**	**2,362**
mTRC (GHG adder 2) | Reference													
Equipment Rebates	676	728	735	833	853	878	894	916	929	930	935	937	931
BROs	213	270	302	338	363	388	414	451	482	514	547	582	613
Low Income	57	57	57	33	33	33	33	33	33	33	33	33	33
Incentive Programs (Subtotal)	946	1,055	1,094	1,203	1,249	1,298	1,341	1,400	1,444	1,477	1,515	1,552	1,577
C&S*	1,212	1,257	1,266	1,304	1,269	1,406	1,347	1,299	1,218	1,173	1,067	966	864
Total	**2,157**	**2,312**	**2,360**	**2,507**	**2,518**	**2,705**	**2,688**	**2,699**	**2,662**	**2,651**	**2,582**	**2,517**	**2,441**
PAC | Reference													
Equipment Rebates	848	891	856	936	948	960	963	971	971	974	975	972	966
BROs	213	270	302	338	363	388	414	451	482	514	547	582	613
Low Income	57	57	57	33	33	33	33	33	33	33	33	33	33
Incentive Programs (Subtotal)	1,118	1,218	1,214	1,306	1,344	1,381	1,410	1,455	1,486	1,521	1,556	1,587	1,611
C&S*	1,212	1,257	1,266	1,304	1,269	1,406	1,347	1,299	1,218	1,173	1,067	966	864
Total	**2,330**	**2,475**	**2,481**	**2,610**	**2,613**	**2,787**	**2,758**	**2,753**	**2,703**	**2,694**	**2,622**	**2,553**	**2,476**
PAC | Aggressive													
Equipment Rebates	896	944	910	998	1,008	1,019	1,021	1,023	1,027	1,029	1,030	1,028	1,027
BROs	264	369	433	479	529	576	654	748	812	884	967	1,059	1,164
Low Income	57	57	57	33	33	33	33	33	33	33	33	33	33
Incentive Programs (Subtotal)	1,217	1,370	1,400	1,510	1,570	1,628	1,707	1,804	1,872	1,946	2,030	2,120	2,224
C&S*	1,212	1,257	1,266	1,304	1,269	1,406	1,347	1,299	1,218	1,173	1,067	966	864
Total	**2,429**	**2,627**	**2,666**	**2,814**	**2,839**	**3,034**	**3,055**	**3,102**	**3,090**	**3,119**	**3,097**	**3,086**	**3,088**

*includes interactive effects

Table 4-2. Statewide Net Incremental Demand Savings by Scenario

Electric Demand (MW)													
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
TRC | Reference													
Equipment Rebates	119	133	126	142	148	154	163	170	175	178	181	182	183
BROs	39	49	55	61	65	70	74	81	87	92	98	104	109
Low Income	10	10	10	6	6	6	6	6	6	6	6	6	6
Incentive Programs (Subtotal)	168	193	191	209	219	229	243	257	267	276	285	292	298
C&S*	272	275	311	368	359	440	422	408	392	382	361	344	327
Total	**440**	**468**	**502**	**577**	**578**	**669**	**665**	**665**	**659**	**658**	**646**	**636**	**625**
mTRC (GHG adder 1) | Reference													
Equipment Rebates	132	150	143	160	164	169	177	182	182	184	187	188	188
BROs	39	49	55	61	65	70	74	81	87	92	98	104	109
Low Income	10	10	10	6	6	6	6	6	6	6	6	6	6
Incentive Programs (Subtotal)	181	209	208	227	235	244	257	269	274	282	291	298	303
C&S*	272	275	311	368	359	440	422	408	392	382	361	344	327
Total	**453**	**485**	**519**	**595**	**594**	**684**	**679**	**677**	**666**	**665**	**652**	**642**	**631**
mTRC (GHG adder 2) | Reference													
Equipment Rebates	137	155	156	181	190	211	217	226	229	231	234	240	239
BROs	39	49	55	61	65	70	74	81	87	92	98	104	109
Low Income	10	10	10	6	6	6	6	6	6	6	6	6	6
Incentive Programs (Subtotal)	186	214	221	247	261	287	297	313	321	329	337	350	354
C&S*	272	275	311	368	359	440	422	408	392	382	361	344	327
Total	**458**	**489**	**532**	**616**	**620**	**727**	**719**	**721**	**713**	**711**	**699**	**694**	**682**
PAC | Reference													
Equipment Rebates	220	239	232	258	260	271	269	270	266	266	267	268	267
BROs	39	49	55	61	65	70	74	81	87	92	98	104	109
Low Income	10	10	10	6	6	6	6	6	6	6	6	6	6
Incentive Programs (Subtotal)	269	299	297	324	331	347	349	357	359	364	371	378	382
C&S*	272	275	311	368	359	440	422	408	392	382	361	344	327
Total	**541**	**574**	**608**	**693**	**690**	**786**	**771**	**765**	**751**	**746**	**732**	**722**	**709**
PAC | Aggressive													
Equipment Rebates	233	255	249	278	279	290	287	285	282	282	283	284	284
BROs	47	64	74	82	91	99	110	126	136	148	161	176	193
Low Income	10	10	10	6	6	6	6	6	6	6	6	6	6
Incentive Programs (Subtotal)	290	329	333	365	376	395	403	416	424	436	450	466	482
C&S*	272	275	311	368	359	440	422	408	392	382	361	344	327
Total	**562**	**604**	**644**	**734**	**735**	**834**	**825**	**824**	**816**	**818**	**812**	**810**	**810**

*includes interactive effects

Table 4-3. Statewide Net Incremental Gas Savings by Scenario

Gas Energy (MMTherm/year)													
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
TRC | Reference													
Equipment Rebates	20	20	18	21	23	23	23	24	26	26	26	26	27
BROs	7	11	14	15	16	17	18	19	19	20	21	22	23
Low Income	6	6	6	5	5	5	5	5	5	5	5	5	5
Incentive Programs (Subtotal)	33	37	38	42	44	45	46	48	50	51	52	53	55
C&S*	39	39	47	54	54	54	54	53	40	36	35	34	35
Total	**72**	**76**	**85**	**95**	**98**	**99**	**99**	**101**	**90**	**87**	**87**	**88**	**90**
mTRC (GHG adder 1) | Reference													
Equipment Rebates	25	27	24	28	30	34	33	32	31	29	29	28	29
BROs	7	11	14	15	16	17	18	19	19	20	21	22	23
Low Income	6	6	6	5	5	5	5	5	5	5	5	5	5
Incentive Programs (Subtotal)	38	44	45	48	51	56	56	56	55	55	55	56	58
C&S*	39	39	47	54	54	54	54	53	40	36	35	34	35
Total	**78**	**83**	**92**	**102**	**105**	**110**	**110**	**109**	**95**	**91**	**90**	**90**	**92**
mTRC (GHG adder 2) | Reference													
Equipment Rebates	29	35	36	40	40	45	43	42	41	39	37	36	36
BROs	7	11	14	15	16	17	18	19	19	20	21	22	23
Low Income	6	6	6	5	5	5	5	5	5	5	5	5	5
Incentive Programs (Subtotal)	42	52	57	60	61	67	66	66	65	64	64	64	64
C&S*	39	39	47	54	54	54	54	53	40	36	35	34	35
Total	**82**	**91**	**104**	**114**	**115**	**121**	**120**	**119**	**105**	**101**	**99**	**98**	**99**
PAC | Reference													
Equipment Rebates	29	31	30	33	36	39	38	37	35	34	34	33	35
BROs	7	11	14	15	16	17	18	19	19	20	21	22	23
Low Income	6	6	6	5	5	5	5	5	5	5	5	5	5
Incentive Programs (Subtotal)	42	48	51	53	57	61	60	61	60	60	60	61	63
C&S*	39	39	47	54	54	54	54	53	40	36	35	34	35
Total	**81**	**87**	**98**	**107**	**111**	**114**	**114**	**114**	**100**	**96**	**95**	**95**	**98**
PAC | Aggressive													
Equipment Rebates	30	33	32	35	38	41	40	39	38	37	37	38	41
BROs	8	13	17	19	20	22	24	27	29	31	34	37	40
Low Income	6	6	6	5	5	5	5	5	5	5	5	5	5
Incentive Programs (Subtotal)	44	51	56	58	64	68	69	71	71	73	76	80	87
C&S*	39	39	47	54	54	54	54	53	40	36	35	34	35
Total	**84**	**90**	**103**	**112**	**117**	**122**	**122**	**124**	**111**	**110**	**111**	**114**	**121**

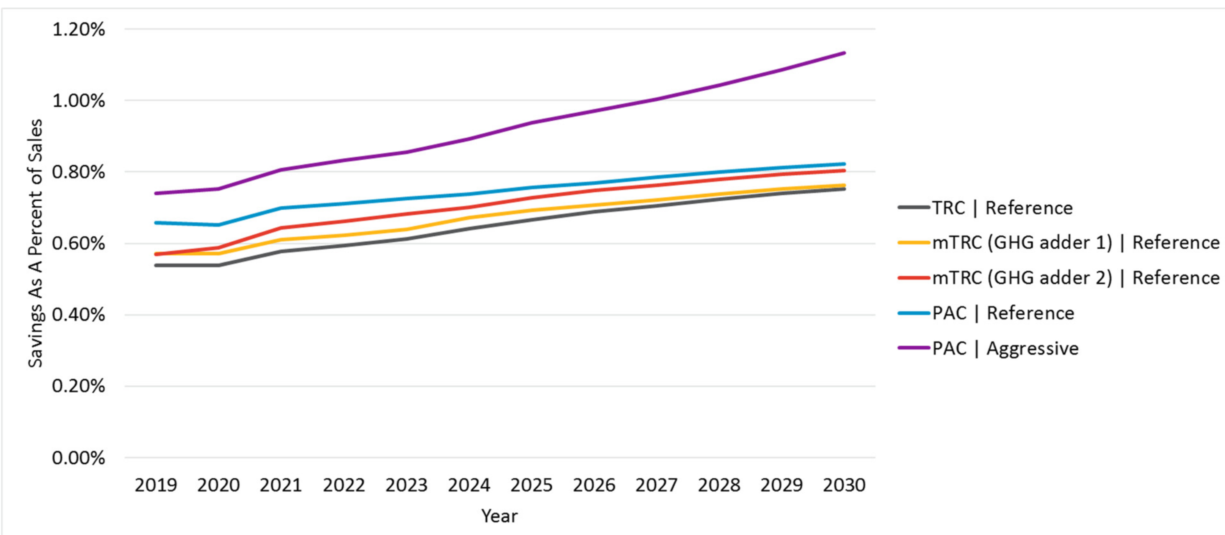
*includes interactive effects

Figure 4-1 and Figure 4-2 compares the savings from all incentives programs, which include savings from Equipment Rebate programs, BROs interventions and Low Income programs, as a percent of IOU sales. Savings as a percent of sales is a common metric provided in other potentials 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.

For electric, market potential savings as a percentage of forecasted electric energy usage grows from 0.48% to 0.75% between 2018 and 2030 under Scenario 1 (TRC Reference). Under the most optimistic case, market potential grows from 0.66% in 2018 to 1.13% by 2030 under Scenario 5 (PAC Aggressive).

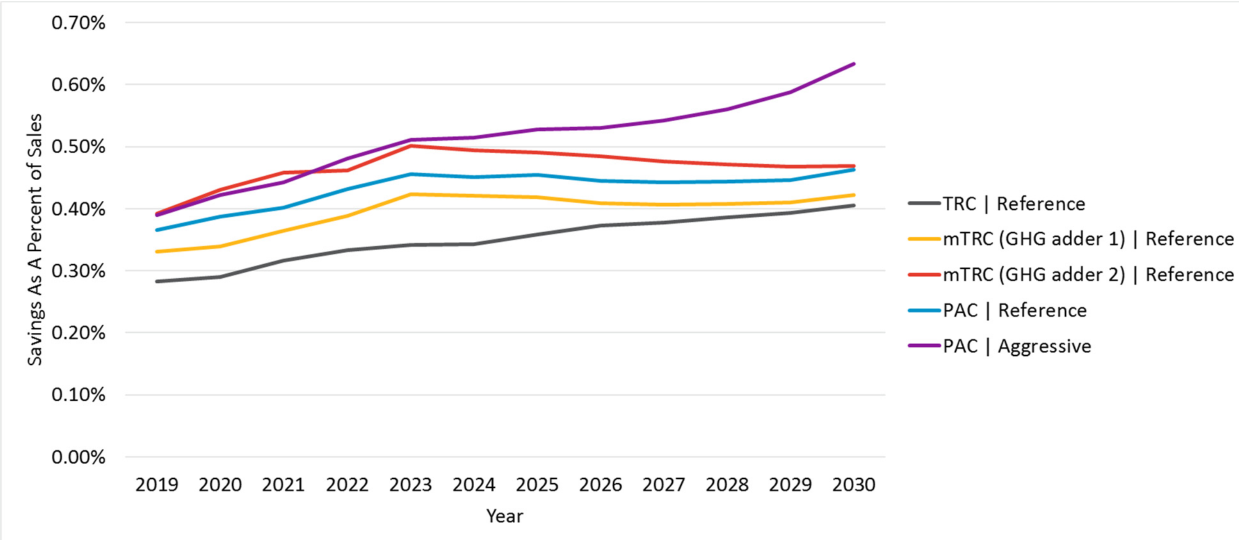
For gas incentive program savings, Scenario 5 (PAC Aggressive) and Scenario 3 (mTRC w/ GHG adder 2) are roughly on par until 2023. This is because the GHG adder, which is high in Scenario 3, is applied uniformly to all gas measures. On the other hand, the impact of the adder on electric measures is loadshape-dependent, which means the benefits of the GHG adder vary by time of day and season. Beyond 2023, Scenario 5 starts to yield the highest gas potential as BROs participation starts to ramp up in the Aggressive scenario.

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



Note: Excludes C&S

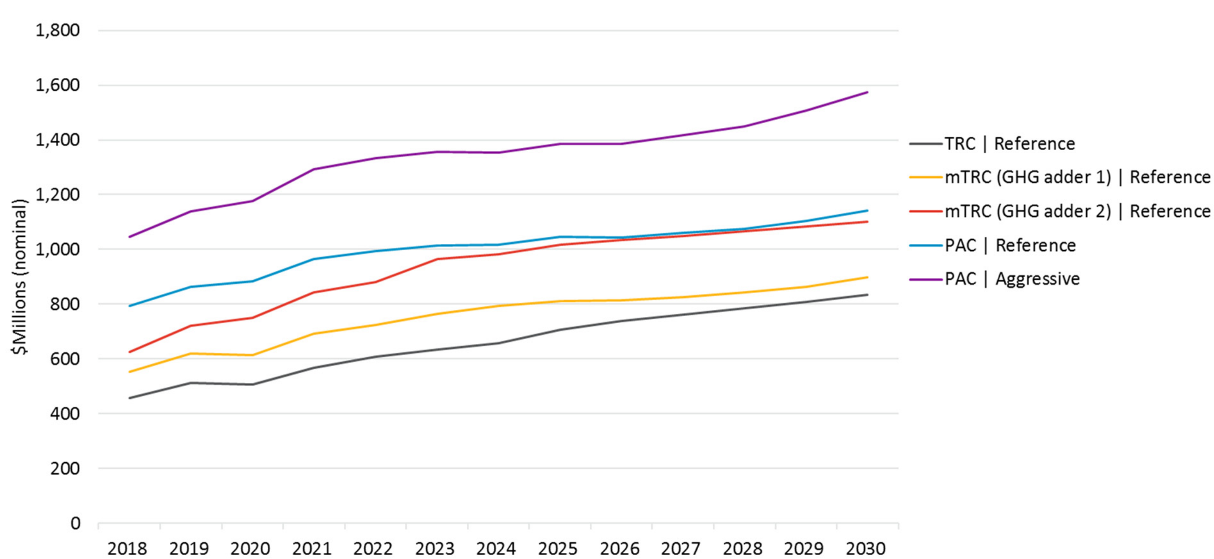
Figure 4-2. Incremental Gas Market Potential as a Percent of Sales



Note: Excludes C&S

Figure 4-3 shows projected statewide spending for rebate programs and BROs 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 Scenario 5 (PAC Aggressive) produces the most expensive portfolio for equipment savings, and Scenario 1 (TRC Reference), the least. By 2030, Scenario 4 (PAC Reference) is expected to cost about 36% more than Scenario 1 (TRC Reference). Aggressive program engagement further increases spending as illustrated by Scenario 5 (PAC Aggressive), which costs about 38% more than Scenario 4 (PAC Reference). Low income program costs were not estimated by this study.

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



Note: Excludes Low Income

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 include savings from Equipment Rebate programs, BROs interventions and Low Income programs. All graphs exclude savings from re-participants and only Scenario 5 (PAC Aggressive) includes the effects of aggressive program engagement.

For electric savings, the commercial and residential sector dominate the savings across all scenarios, with the commercial 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 sectoral growth but also reflects greater levels of market uptake for BROs in the later years. Conversely, the incremental savings potential declines for the industrial, mining and streetlighting sectors. For industrial and mining, this savings decline is highly correlated with flat or negative customer growth rates during the time horizon. For streetlighting, the market potential for high efficiency measures becomes more saturated over time.

For gas savings, the largest savings potential comes from the residential sector, with smaller savings for industrial and commercial, and minimal savings for the agricultural and mining sectors.

Figure 4-4. Statewide Incremental Net Electric Market Potential by Sector for Incentive Programs in Scenario 1 (TRC Reference)

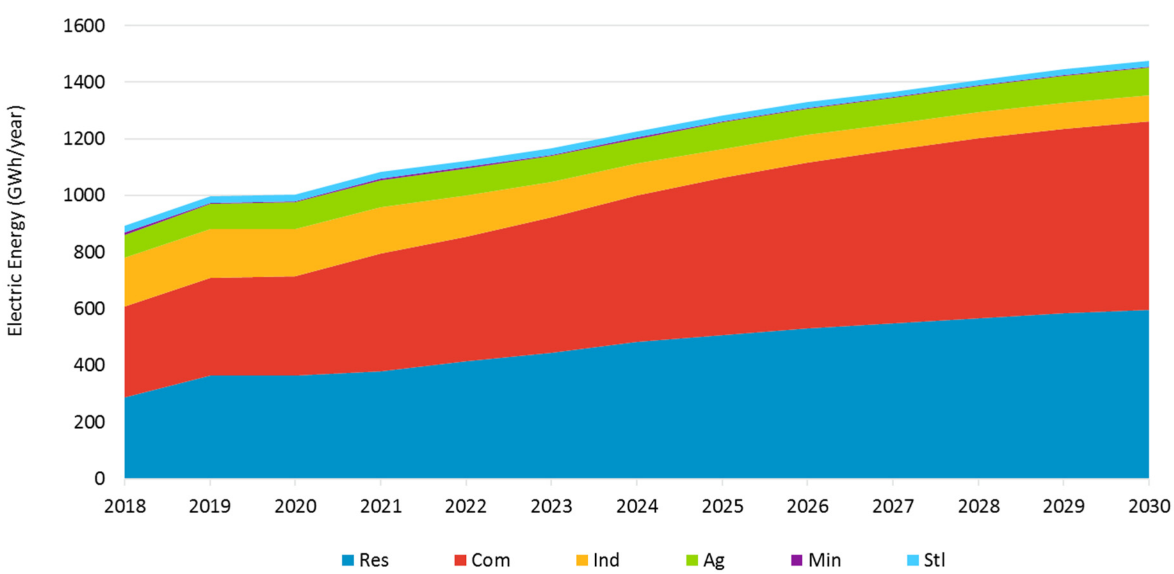


Figure 4-5. Statewide Incremental Net Electric Market Potential by Sector for Incentive Programs in Scenario 2 (mTRC w/ GHG adder 1)

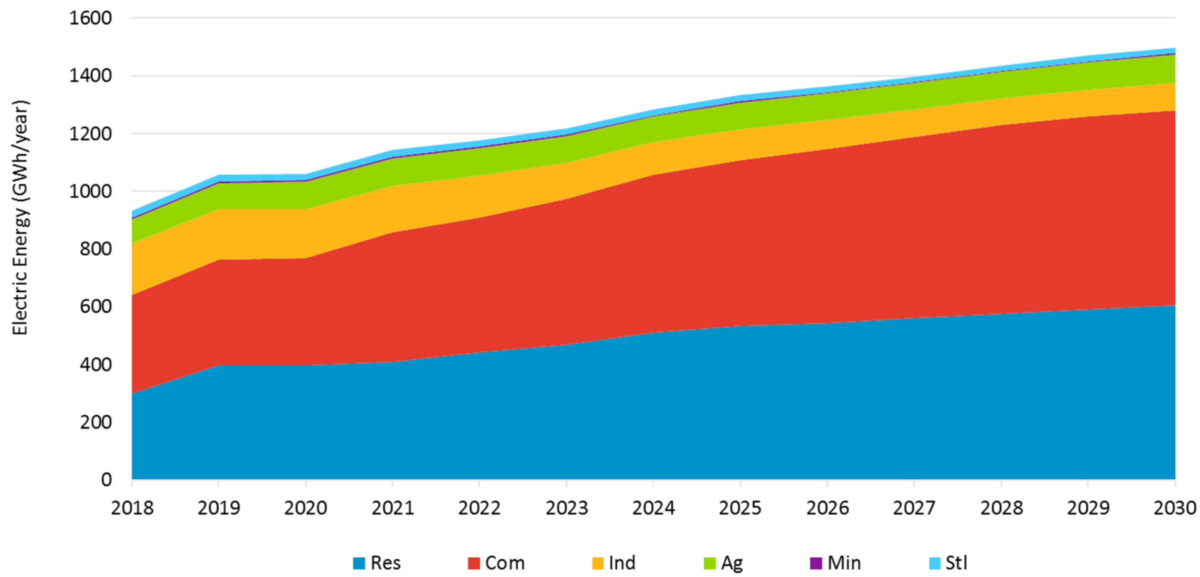


Figure 4-6. Statewide Incremental Electric Market Potential by Sector for Incentive Programs in Scenario 3 (mTRC w/ GHG adder 2)

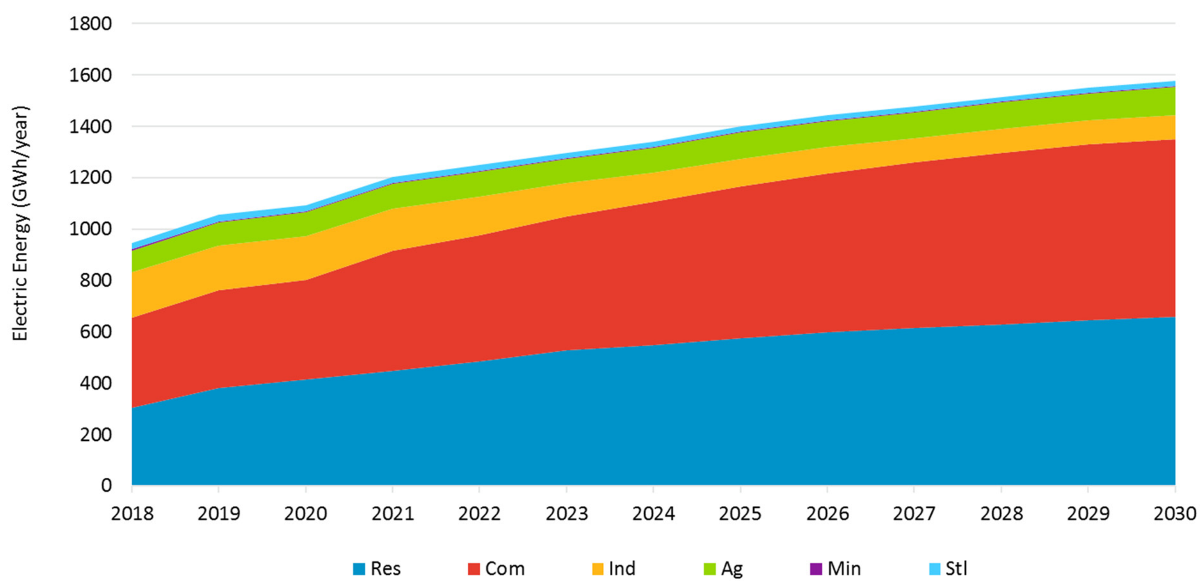


Figure 4-7. Statewide Incremental Electric Market Potential by Sector for Incentive Programs in Scenario 4 (PAC Reference)

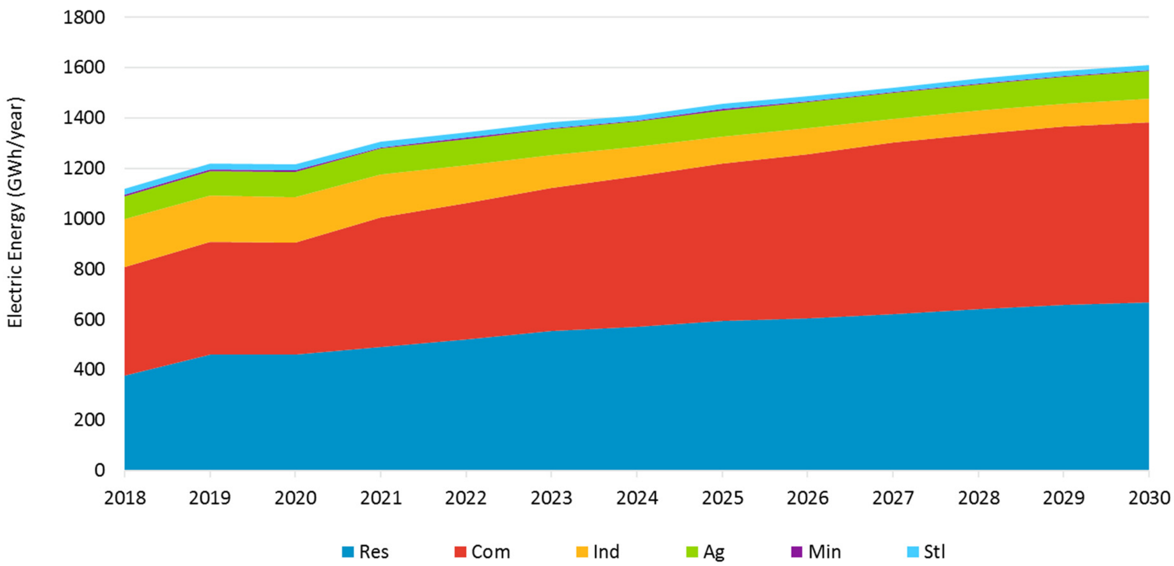


Figure 4-8. Statewide Incremental Electric Market Potential by Sector for Incentive Programs in Scenario 5 (PAC Aggressive)

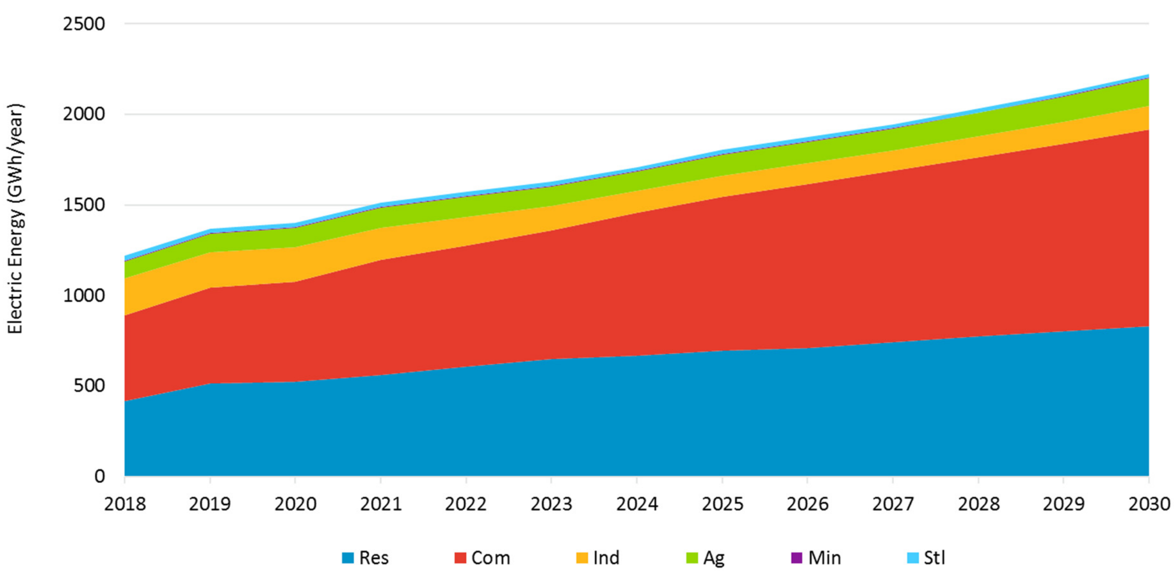


Figure 4-9. Statewide Incremental Gas Market Potential by Sector for Incentive Programs in Scenario 1 (TRC Reference)

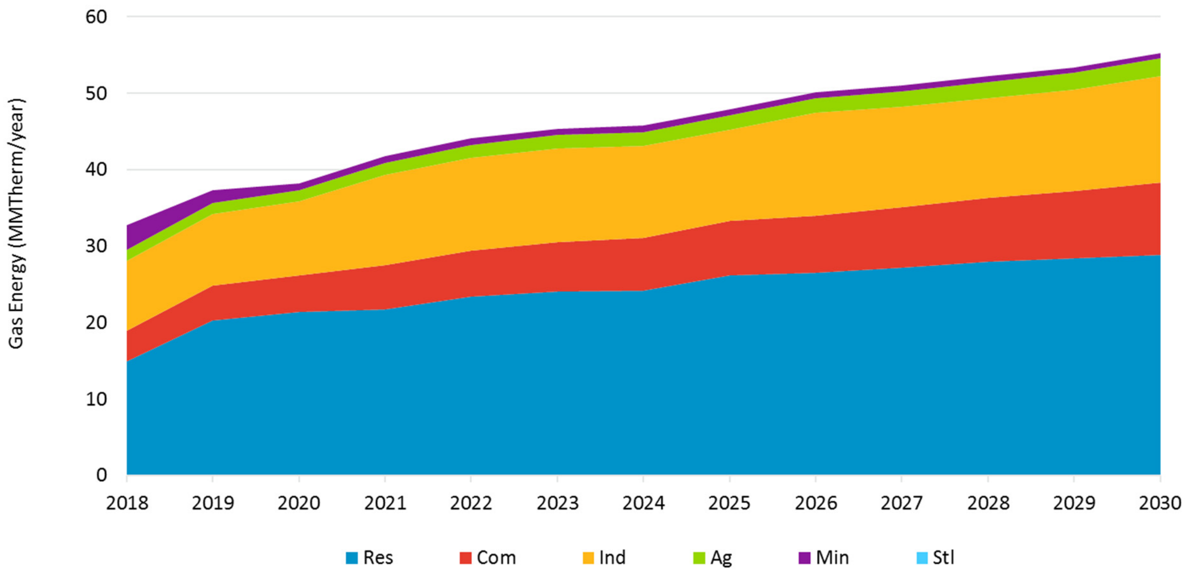


Figure 4-10. Statewide Incremental Gas Market Potential by Sector for Incentive Programs in Scenario 2 (mTRC w/ GHG adder 1)

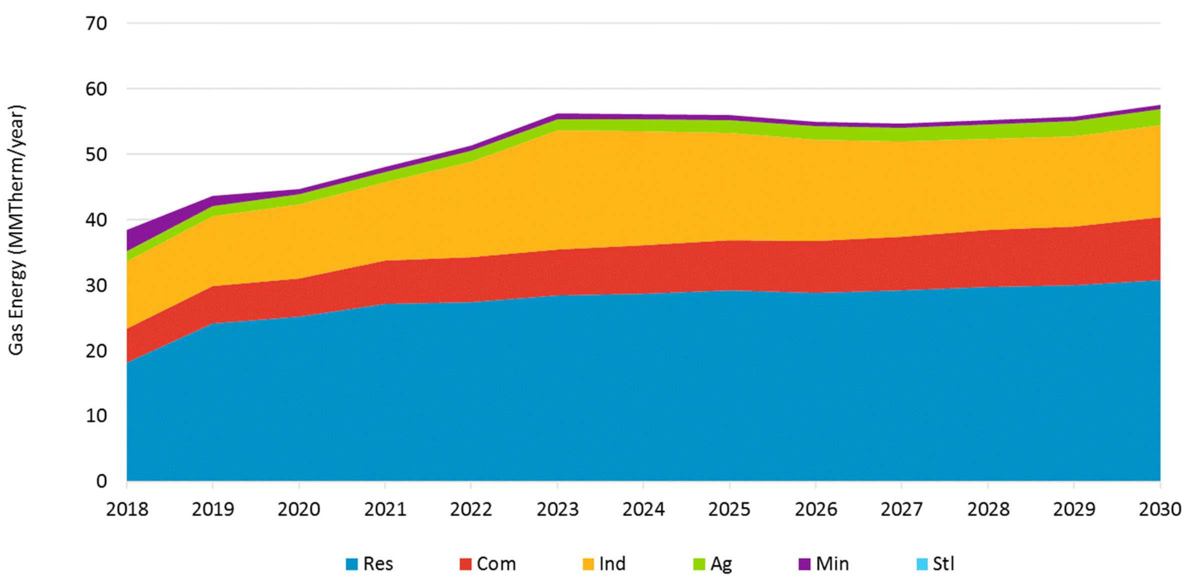


Figure 4-11. Statewide Incremental Gas Market Potential by Sector for Incentive Programs in Scenario 3 (mTRC w/ GHG adder 2)

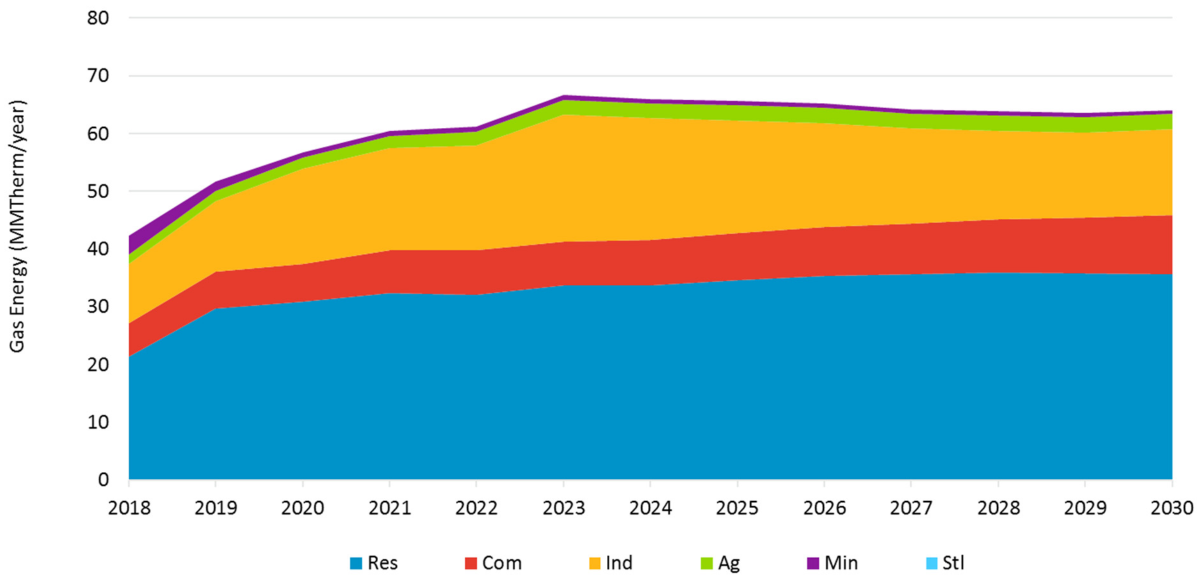


Figure 4-12. Statewide Incremental Gas Market Potential by Sector for Incentive Programs in Scenario 4 (PAC Reference)

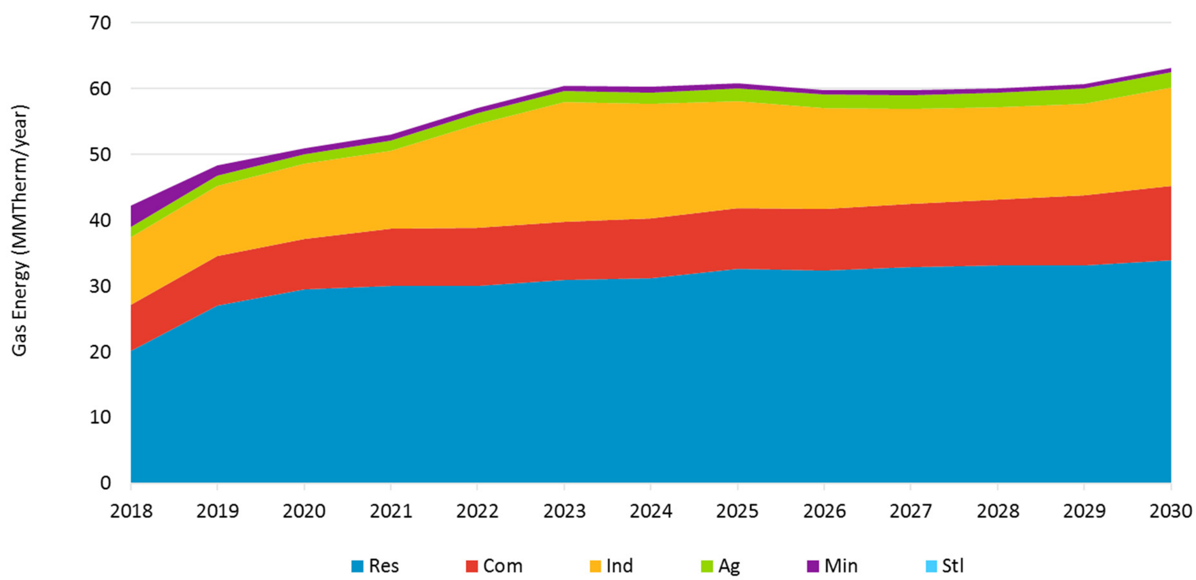
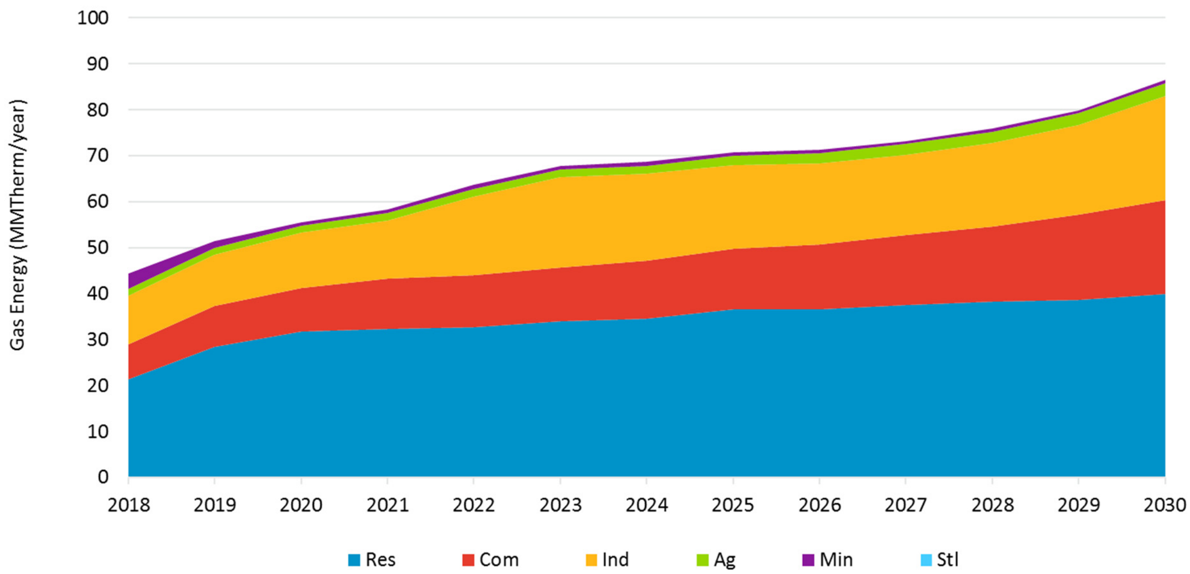


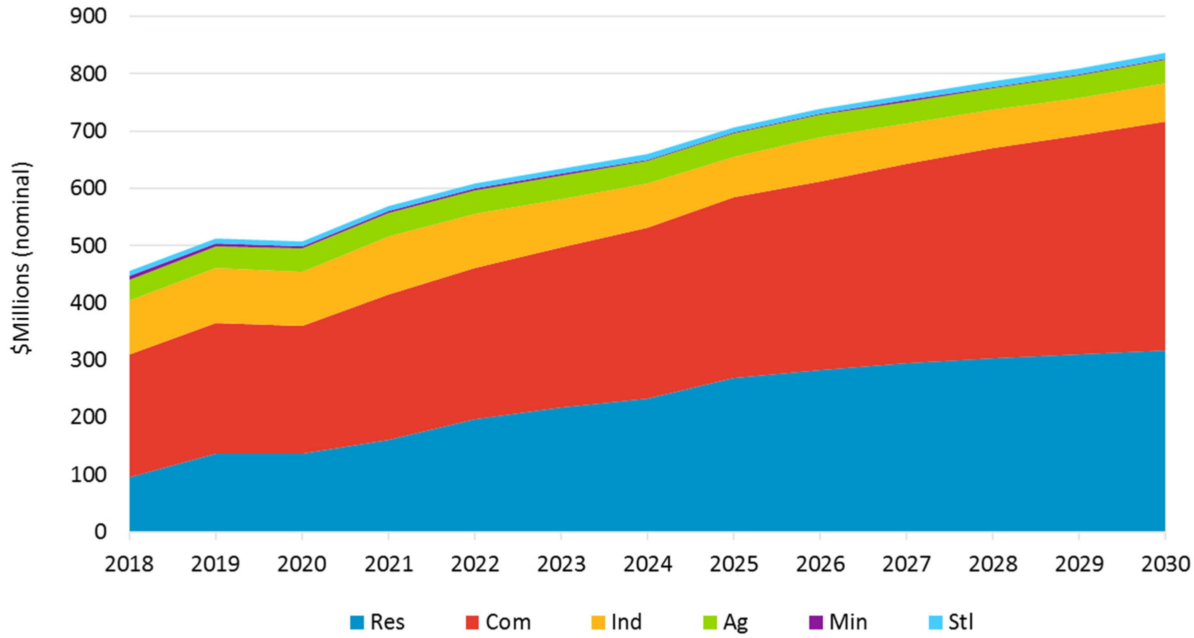
Figure 4-13. Statewide Incremental Gas Market Potential by Sector for Incentive Programs in Scenario 5 (PAC Aggressive)



A peak demand savings version of the above figures can be found in the results viewer under the "Total Incr Potential by Sector" tab.

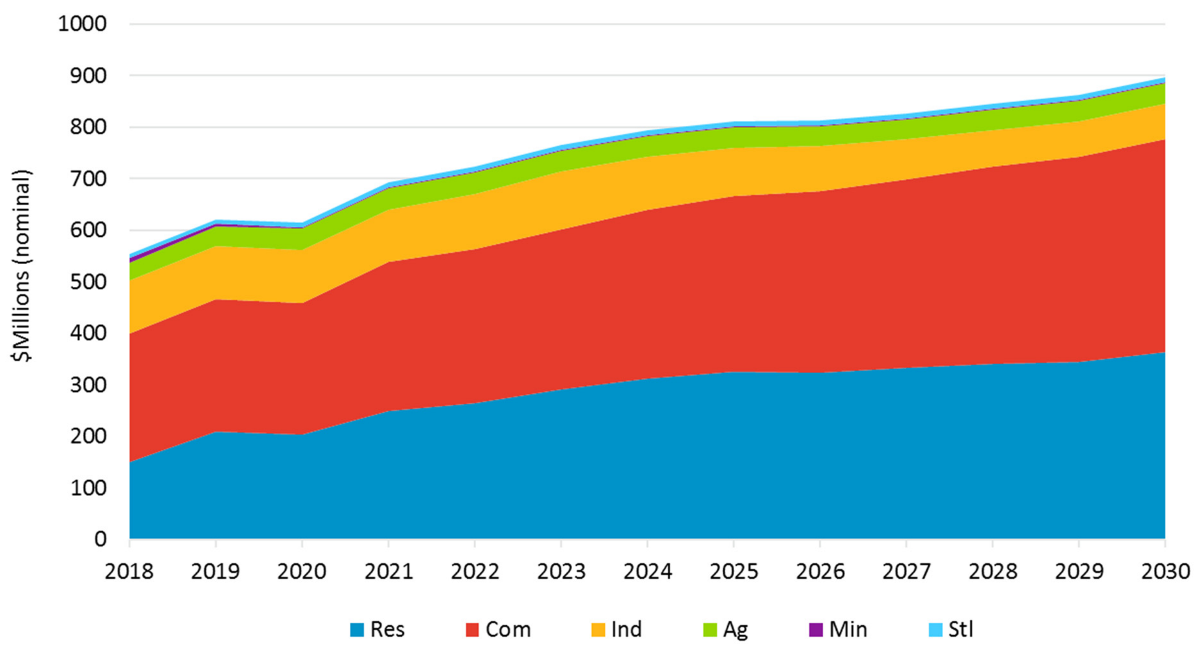
Figure 4-14 through Figure 4-18 show the breakdown of statewide spending by sector for incentive programs, which include savings from Equipment Rebate programs and BROs interventions. We do not report spending for low income programs. One again, a key takeaway from these graphs is that the share of each sector's savings generally remains the same across scenarios, with the residential and commercial sectors generally dominating spending.

Figure 4-14. Statewide Spending by Sector for Incentive Programs in Scenario 1 (TRC Reference)



Note: Excludes Low Income

Figure 4-15. Statewide Spending by Sector for Incentive Programs in Scenario 2 (mTRC w/ GHG Adder 1)



Note: Excludes Low Income