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California Energy Commission

FINAL COMMISSION REPORT

Senate Bill 350: Doubling Energy Efficiency Savings by 2030

California Energy Commission

Edmund G. Brown Jr., Governor

October 2017 | CEC-400-2017-010-CMF

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ABSTRACT

Senate Bill 350, the Clean Energy and Pollution Reduction Act of 2015 (De León, Chapter 547, Statutes of 2015), requires the California Energy Commission to establish annual targets that will achieve a cumulative doubling of statewide energy efficiency savings and demand reductions in electricity and natural gas final end uses. This report establishes the proposed statewide doubling targets for electricity and natural gas end uses that must be achieved by 2030. It proposes subtargets for the portion of projected energy efficiency savings that can be achieved through programs funded by the state's investor-owned and publicly owned electric and natural gas utilities. The report also proposes subtargets for nonutility programs funded through government, private and utility ratepayer sources. In addition, the report identifies projected efficiency savings from the industrial and agricultural sectors. The report outlines recommendations to ensure that California meets SB 350 energy efficiency doubling targets.

Keywords: Energy efficiency, SB 350, publicly owned, investor-owned, utility, codes and standards, financing, fuel substitution, nonutility, programs

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EXECUTIVE SUMMARY

Overview

Senate Bill 350, the Clean Energy and Pollution Reduction Act (De León, Chapter 547, Statutes of 2015) requires the California Energy Commission to set annual targets to achieve a statewide cumulative doubling of energy efficiency savings in electricity and natural gas final end uses by January 1, 2030. The Energy Commission also must report biennially to the Legislature on progress achieved toward meeting the statewide SB 350 energy efficiency doubling targets and the impacts on disadvantaged communities.

The targets for doubling energy efficiency savings are ambitious. These bold targets will help focus the necessary attention and creativity on harnessing emerging technologies, progressive program designs, and innovative market solutions that together can move the savings trajectory upward. Meeting the targets will require the collective effort of many entities, including state and local governments, utilities, program deliverers, private lenders, market participants, and end-use customers. But with proper tracking of energy efficiency savings, midcourse corrections in both utility and nonutility programs, and ongoing support from California's leading elected officials, the state is well-positioned to meet the doubling targets by 2030.

Much of the untapped energy efficiency potential to meet the doubling targets can be achieved by improving the energy efficiency of existing buildings, as well as the appliances, and other devices used in them. The Energy Commission developed the *Existing Buildings Energy Efficiency Action Plan* to improve the energy efficiency of existing residential, commercial, and government buildings. The plan relies on measures and programs to increase energy efficiency markets, create more effective targeting and delivery of energy efficiency upgrade services, improve the decision making of occupants and investors, and advance improvements to the performance of California's buildings.

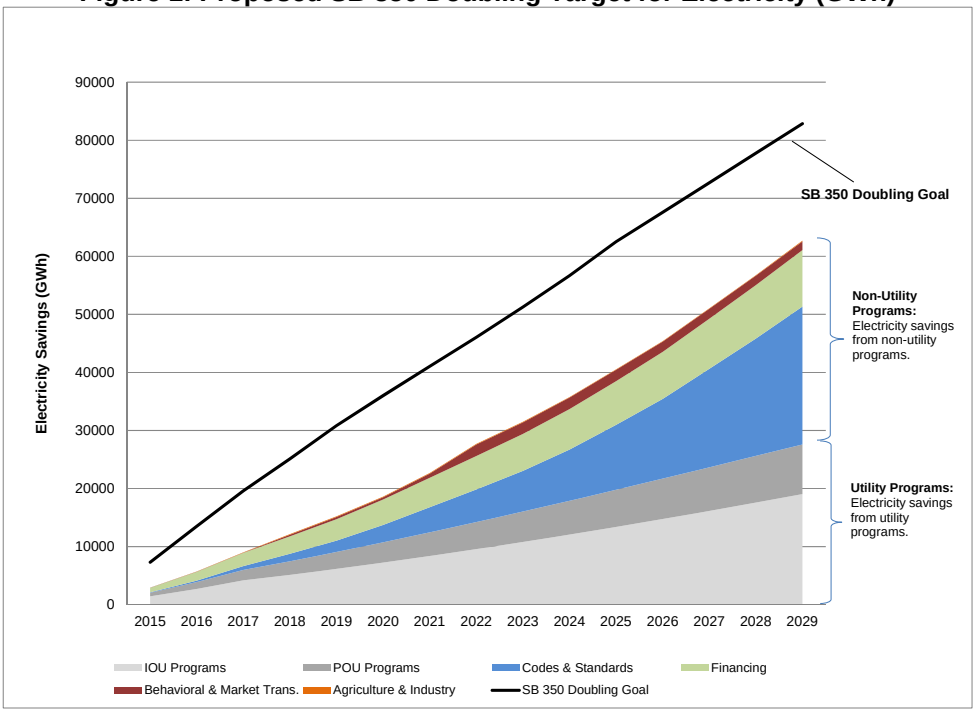
The Energy Commission is establishing separate targets for electricity and natural gas to achieve a cumulative doubling of statewide energy efficiency savings by January 1, 2030, as called for in SB 350. Both utility and nonutility energy efficiency programs will be necessary to achieve the doubling targets. The report proposes subtargets for individual utilities and nonutility energy efficiency programs. Finally, it presents recommendations and next steps to ensure that California achieves the SB 350 doubling targets.

SB 350 Energy Efficiency Doubling Targets

SB 350 directs the Energy Commission to base the SB 350 energy efficiency targets on a doubling of the additional achievable energy efficiency contained in the *California Energy Demand Updated Forecast, 2015-2025,* extrapolated to 2030. For the publicly owned utilities, the target is based on their most recent adopted energy efficiency targets, also extrapolated to 2030. **Figure 1** and **Figure 2** show the proposed SB 350 doubling targets for savings of electricity and natural gas with the projected contributions of the different programs, including utility and nonutility programs, to achieve the targets. Because the SB 350 deadline is January 1, 2030, the last full year of the Energy Commission's analysis is 2029. The Energy

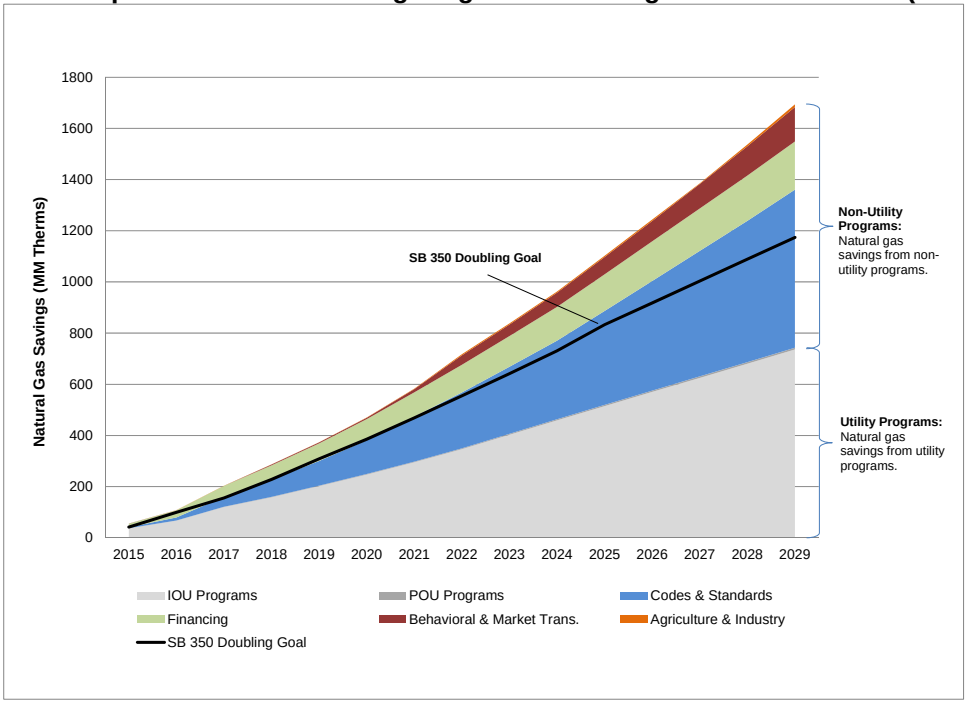
Commission established subtargets for utility savings from investor-owned and publicly owned utilities based on projected energy efficiency savings from utility programs. For the nonutility programs, the Energy Commission established subtargets based on the savings estimates for codes and standards, financing programs, and behavioral and market transformation program. In addition, preliminary assessments of possible energy savings from the agricultural and industrial sectors are included in the nonutility savings subtargets.

Figure 1: Proposed SB 350 Doubling Target for Electricity (GWh)



Source: California Energy Commission staff, Efficiency Division. Based on work in Appendix B by NORESCO. August 2017.

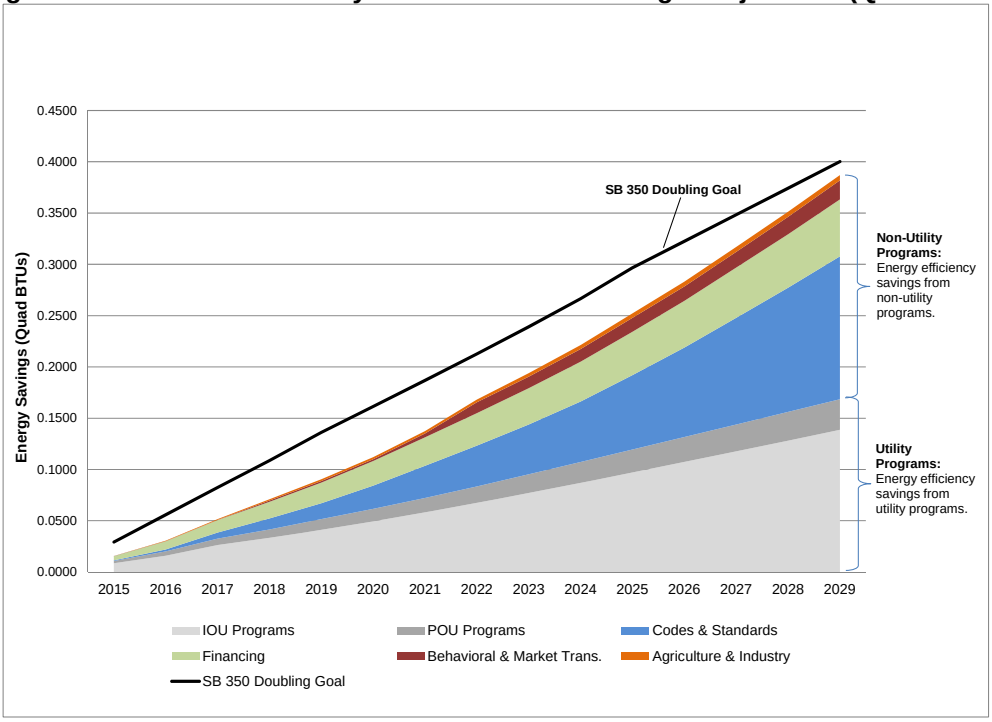
Figure 2: Proposed SB 350 Doubling Target and Subtargets for Natural Gas (Therms)



Source: California Energy Commission staff, Efficiency Division. Based on work in Appendix B by NORESCO. August 2017.

Figure 3 shows the combined site-level electricity and natural gas projected savings from utility and non-utility programs (in Quadrillion [Quad or 10^{15}] British thermal units [BTUs]). The top line represents the combination of the doubling targets for electricity and natural gas, not the aggregate, or combined, target provided for in SB 350, which would require the Energy Commission to consider the relative cost-effectiveness and the GHG reductions of electricity versus natural gas savings, among other issues.

Figure 3: Combined Electricity and Natural Gas Savings Projections (Quad BTUs)



Source: California Energy Commission staff, Efficiency Division. Based on work in Appendix B by NORESCO. August 2017.

The projected program savings shown in **Figure 1, Figure 2**, and **Figure 3** did not take advantage of the full economic potential identified in the various energy efficiency potential studies. In the studies, several scenarios were constructed based on different assumptions about cost-effectiveness, program participation, funding, and others. The scenarios reflected in savings projections were not based on the most aggressive scenarios, leaving additional savings potential available to fill the gap between the doubling target for electricity shown in **Figure 1** and the combined electricity and natural gas savings shown in **Figure 3**. For example, market transformation, as well as agriculture and industrial program savings, should help fill any remaining gaps. The contributions of the various efficiency programs and measures will be tracked in the SB 350 energy efficiency doubling target updates as part of future IEPRs.

Utility Programs Savings Projections

SB 350 directs the Energy Commission, when assessing the feasibility and cost-effectiveness of utility energy efficiency programs, to consider the results of the energy efficiency potential studies. Two important studies of energy efficiency savings potential were conducted by the California Public Utilities Commission (CPUC) for its jurisdictional entities, primarily investor-owned utilities, and by the California Municipal Utilities Association on behalf of the publicly owned utilities. Since the studies were underway when SB 350 implementation was just beginning, neither study identifies specifically how utilities might accomplish a large increase in savings associated with the SB 350 doubling targets. Each study is designed to determine a market-based savings potential for voluntary utility-incentive retrofit and new construction programs, along with codes and standards, under a given a set of assumptions. These studies are detailed in Chapters 3 and 4 and Appendix A.

In developing projections of energy efficiency savings for utility programs, the Energy Commission analyzed the electricity and natural gas efficiency savings projections for 2018 and beyond from the two potential studies. The studies lacked a uniform set of assumptions applicable to all utilities, resulting in inconsistent reporting of expected energy efficiency savings. The Energy Commission adjusted the savings projections to address this issue. The reported savings for some publicly owned utilities were adjusted from gross to net, since many utilities use net savings in assessing energy efficiency potential. The 2027 projections of efficiency savings for publicly owned utilities were extrapolated to 2030. For both investor-owned and publicly owned utilities the years 2015-2017 were added to the 2018-2030 savings projections. The final adjustment was to remove codes and standards savings from investor-owned and publicly owned utility projections and count them as part of the nonutility subtargets. The savings projections for investor-owned and publicly owned utilities for electricity and natural gas end uses are shown in **Figure 1** and **Figure 2**. In addition, Chapters 3 and 4 and Appendix A of this report detail how the investor-owned and publicly owned utility subtargets were established.

Nonutility Program Savings Projections

The nonutility subtargets include projected savings from programs at the Energy Commission, other state agencies, private lenders, local governments, and other local entities. The Energy Commission is responsible for a portion of the nonutility savings, including the Building Energy Efficiency Standards, the Appliance Efficiency Regulations, multiple financing programs (such as Proposition 39 and Energy Conservation Assistance Act programs), and programs to transform markets. The *Existing Buildings Energy Efficiency Action Plan* outlines many of the Energy Commission's energy savings strategies. Several other financing programs offered by other state agencies and private entities are major contributors to nonutility energy savings. The additional utility incentive program participation anticipated from expanded access to capital increases the savings possible from these other financing programs. The largest contributor to natural gas market transformation energy savings is expected to come from fuel substitution programs. The programs and the associated contributions to projected savings to meet the SB 350 doubling targets are shown in **Figure 1**and **Figure 2** and detailed in Chapter 6 and Appendix B.

The Energy Commission developed preliminary projections of nonutility programs that are incremental to the energy savings identified in the utility potential studies to minimize possible overlap in savings projections. The preliminary estimates in the draft Commission report were further analyzed, and revised projections of energy savings are included in this final report. Programs that are cost-effective and feasible and did not adversely affect public health and safety were included in the projected savings estimates. Many of the programs have a cost-effectiveness metric that was evaluated in developing the savings estimates. The detailed methods for developing nonutility savings subtargets are described in Appendix B.

Recommendations

Fund and Improve Energy Efficiency Programs

Efficiency programs, especially financing programs, are assumed to be funded through 2029, yet many of them do not have an ongoing funding source or are expected to end before then. The following recommendations will help ensure adequate funding for energy efficiency programs to achieve SB 350 savings targets.

- Maintain or expand current levels of funding for finance programs, including the Water Energy Grant, Low-Income Weatherization Program, Proposition 39, and others. Coordinate with state and local agencies that deliver energy efficiency programs, along with stakeholders.
- Develop and reward programs that most effectively attract and leverage private capital; simplify and reduce the cost of program participation; and offer incentives for measured and sustained performance.
- Increase the funding of the Energy Conservation Assistance Act program to allow more access to schools, cities, counties, and special districts for energy efficiency projects.
- Improve code compliance by increasing interagency collaboration, stakeholder engagement, and funding for outreach and education at the local level, especially for local building permit offices and the contractor communities.

Achieve Additional Energy Efficiency Savings

To meet the SB 350 electricity and natural gas doubling targets, it will be necessary to identify new or improved efficiency measures and technologies, and develop new programs or expand existing ones. The following recommendations will help deliver additional energy efficiency savings.

- Identify new energy savings opportunities by working with state, regional, and local governments, building owners, builders, financial institutions, small businesses, inspectors, consumer groups, environmental and environmental justice groups and other stakeholders.
- Establish specific action steps and timelines for responsible entities to realize significant increases in energy efficiency savings, through ongoing collaborations with the CPUC, other state and local governments, and stakeholders, as part of the required update to the *Existing Buildings Energy Efficiency Action Plan*.
- Expand the workforce training available to improve the quality of energy efficiency equipment installation, consistent with recommendations from the *Low-Income Barriers Report* and the *Existing Building Energy Efficiency Action Plan*.
- Develop a comprehensive approach to implement fuel substitution programs that maximizes cost-effective efficiency savings and greenhouse gas emission reductions in collaboration with the CPUC, California Air Resources Board (CARB), utilities, and stakeholders.
- Continue the ongoing partnership with the CPUC, ARB, California Department of Food and Agriculture, the Treasurer's Office, and food processing industry members to

examine efficiency issues and identify strategies that will assist food processors reduce energy use and GHG emissions.

Improve Reporting and Estimating of Efficiency Savings

SB 350 requires the Energy Commission to report to the Legislature every two years on progress toward achieving the energy efficiency doubling targets. It also requires an assessment of the impact of such savings on hourly and seasonal electricity demand patterns in local utility service territories and on disadvantaged communities. To carry out these responsibilities and determine that progress is being achieved in meeting SB 350 targets, the Energy Commission will need to collect additional data, develop better estimation methods, and expand evaluation, measurement, and verification efforts. The Energy Commission is already revising data collection regulations and proposes to collect hourly data from the IOUs and the two large POUs, LADWP and SMUD. The following recommendations will need to be implemented.

Standardized Historical Savings Estimates

- Ensure that sufficient disaggregated (or broken-down) data, including hourly and seasonal, is available on historical energy consumption and efficiency savings estimates in coordination with the CPUC, investor-owned utilities, and publicly owned utilities.
- Ensure access to additional energy savings data from nonutility programs in coordination with energy efficiency program deliverers, including other state, regional, and local agencies. Next steps include the following:
    - Incorporate appropriate regulatory requirements in the Energy Commission's update of data collection regulations (Phase II of Title 20 Data Collection Regulations).
    - Work with nonutility program deliverers, including PACE program administrators, to voluntarily report energy savings while data collection regulations are being developed.
    - Work with new responsible entities not now implementing formal EM&V to help establish a credible basis for estimating historical and projected energy efficiency savings for the energy efficiency activities of each.

Reporting on Disadvantaged Communities

- Determine and apply the best methods to ensure adequate reporting of energy efficiency impacts in disadvantaged communities, including whether simplified methods should be used initially while more definitive methods are developed and implemented.

Reporting Hourly and Seasonal Impacts

- Improve estimation of hourly impacts of energy efficiency savings for each utility in cooperation with the CPUC, investor-owned utilities, and publicly owned utilities.

Improve Evaluation, Measurement, and Verification

- Establish robust evaluation, measurement, and verification to estimate savings projections for target setting for Energy Commission Title 24 and Title 20 standards and use the results to improve and expand compliance and enforcement.
- Place a high priority on understanding energy efficiency savings decay to obtain a better understanding of this topic for use in improving projections of cumulative savings.

Projecting Future Energy Efficiency Savings

- Ensure that the next round of potential and goals studies support SB 350 implementation by using consistent reporting conventions and assumptions for target setting and tracking in collaboration with the CPUC and publicly owned utilities.
- Develop improved methods to estimate additional savings potential beyond existing programs from the agricultural and industrial sectors and the of these programs contribution to the SB 350 doubling target in collaboration with utilities, agricultural, and industrial stakeholders.

Establish Aggregate Electricity and Natural Gas Targets

The Energy Commission has the authority to base targets on aggregate (or collective) electricity and natural gas projected savings. Before establishing aggregate targets, the Commission must adopt an aggregation method in a public process that allows input from stakeholders. The following recommendation will allow for aggregate targets.

- Develop a specific aggregation method for consideration in the next cycle of target setting in the *2019 Integrated Energy Policy Report* (*IEPR)* process in collaboration with the California Public Utilities Commission, investor-owned and publicly owned utilities, and other stakeholders.

CHAPTER 1: Introduction

On October 7, 2015, Governor Edmund G. Brown Jr. signed into law Senate Bill 350, which sets ambitious annual targets for energy efficiency and renewable electricity aimed at reducing greenhouse gas (GHG) emissions. SB 350 directs the California Energy Commission to establish annual targets that will achieve a statewide cumulative doubling of energy efficiency savings and demand reductions in electricity and natural gas final end uses by January 1, 2030. This mandate is one of the primary measures to help the state achieve its long-term climate goal of reducing GHG emissions to 40 percent below 1990 levels by 2030.

This chapter outlines the organization and content of the remaining chapters of the report, discusses the purpose of the report, and defines several important terms and topics related to energy efficiency programs and savings projections used in the report.

Outline of Chapters

Chapter 2 presents the proposed statewide cumulative energy efficiency doubling targets for electricity and natural gas as called for in SB 350, as well as the associated combined energy savings. It also summarizes the energy efficiency savings projections developed for utility and nonutility programs to meet the doubling targets.

Chapter 3 discusses investor-owned utility (IOU) programs that are expected to contribute to meeting the SB 350 energy efficiency doubling targets. It discusses the energy efficiency potential and goals study conducted by the California Public Utilities Commission (CPUC) that was relied on to estimate projected savings and set subtargets for the electric and gas IOUs.

Chapter 4 presents the projected energy efficiency savings from publicly owned utilities' (POU) programs. Like the IOUs, the savings for POU programs were based on a potential and goals study conducted for California Municipal Utilities Association (CMUA) on behalf of the POUs. The chapter outlines the subtargets proposed for each POU.

Chapter 5 discusses additional energy efficiency programs that can contribute to meeting the SB 350 doubling targets. The chapter discusses issues relating to fuel substitution, such as changing from natural gas to electricity and conservation voltage reduction, which involves optimizing voltage on the distribution system to reduce losses. In addition, preliminary estimates of projected nonutility agricultural and industrial energy efficiency savings are presented.

Chapter 6 describes the projected energy savings from nonutility energy efficiency programs and establishes subtargets for the different programs. Nonutility programs are grouped into the following categories: codes and standards, financing programs, behavioral and market transformation programs, and agricultural and industrial. Utility programs also include behavioral and market transformation programs that are discussed in Chapters 3 and 4.

Chapter 7 outlines proposed recommendations and next steps that will be necessary to achieve the SB 350 doubling targets.

Scope of Report

This report will begin implementing the complex and ambitious efficiency doubling targets called for in SB 350. In this proceeding, the Energy Commission has focused on developing comprehensive, aggregate energy efficiency savings targets for the state based on numerous utility and other programs. In addition, the Energy Commission has undertaken one of the most comprehensive assessments of energy efficiency savings potential from all types of efficiency programs and measures conducted to date in the state. The Energy Commission has also endeavored to forge a partnership with the much broader and diverse set of stakeholders, whose actions will be necessary to achieve the doubling targets.

In comments, some parties suggested the report be expanded to include detailed actions and next steps for agencies to take, including specifically identifying the most important new or improved strategies to bring about efficiency savings.[1] Others suggested reorganizing the information presented in the report to aid market players in developing business planning and investment to capture energy efficiency savings.[2] This report is not intended to develop the kind of detailed roadmap suggested by some parties. Many recommendations already build off the *Existing Building Energy Efficiency Action Plan* and actions identified in the Low-Income Barriers Report. The Energy Commission intends to work with the CPUC, POUs, state and local governments, and stakeholders to identify specific actions steps and timelines for responsible entities that will ensure that the SB 350 doubling targets as part of the required updates to the *Existing Buildings Energy Efficiency Action Plan.*

The report also is not designed to address all of the more detailed issues related to SB 350 raised during the proceeding, including comments on how fuel substitution programs should be designed. Instead, the report is intended to identify the needs and gaps to be addressed in other venues and proceedings to successfully implement the portions of SB 350 requiring the Energy Commission to establish annual targets to achieve a cumulative doubling of energy efficiency savings. As indicated in the recommendations, several issues will be taken up in the Energy Commission's biennial update on the progress towards achieving the doubling targets called for by SB 350.

Definitions

Several terms related to the SB 350 energy efficiency targets and the savings projections presented in this report have specific meanings that require explanation. SB 350 requires that the Energy Commission establish the energy efficiency doubling targets "to the extent doing

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1 For example, Comments of the Natural Resources Defense Council (NRDC) on the 2017 Integrated Energy Policy Report (IEPR) Staff Workshop on Methodologies for 2030 Energy Efficiency Target Setting (September 7th, 2017), Docket Number 17-IEPR-06. September 21, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN221291_20170921T164333_Mohit_Chhabra_Comments_Comments_of_the_Natural_Resources_Defens.pdf.

2 Clinton, Jeanne. Comments and Questions on CEC Draft Commission Report Doubling EE Savings Targets by 2030 (August 2017). Docket Number 17-IEPR-06, September 21, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN221278_20170920T212931_Jeanne_Clinton_Comments_Jeanne_Clinton_comments_and_questions_o.pdf.

so is cost-effective, feasible, and will not adversely impact public health and safety."[3] These terms are explained below. In addition, several other terms related to the energy efficiency and doubling targets are discussed below.

Utility and Nonutility Program Categories

To assess projected energy savings from various energy efficiency programs and measures, the Energy Commission created two categories: utility and nonutility programs. Utility savings estimates were based on the potential and goals studies conducted by the CPUC and POUs. The separate category of nonutility programs was created to capture savings beyond those programs and measures included in the utility potential and goals studies, while minimizing overlap in accounting for efficiency savings.

In previous Energy Commission staff papers and the draft report on doubling energy efficiency savings, nonutility programs were characterized as programs *not funded by utility ratepayers*. Some parties noted at the September 7, 2017, workshop,[4] including the joint POUs, Sacramento Municipal Utilities District (SMUD), Southern California Public Power Authority (SCPPA), and Southern California Edison (SCE), that this characterization was not accurate, because, in addition to government and private funding, utility ratepayers also fund nonutility programs.[5] In the final report, this language has been removed to reflect that some utility efforts are expected to continue to support energy efficiency programs and measures in the nonutility category, particularly for codes and standards and market transformation.[6] In future update cycles, it may be possible to more clearly delineate categories of savings. Because of the interconnected nature of utility and other efficiency programs, however, there is no bright line that separates them, and some level of overlap in projected savings may remain.

Targets and Subtargets

As used in this report, the term *target* is used to refer to the separate targets for electricity and natural gas end-use savings called for under SB 350. The term *subtarget* is used in two ways. For utility programs, sub-targets are set for each IOU and POU. For nonutility programs, subtargets are set for each program. The program subtargets are grouped into categories of like programs as outlined in Chapter 6, but no targets or subtargets are proposed for these categories.

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3 Public Resources Code Section 25310(c)(1).

4 Transcript from September 7, 2017, Joint IEPR Commissioner Workshop on SB 350 Energy Efficiency Savings Doubling. Pp. 128, 148-149.

5 Joint Publicly Owned Utilities' Comments on Draft Commission Report: Senate Bill 350: Doubling Energy Efficiency Savings by 2030. Docket Number 17-IEPR-06. September 22, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN221304_20170922T163152_Jonathan_Changus_Comments_CMUA_NCPA_and_SCPPA_Joint_Comments_on.pdf .

6 Market transformation is the strategic process of intervening in a market to create lasting change in market behavior by removing barriers or exploiting opportunities to accelerate the adoption of cost-effective energy efficiency as a matter of standard practice.

Cost-Effectiveness

In determining cost-effectiveness of the energy efficiency programs and measures for inclusion in the SB 350 doubling targets, different cost-effectiveness metrics are used, many of which are established by statute or regulation. An overview of the definitions of cost-effectiveness for utility and nonutility programs is presented below.

Utility Programs

In evaluating the cost-effectiveness of IOU programs, the CPUC uses several avoided cost tests from the *California Standard Practices Manual*, the most common of which are the total resource cost (TRC) and the program administrator cost (PAC) tests.[7] The "total costs" differ in each of these tests. The TRC test compares the benefits, which are the avoided cost of generating electricity and supplying natural gas, with the total costs, which include program administration and participant costs, but not the incentive costs. The PAC test compares the same avoided cost benefits with the total costs, which include program administration and incentive costs, but not the out-of-pocket costs paid by customers. The POUs use similar cost-effectiveness tests and in the latest study of projected energy efficiency program savings used the TRC test based on 2016 avoided cost estimates.

Codes and Standards

The building standards must be cost-effective when taken in entirety and when amortized over the economic life of the structure compared with historical practice.[8] The Energy Commission considers what is the value of the energy saved, whether there is any effect on product efficacy for the consumer, and what is the life-cycle cost of complying with the standards. In addition to cost-effectiveness, the Energy Commission considers the effect on housing costs, total statewide costs and benefits over the lifetime of the standard, economic impacts on business, and alternative approaches and the associated costs. The current building standards use a time-dependent valuation (TDV) metric to calculate the energy benefits of building efficiency measures (space heating, space cooling, indoor air quality and ventilation, and water heating).[9] To comply with the standards, a proposed building design must not exceed a given energy budget for energy use related to space heating, space cooling, indoor air ventilation, and water heating.

The appliance standards must not result in added costs to consumers over the life of the appliance.[10] In determining cost-effectiveness, the Energy Commission must consider what is value of the energy (or water) saved, whether there is any effect on product efficacy for the consumer, and what is the life-cycle cost to the consumer of complying with an adopted

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7 *Energy Efficiency Policy Manual Version* 5. July 2013. http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/EEPolicyManualV5forPDF.pdf.

8 Public Resources Code Section 25402(b)(3).

9 For electricity, a TDV factor is assigned to each hour of the year in each of the 16 climate zones, based on hourly marginal electricity costs, including energy, losses, transmission and distribution, capacity, ancillary services, and a Renewables Portfolio Standard ("RPS") adder, then scaled up to match average retail rate. For natural gas and propane, monthly TDV factors are used.

10 Public Resources Code Section 25402(c)(1).

standard. To meet this requirement, the Energy Commission uses one of two cost-effectiveness metrics: simple payback and life-cycle benefit. If the payback period (in years) is less than the design life of the appliance, then it is cost-effective.[11] The second type of cost-effectiveness is life-cycle benefit (in dollars), which has to be positive for the standard to be cost-effective.[12]

Other Efficiency Programs

In evaluating the cost-effectiveness of the remaining nonutility programs, the Energy Commission relied on a general definition in calculating cost-effectiveness of energy resources, including conservation and load management programs. Cost-effectiveness means that project benefits must outweigh the project costs, including a value for any costs and benefits to the environment.[13] For Proposition 39 projects however, the total benefits must be greater than project costs over time.[14]

11 *Simple payback* is the incremental cost to improve an appliance divided by the average annual present value savings.

12 *Life-cycle benefit* is the difference between the annual average present value savings multiplied by the design life and the incremental cost of improvement.

13 Public Resources Code Section 25001(c).

14 Public Resources Code Section 26206(c).

In selecting projects, the Energy Commission may consider non-energy benefits, such as health and safety, in addition to energy benefits.[15] Where specific cost-effectiveness tests were used to evaluate projected savings from non-utility energy efficiency programs, they are addressed in the various sections of the report, including Appendix B.

Feasible

A common sense definition of *feasible* is contained in the California Environmental Quality Act: "Feasible means capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors."[16] For SB 350, feasibility includes how technically achievable the energy efficiency program is, how likely participation is in an energy efficiency program, and how realistic savings projections are given economic, social, technological, and environmental constraints.

In assessing the feasibility of energy efficiency savings, SB 350 requires the Energy Commission and the CPUC to "consider the results of energy efficiency potential studies that are unrestricted by previous levels of utility energy efficiency savings."[17] From the utility perspective, some considerations could include expected consumer behavior in response to programs. A high-level examination of feasibility was done for the different programs.

Adversely Impact Public Health and Safety

The Energy Commission interprets the clause "will not adversely impact public health and safety" to mean primarily ensuring reliability of electricity supply.[18] Energy efficiency savings are relied upon in the generation, transmission, and distribution system planning of utilities and state entities. If energy efficiency program savings do not materialize as expected, reliability could be adversely impacted. A high-level assessment on the potential impact of the different program types on grid reliability was performed.

In addition, the phrase is broad enough to allow the Energy Commission to assess the effect of targets on GHG and other air pollutant emissions. Energy efficiency programs should reduce the need for power generation and result in fewer emissions of harmful air pollutants. If expected energy efficiency fails to occur, however, there could be a negative impact on the environment and public health.

Additional Achievable Energy Efficiency

For setting SB 350 targets, *cumulative doubling* of energy efficiency savings means the savings realized in 2030, not the sum of the cumulative energy efficiency savings realized in

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15 *Energy Commission Proposition 39: California Clean Energy Jobs Act, 2016 Program Implementation Guidelines.* July 2016. P. 22. An eligible energy project must achieve a minimum savings-to-investment ratio (SIR) of 1.01; for every dollar invested in the eligible energy project, the local educational agency will accrue $1.01 in savings. The SIR is based on the cumulative present value of the savings benefits realized over the life of the eligible energy project. http://www.energy.ca.gov/2016publications/CEC-400-2016-005/CEC-400-2016-005-CMF.pdf.

16 Public Resources Code Section 21061.1.

17 Public Resources Code Section 25310(c)(4).

18 Public Resources Code Section 25300 asserts that "reliable supply of energy [be] consistent with protection of public health and safety."

every year from 2015 through 2030. Under SB 350, the baseline for this doubling is the sum of the midcase estimate of *additional achievable energy efficiency* (AAEE) savings, as contained in the *California Energy Demand Update Forecast, 2015-2025* and the targets set by local publicly owned electric utilities under Section 9505 of the Public Resources Code.[19] AAEE savings are in addition to the *committed* energy efficiency savings already embedded in the forecast. AAEE is the incremental energy savings from the future market potential identified in utility potential studies not included in the baseline demand forecast but reasonably expected to occur, including future updates of building codes, appliance regulations, and new or expanded IOU or POU energy efficiency programs.[20]

Net Versus Gross Energy Savings

The energy efficiency evaluation community introduced the concept of *net* and *gross* savings to address program *free ridership*.[21] Generally, gross savings are the observed savings among program participants. They include savings from consumers who would have implemented measures even if they were not participants in a program (free riders), savings when the same measures in a program are installed without incentives, or savings that extend beyond the specific measures offered as incentives in a program, also referred to as *spillover*.[22] Net savings adjust for these two components of savings. There is no single analytic method for computing net savings from gross savings, and at the national level, there are numerous approaches for estimating net-to-gross ratios.

19 Pubic Resources Code Section 25310(c)(1) and 2531(c)(2).

20 California Energy Commission. 2015. *2015 Integrated Energy Policy Report*. Pp. 138-139. Publication Number: CEC-100-2015-001-CMF. http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-01/TN212017_20160629T154354_2015_Integrated_Energy_Policy_Report_Small_File_Size.pdf.

21 *Free ridership* refers to someone who would install an energy efficiency measure without any program incentives because of the return on investment for the measure but receives a financial incentive or rebate anyway.

22 *Spillover* refers to additional reductions in energy consumption or demand that is due to program influences beyond those directly associated with program participation. As a result, these savings may not be recorded in the program tracking system and credited to the program.

CHAPTER 2:
Doubling Energy Efficiency Savings

The proposed SB 350 doubling targets for electricity and natural gas consist of projected energy efficiency savings from programs and measures funded by utility ratepayers and from nonutility programs. Utility programs include programs funded by the state's IOUs, community choice aggregators (CCA), and regional energy networks (REN)[23] under the CPUC's jurisdiction, as well as the state's POUs that are governed by local boards. Utility programs use a variety of mechanisms to encourage energy efficiency such as rebates and energy audits. The funding for nonutility efficiency programs comes from government, private, and utility sources. These state agency and local government programs can increase energy efficiency at the customer end-use level through financing, directly installing energy efficiency measures, and increasing public awareness of energy efficiency best practices.

SB 350 Energy Efficiency Doubling Targets

SB 350 directs the Energy Commission to use the additional achievable energy efficiency (AAEE) contained in the *California Energy Demand Updated Forecast, 2015-2025* and the 2013 energy efficiency projections adopted by POUs and extend them both to 2030.[24] It then directs the Energy Commission to double those savings projections to arrive at the SB 350 targets for electricity and natural gas, to the extent doing so is cost-effective and feasible and will not adversely impact public health and safety. AAEE is credible, incremental energy savings not yet considered committed or firm but deemed reasonably likely to occur, including savings from future updates of building codes, appliance standards, and new or expanded utility programs.[25]

Projected energy efficiency savings for utility ratepayer-funded programs are categorized by IOU and POU, with proposed subtargets for each utility. Projected efficiency savings from nonutility energy efficiency efforts were separated into categories representing similar types of programs, including codes and standards, financing programs, behavioral and market transformation measures, and agricultural and industrial programs.[26] Subtargets have been proposed for programs within the nonutility savings categories.

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23 *Community choice aggregators* (CCAs) and *regional energy networks* (RENs) are local government entities that offer energy efficiency programs to residents and businesses.

24 Kavalec, Chris. 2015. *California Energy Demand Updated Forecast, 2015-2025*. California Energy Commission. Publication Number: CEC-200-2014-009-CMF. http://www.energy.ca.gov/2014publications/CEC-200-2014-009/CEC-200-2014-009-CMF.pdf.

25 AAEE is the incremental energy efficiency savings beyond the committed energy efficiency included in the Energy Commission's baseline demand forecast. The AAEE is subtracted from the baseline forecast to create a "managed" forecast for use in the state's energy planning.

26 Behavioral and market transformation measures, as used in this report, include measures and programs that in the industry are referred to as behavioral, retrocommissioning, and operational, or BROs. These include home energy reports, residential real-time feedback, residential competitions or challenges, energy management systems, building certification, and numerous others.

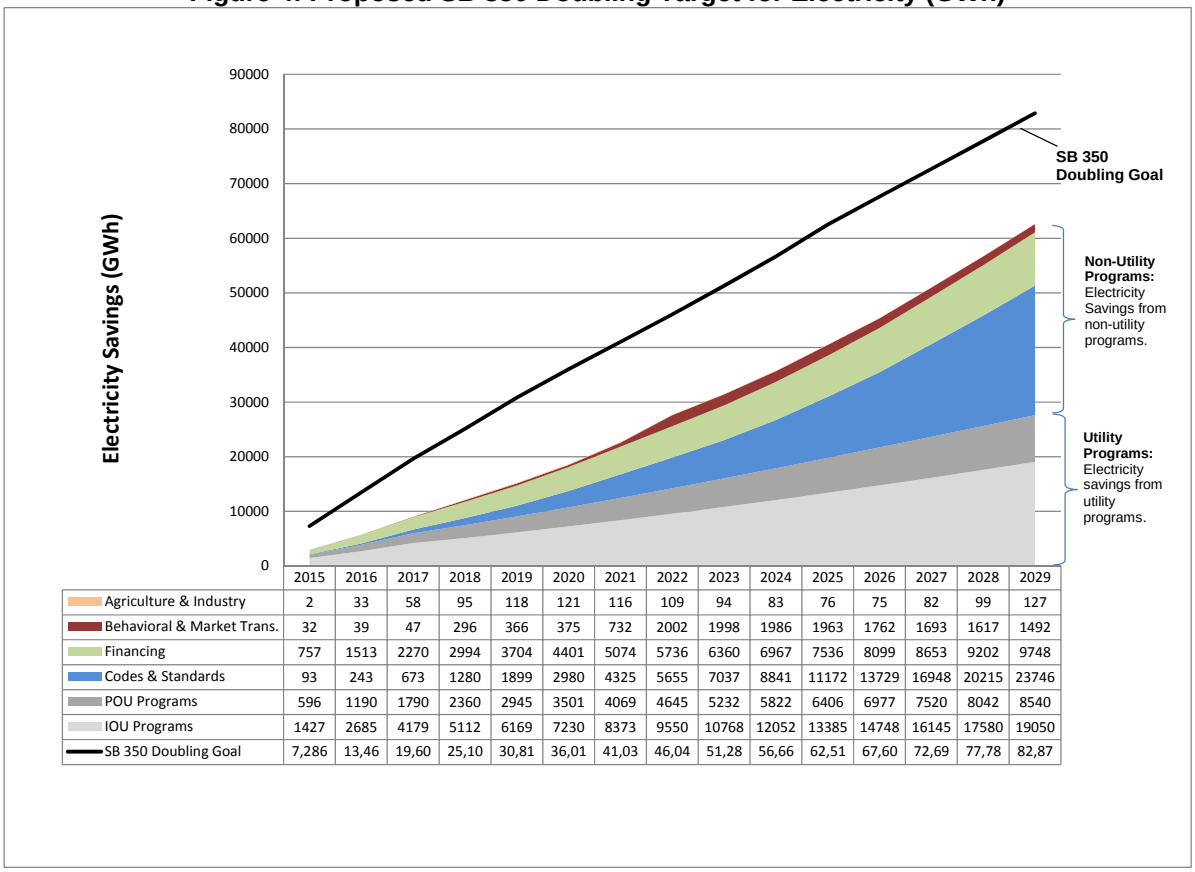
Projected energy efficiency savings are calculated for electricity in gigawatt hours (GWh) and for natural gas in millions of therms (MM therms or 1 million therms). The combined energy savings projections from electricity and natural gas are also presented using a common unit, British thermal units (BTUs).

SB 350 Doubling Target for Electricity

The statewide cumulative energy efficiency savings target for electricity, along with projected savings for utility and nonutility programs, is presented in **Figure 4**. The top line is the arithmetic doubling of projected AAEE savings from 2015 to 2025, with the 2026-to-2030 projected savings extrapolated using a trend line.

Utility electricity programs, as shown in **Figure 4,** account for about 44 percent of total projected savings, while nonutility programs contribute the remaining savings. The IOU programs account for about 30 percent of total projected savings, while POUs account for about 13 percent. About 36 percent of total projected savings is contributed by codes and standards, while financing programs make up
15 percent, and behavioral and market transformation comprise 2 percent. Nonutility agricultural and industrial sector savings make up about 1 percent of total projected savings.

Figure 4: Proposed SB 350 Doubling Target for Electricity (GWh)



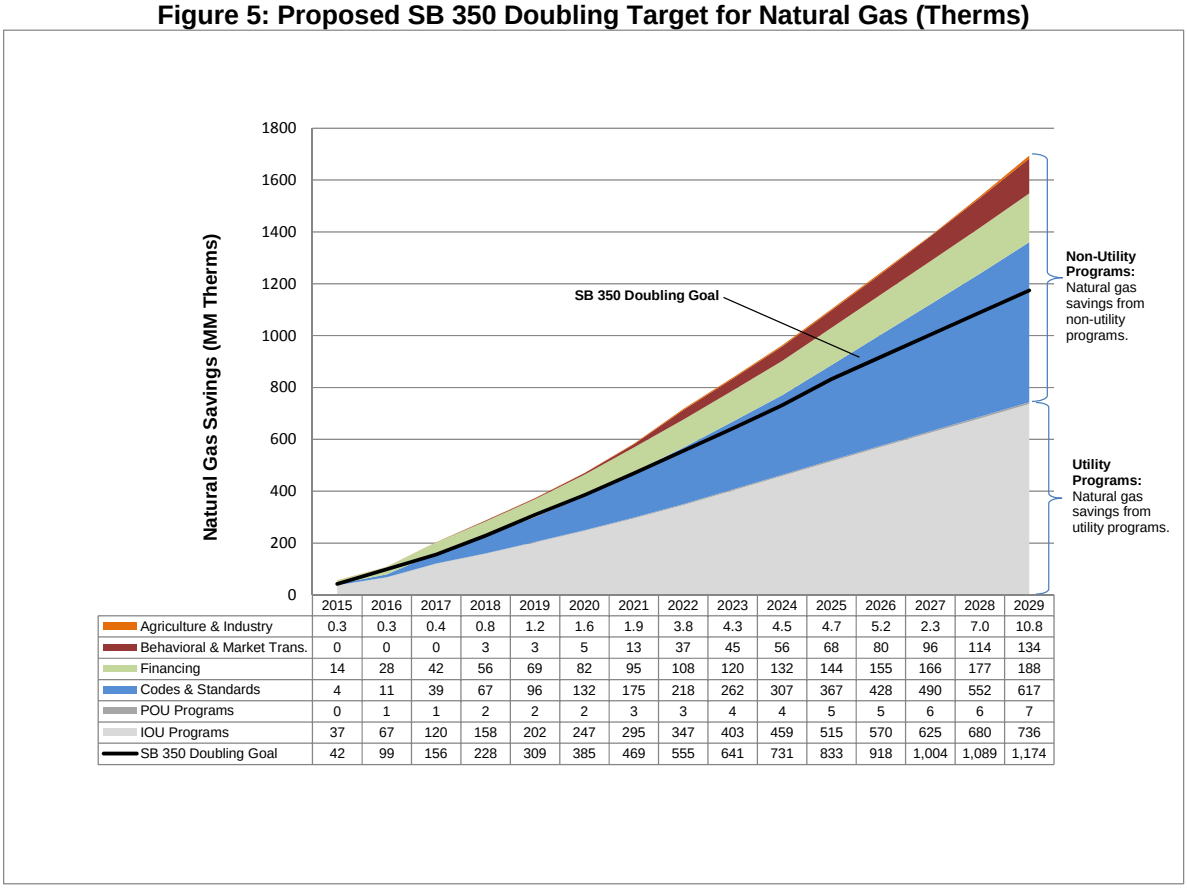
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Agriculture & Industry	2	33	58	95	118	121	116	109	94	83	76	75	82	99	127
Behavioral & Market Trans.	32	39	47	296	366	375	732	2002	1998	1986	1963	1762	1693	1617	1492
Financing	757	1513	2270	2994	3704	4401	5074	5736	6360	6967	7536	8099	8653	9202	9748
Codes & Standards	93	243	673	1280	1899	2980	4325	5655	7037	8841	11172	13729	16948	20215	23746
POU Programs	596	1190	1790	2360	2945	3501	4069	4645	5232	5822	6406	6977	7520	8042	8540
IOU Programs	1427	2685	4179	5112	6169	7230	8373	9550	10768	12052	13385	14748	16145	17580	19050
SB 350 Doubling Goal	7,286	13,46	19,60	25,10	30,81	36,01	41,03	46,04	51,28	56,66	62,51	67,60	72,69	77,78	82,87

Source: California Energy Commission staff, Efficiency Division. Based on work in Appendix B by NORESCO. August 2017.

SB 350 Doubling Target for Natural Gas

The energy efficiency doubling target for natural gas (in MM therms), along with projected savings for utility and non-utility programs, is presented in **Figure 5**. For natural gas, as shows in **Figure 5**, utility programs account for 44 percent of total projected savings, while nonutility programs contribute the remaining savings. Of the savings from nonutility programs, about 35 percent is contributed by codes and standards, while financing programs make up roughly 13 percent, and behavioral and market transformation comprise about 7 percent. Projected savings from the nonutility agricultural and industrial sector make up less than1 percent of total savings.

Figure 5: Proposed SB 350 Doubling Target for Natural Gas (Therms)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Agriculture & Industry	0.3	0.3	0.4	0.8	1.2	1.6	1.9	3.8	4.3	4.5	4.7	5.2	2.3	7.0	10.8
Behavioral & Market Trans.	0	0	0	3	3	5	13	37	45	56	68	80	96	114	134
Financing	14	28	42	56	69	82	95	108	120	132	144	155	166	177	188
Codes & Standards	4	11	39	67	96	132	175	218	262	307	367	428	490	552	617
POU Programs	0	1	1	2	2	2	3	3	4	4	5	5	6	6	7
IOU Programs	37	67	120	158	202	247	295	347	403	459	515	570	625	680	736
SB 350 Doubling Goal	42	99	156	228	309	385	469	555	641	731	833	918	1,004	1,089	1,174

Source: California Energy Commission staff, Efficiency Division. Based on work in Appendix B by NORESCO. August 2017.

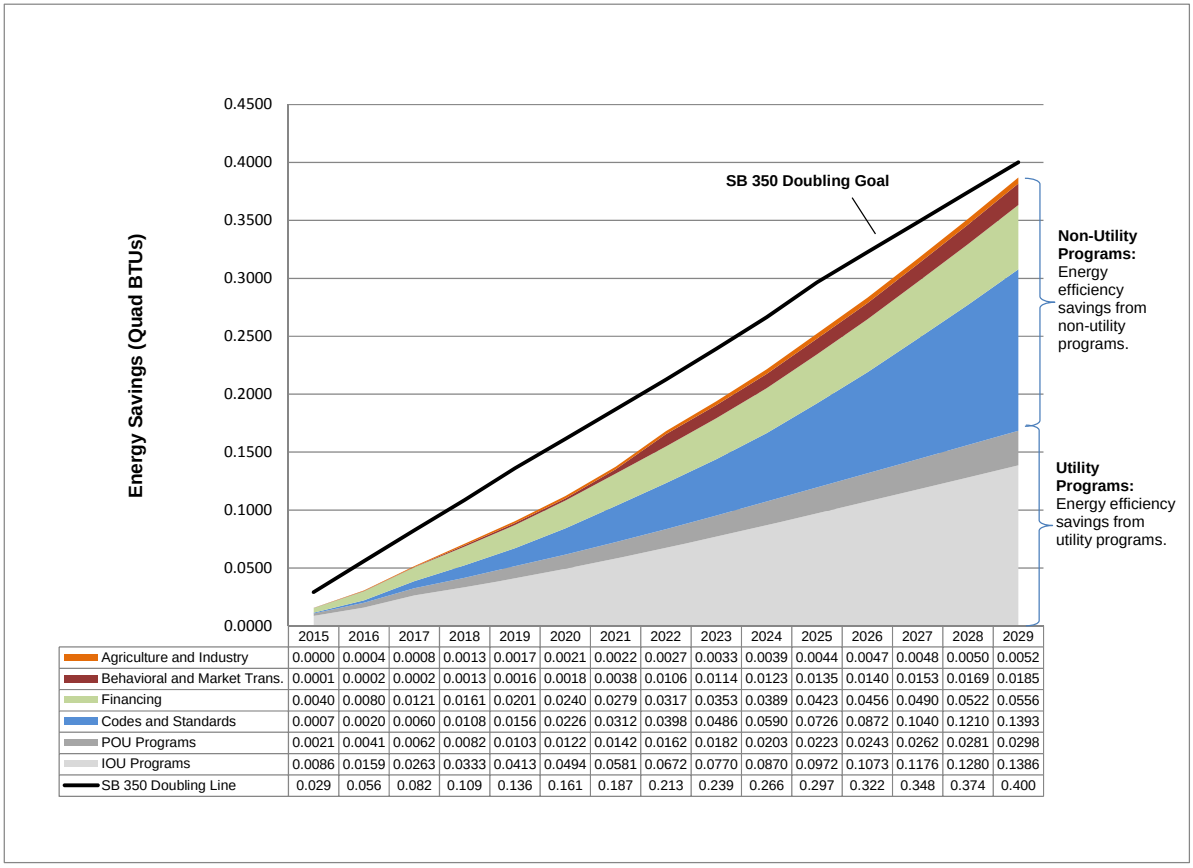
The combined projected energy efficiency savings for electricity and natural gas, along with the projections of savings for each program in the utility and nonutility categories, are presented in

Figure 6, which shows the combined site-level projected savings.[27]

27 **Figure 5** combines electricity and natural gas savings into site-level quads (1,015 BTUs) using fuel-specific unit conversions. There are 3.413x10-^{6} Quads per GWh and 10-^{4} Quads per MM Therms. A quad is a unit of energy equal to one quadrillion British thermal units. A quadrillion is 1 x 10^{15}, or a number equal to one following 15 zeros.

The top line represents the combination of the cumulative doubling target for electricity and natural gas that was developed through an arithmetic doubling of projected AAEE savings from 2015 to 2025, with the 2026 to 2030 projected savings extrapolated using a trend line.[28] Aggregated electricity and natural gas savings projections allowed under SB 350 have not been incorporated in this first target-setting effort but will be addressed in future cycles of Energy Commission review of the SB 350 targets and progress in achieving efficiency savings in the state.

Figure 6: Projected Combined Electricity and Natural Gas Savings (Quad BTUs)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Agriculture and Industry	0.0000	0.0004	0.0008	0.0013	0.0017	0.0021	0.0022	0.0027	0.0033	0.0039	0.0044	0.0047	0.0048	0.0050	0.0052
Behavioral and Market Trans.	0.0001	0.0002	0.0002	0.0013	0.0016	0.0018	0.0038	0.0106	0.0114	0.0123	0.0135	0.0140	0.0153	0.0169	0.0185
Financing	0.0040	0.0080	0.0121	0.0161	0.0201	0.0240	0.0279	0.0317	0.0353	0.0389	0.0423	0.0456	0.0490	0.0522	0.0556
Codes and Standards	0.0007	0.0020	0.0060	0.0108	0.0156	0.0226	0.0312	0.0398	0.0486	0.0590	0.0726	0.0872	0.1040	0.1210	0.1393
POU Programs	0.0021	0.0041	0.0062	0.0082	0.0103	0.0122	0.0142	0.0162	0.0182	0.0203	0.0223	0.0243	0.0262	0.0281	0.0298
IOU Programs	0.0086	0.0159	0.0263	0.0333	0.0413	0.0494	0.0581	0.0672	0.0770	0.0870	0.0972	0.1073	0.1176	0.1280	0.1386
SB 350 Doubling Line	0.029	0.056	0.082	0.109	0.136	0.161	0.187	0.213	0.239	0.266	0.297	0.322	0.348	0.374	0.400

Source: California Energy Commission staff, Efficiency Division. Based on work in Appendix B by NORESCO. August 2017.

The projected program savings from the two energy efficiency potential studies relied upon in this report did not take advantage of the full economic potential that exists for energy efficiency programs and measures. As part of the potential studies, scenarios were constructed based on differing assumptions about cost-effectiveness, program participation, funding, and others. The scenarios generally range from conservative to more aggressive. For example, the analysis of nonutility programs included a conservative, reference, and aggressive case, as described for each program in Appendix B. The projected nonutility

28 Under Public Resources Code Section 25310(c)(2), the Energy Commission can establish a target that aggregates projected electricity and natural gas savings, which implies considering relative cost-effectiveness of electricity versus natural gas savings potential, relative contribution of electricity versus natural gas in reducing GHG emissions, and other issues. The Energy Commission has not exercised this authority for this report but will examine aggregated targets in future target-setting cycles.

savings for this report were based on the reference case, leaving additional savings potential from the aggressive case that could be used to fill any gap between projected savings and the doubling targets.[29] Further analysis of energy efficiency savings potential, including the examination of more aggressive scenarios, will need to be conducted. Market transformation and savings strategies for the industrial and agricultural sectors are likely to deliver additional savings. In the update cycle, the Energy Commission will have the opportunity to work with stakeholders to identify the best way to fill any remaining gaps in meeting the SB 350 targets. As part of this effort, the Energy Commission will also have the opportunity to examine in detail the GHG emission implications associated with the different savings programs and measures to ensure programs are achieving the state's climate goals.

Public Process for SB 350 Target Setting

The doubling targets proposed in this report were developed in collaboration with the CPUC, IOUs, POUs, and other stakeholders in a public process. Working closely with the CPUC, the Energy Commission held a series of workshops to solicit stakeholder feedback and discuss issues related to the SB 350 doubling energy efficiency savings targets. The first workshop, held on July 11, 2016, was a joint workshop with the CPUC to address data and analytical needs for the doubling of energy efficiency.

In January 2017, the Energy Commission published the *Framework for Establishing the Senate Bill 350 Energy Efficiency Savings Doubling Targets* (Framework Paper), which provided a process and policy framework for establishing the energy efficiency targets that SB 350 requires. Energy Commission staff also published a draft of the *SB 350 2030 Energy Efficiency Savings Goal* for stakeholder comment. On January 23, 2017, the Energy Commission held a workshop on SB 350 energy efficiency doubling to solicit input on the proposed doubling target and questions raised in the Framework Paper.

On June 19, 2017, the Energy Commission held a workshop on methods for SB 350 energy efficiency target setting. Building upon the Framework Paper and input from stakeholders, two staff papers were released in July 2017 for public comment that presented analyses of the energy efficiency savings that can be achieved for utility programs and other energy efficiency savings efforts.

One paper laid out the staff's projections of the energy efficiency savings that can be achieved by electric and gas utilities toward the doubling targets. Energy Commission staff analyzed two studies commissioned by the CPUC and POUs that identified energy efficiency savings potential that could be achieved by utilities.

A companion staff paper focused on savings from sources other than utility programs, also referred to as "nonutility" programs. Energy Commission staff, with the help of its contractor NORESCO (and subcontractors), estimated energy savings potential from nonutility programs

29 Similarly, as described in Chapter 3, the CPUC constructed five scenarios of energy savings, with the goals in the final decision based on the mTRC (GHG Adder #1) reference case, leavings additional energy efficiency savings that could be taken advantage of in the future.

in three program areas: codes and standards, financing, and behavioral and market transformation programs.

The Energy Commission held an additional workshop on the draft Commission report on September 7, 2017.[30] Comments from the September 7, 2017, workshop, along with written comments following the workshop, have been addressed in this final report. The Energy Commission anticipates consideration of the report for adoption at the November 8, 2017, business meeting.

30 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 203*0. California Energy Commission. Publication Number: CEC-400-2017-010-CMD. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220927_20170828T144323_Senate_Bill_350_Doubling_Energy_Efficiency_Savings_by_2030.pdf.

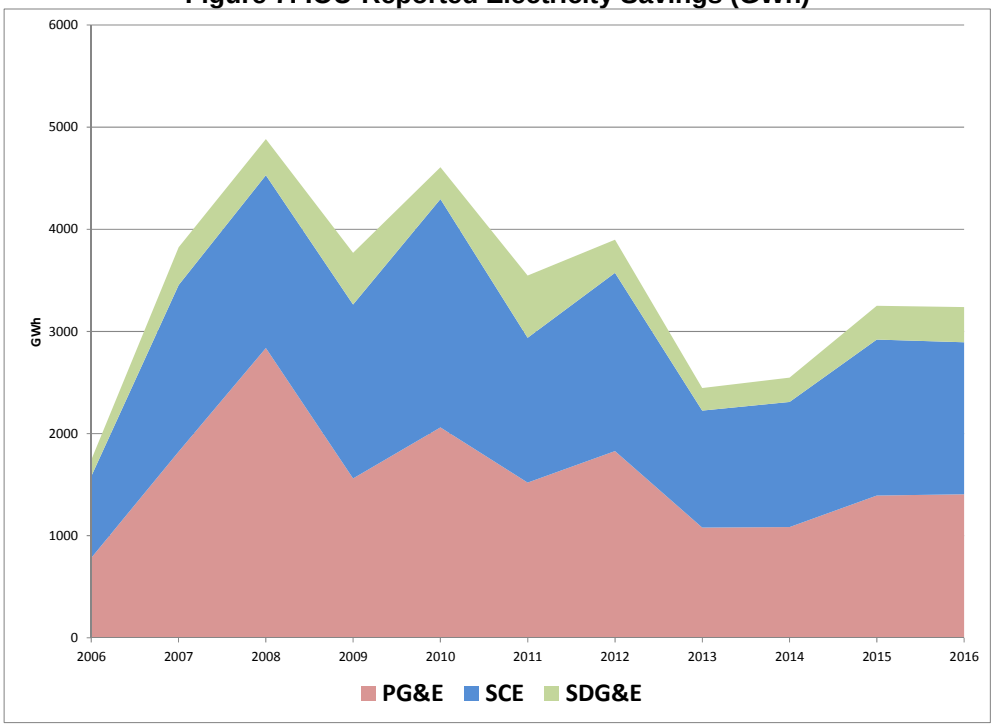
CHAPTER 3:
Investor-Owned Utility Energy Efficiency Programs

Since the 1970s, California utilities have been offering energy efficiency programs to their customers in the residential and nonresidential sectors, as well as the agriculture and industrial segments. A variety of ratepayer-funded programs, from financial assistance to workforce education and public outreach, are helping businesses and homes reduce energy costs and carbon emissions. These energy efficiency programs are important as they reduce GHG emissions, represent the lowest-cost energy resource option and the cleanest form of energy available, and play significant roles in meeting California's energy and climate policy objectives. This chapter discusses utility ratepayer-funded programs that are an important part of the state's strategy to achieve the SB 350 energy efficiency savings doubling targets.

Historical Energy Efficiency Savings

The IOU electricity savings accomplishments are shown in **Figure 7**. IOU gross electricity savings from first-year efficiency measure installations totaled around 3,239 GWh in 2016, a slight decrease of less than 1 percent from 2015. Cumulatively, for the past 10 years IOUs reported almost 38,000 GWh in gross electricity savings. IOUs' electricity savings have varied significantly from year to year since 2012.

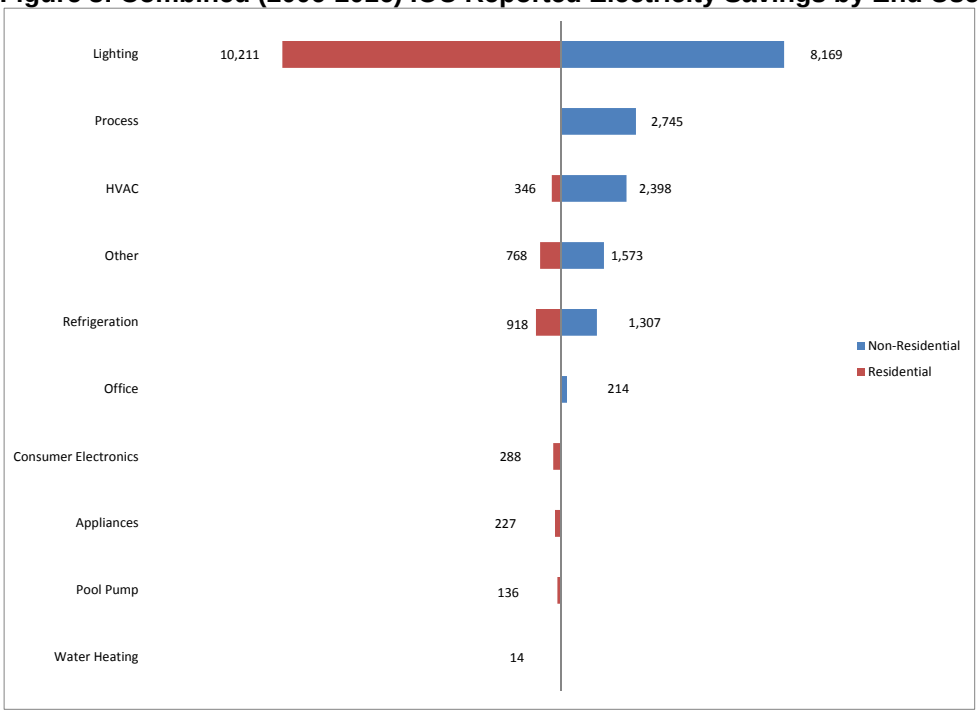
Figure 7: IOU-Reported Electricity Savings (GWh)



Source: California Energy Commission staff, Energy Assessments Division, July 2017, based on the IOUs' Annual Energy Efficiency Reports. These savings numbers are reported savings and not evaluated savings.

The IOU electricity savings by end use in both residential and nonresidential sectors are shown in **Figure 8**. Three of the largest end uses – lighting, process, and heating, ventilation, and air-conditioning (HVAC) equipment – account for the majority of savings.

Figure 8: Combined (2006-2016) IOU Reported Electricity Savings by End Use



Source: California Energy Commission staff, Energy Assessments Division, July 2017.

In past years, the CPUC approved three-year energy efficiency program cycles, which often were followed by a one- or two-year bridge period. This starting and stopping of efficiency funding are not well-suited to bring about long-term energy efficiency savings, as shown in **Figure 7**. In 2014, the CPUC authorized 10-year funding referred to as a "rolling portfolio cycle" that established firm future funding commitments. Additional rules are being established by the CPUC to identify a clear timeline for coordinating various activities in its regulatory process that have until now been difficult to align appropriately. These activities include technical updates, program design and portfolio planning, program operations, and program reporting and evaluation. These rules will also allow different types of evaluation, measurement, and verification (EM&V) studies to have faster turn-around times and to be incorporated into portfolios on a more frequent and timely basis.

IOU Energy Efficiency Target Setting

The following sections discuss and quantify projected savings from IOU energy efficiency programs that can contribute to meeting the SB 350 doubling targets. Chapter 5 discusses additional opportunities for utility energy savings from fuel substitution and conservation voltage reduction (CVR). In addition, estimated savings from the nonutility agricultural and industrial sectors are presented in Chapter 5. Chapter 6 identifies the potential savings from nonutility fuel substitution.

Energy Efficiency Potential and Goals

Starting in 2006 with the passage of Senate Bill 1037 (Kehoe, Chapter 366, Statutes of 2005), the CPUC, in consultation with the Energy Commission, has been required to identify all potentially achievable cost-effective energy efficiency savings and establish energy efficiency goals every other year for investor-owned electrical and gas corporations. The energy efficiency savings goals are based on findings of the potential and goals studies, which are also done every other year. These studies estimate all the potential energy savings available through different technologies, program measures, codes and standards, and behavioral and market transformation programs that the IOUs can use in their energy efficiency portfolios. Potential and goals studies typically identify energy efficiency savings based on technical, economic, and market potential.

The most recent *2018 IOU Potential and Goals Study* is designed to determine a version of market-based savings potential under a given set of assumptions.[31] The most recent study, which was already underway when SB 350 was being implemented, was not specifically designed to identify how utility programs might contribute to the large increase in energy efficiency savings necessary to achieve the SB 350 doubling goals. Additional efforts will be necessary to identify utility program savings beyond the current goal setting.

For the most recent goal setting, *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. The technical potential represents the projected total energy savings available each year that is above the baseline of the Title 20 and Title 24 codes and federal appliance standards.

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, as determined by the cost-effectiveness metrics described in the section on cost-effectiveness below. All components of economic potential are a subset of technical potential. Finally, a market potential analysis is conducted that calculates the energy efficiency savings that could be expected in response to specific levels of incentives and assumptions about market influences and barriers.

All components of market potential are a subset of economic potential.[32] Assumptions about stock turnover rates are not applied annually to these categories of efficiency potential. Instead, efficiency improvements are assumed to be applied to all applicable equipment and systems in the first year that those improvements are available.

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31 CPUC R.13-11-005, Appendix A. Prepared by Navigant for the CPUC, *Energy Efficiency Potential and Goals Study for 2018 and Beyond.* June 2017. http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M190/K624/190624112.PDF.

32 Some studies also refer to this as *maximum achievable potential.* Market potential is used to establish the utilities' energy efficiency goals, as determined by the CPUC.

Net and Cumulative Savings Goals

After seven years of gross savings goals, the CPUC is returning to setting net savings goals for the IOU energy efficiency portfolios beginning in 2018 because net savings numbers are used in many proceedings, including the CPUC's long-term procurement planning proceeding,[33] and in calculating AAEE for the Energy Commission's energy demand forecast.[34] In 2016, the CPUC ordered staff to collaborate with the Energy Commission and other stakeholders through the Joint Agency Steering Committee and the Demand Analysis Working Group to update the method used to develop cumulative goals and potentially support cumulative goals for the update of the *2018 IOU Potential and Goals Study*. This process is ongoing. As a reliable method for developing cumulative goals has not yet been developed, CPUC Decision 17-09-025 adopting energy efficiency goals for 2018 through 2030 does not set cumulative goals. Instead, the decision instructs CPUC staff to assess the viability of using a method for calculating persistence decay, to be considered by the Energy Commission for SB 350 target setting.[35]

Although the CPUC has decided not to adopt cumulative savings for its internal energy efficiency goal setting, the Energy Commission believes cumulative targets are required for SB 350. It is crucial to focus on longer-lived measures and/or processes that lead to measure replacement upon decay. Resolving this issue requires distinguishing between physical decay in performance of a measure versus the customer behavioral issues associated with replacing that measure. While this will likely require intensive research studies taking years to implement, narrowing the uncertainty about savings decay is fundamental to relying on cumulative energy efficiency savings projections that are used to displace other resource additions in pursuing the overall goal of GHG emission reductions. The Energy Commission acknowledges analytic issues in setting these targets in this initial round of SB 350 analyses. However, the Energy Commission believes it is important to establish an enduring framework for future improvements.

Cost-Effectiveness

The *2018 IOU Potential and Goals Study* constructed scenarios to examine the market potential using a range of cost-effectiveness tests. As discussed in Chapter 1, the two most commonly used methods for determining cost-effectiveness of IOU programs are the TRC and the PAC. Because the primary emphasis of SB 350 is on GHG emission reductions, determining cost-effectiveness accounting for these reductions is important in setting energy efficiency targets.

In April 2017, the CPUC released a staff proposal for an interim GHG adder to be used as an input into different cost-effectiveness tests for evaluating distributed energy resources.[36] The

33 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K663/158663325.PDF.

34 http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-200-2016-016-CMF.

35 http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M194/K656/194656346.PDF.

36 Rulemaking 14-10-003, Administrative Law Judge Ruling Requesting Comment on an Interim Greenhouse Gas Adder, *Energy Division Staff Proposal Addendum: Interim GHG Adder*, April, 3, 2017. https://apps.cpuc.ca.gov/apex/f?p=401:58:0::NO:RP,59,RIR:P5_PROCEEDING_SELECT:R1410003.

CPUC staff proposed adopting an annualized straight line escalation from $0 per metric ton (tonne) carbon dioxide (CO_2) in 2017 to $250 in 2030, which is the marginal abatement cost for that year based on preliminary integrated resource planning (IRP) modeling results. The IOUs proposed an alternate GHG adder curve based on the Allowance Price Containment Reserve used in the Cap-and-Trade Program.[37] This curve is an extrapolation of the preliminary values used by California Air Resources Board in the *2030 Scoping Plan Update*.[38]

IOU Market Potential

The two GHG adders discussed in the previous section were used in constructing the scenarios for consideration in the IOU goal setting. To keep the number of scenarios manageable but still provide a range of alternatives to bound market potential, five scenarios were proposed and are listed in **Table 1**. The TRC | Reference scenario represents "business as usual" and continues current policies. Three 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 for the combination of program participation and cost-effectiveness screens relying on existing and enhanced or expanded programs or both.

Table 1: Scenarios for Energy Efficiency Potential

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

Source: CPUC, *2018 IOU Potential and Goals Study,* June 2017.
http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M190/K624/190624112.PDF

CPUC-Adopted IOU Energy Efficiency Goals

The CPUC released Decision 17-09-025 in late September 2017, with the IOU energy efficiency goals for 2018-2030.[39] These goals were adopted by the CPUC on September 28, 2017, and were based on the mTRC (GHG Adder #1) reference scenario. To set IOU goals for SB 350, the Energy Commission proposes to use the individual IOU targets established by the CPUC, minus the savings from codes and standards for this first iteration of SB 350 savings assessment. Further analysis will be necessary in upcoming *IEPRs* to adjust the SB 350 targets

37 *Joint IOUs Opening GHG Adder Comments*, P. 6
http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M185/K576/185576217.PDF.

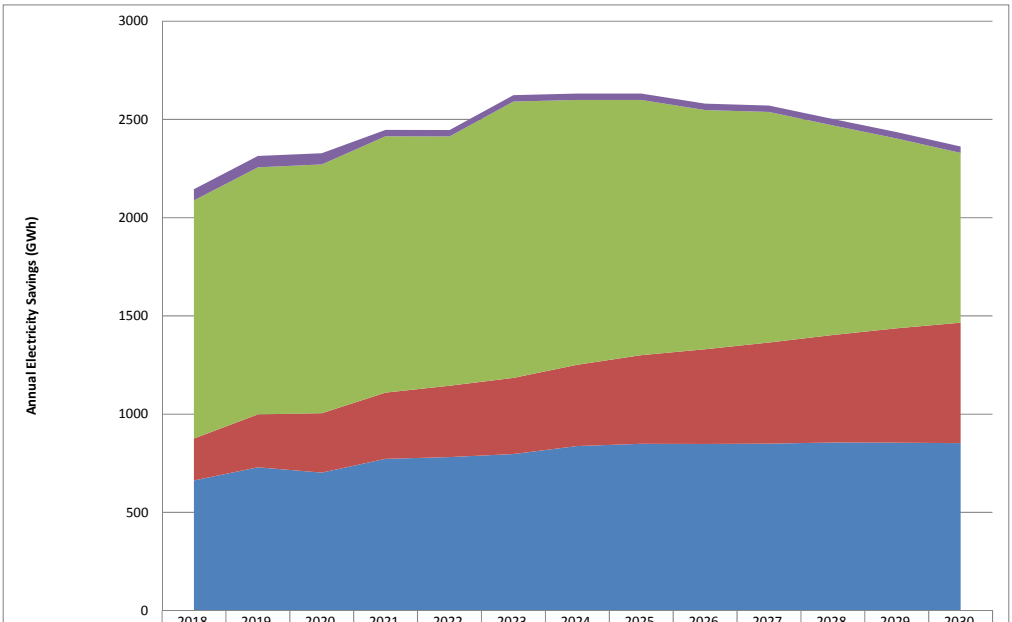
38 The curve is an extrapolation of the prices in California Air Resources Board staff report, *Initial Statement of Reasons*, Appendix C, August 2, 2016, Table 5. Available at
https://www.arb.ca.gov/regact/2016/capandtrade16/appc.pdf.

39 CPUC Decision Adopting Energy Efficiency Goals for 2018 – 2030. September 28, 2017.
http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M194/K656/194656346.PDF.

to reflect changing market conditions or other external factors and to report on IOU progress in achieving doubling targets.

Figure 9 and **Figure 10** reflect the annual electricity and natural gas savings for the IOUs using the mTRC (GHG Adder #1) scenario, which is the scenario relied upon for setting the IOU goals in the CPUC's decision. For 2018, the IOUs' electricity goals are proposed to be about 3 percent higher than the electricity goals adopted from the 2015 Potential and Goals Study, and in 2024 the goals will be about 70 percent higher for electricity. The 2018 gas goals are proposed to be 48 percent higher than the 2015 Potential and Goals Study and 103 percent higher in 2024. Much of the increase in savings is due to behavior, retrocommissioning,[40] and operational savings (BROs) reflecting greater market adoption as incentives increase and consumers become more aware of such programs, leading to higher levels of customer uptake.

Figure 9: Annual Electricity Savings—mTRC (GHG Adder #1) Reference Scenario (GWh)



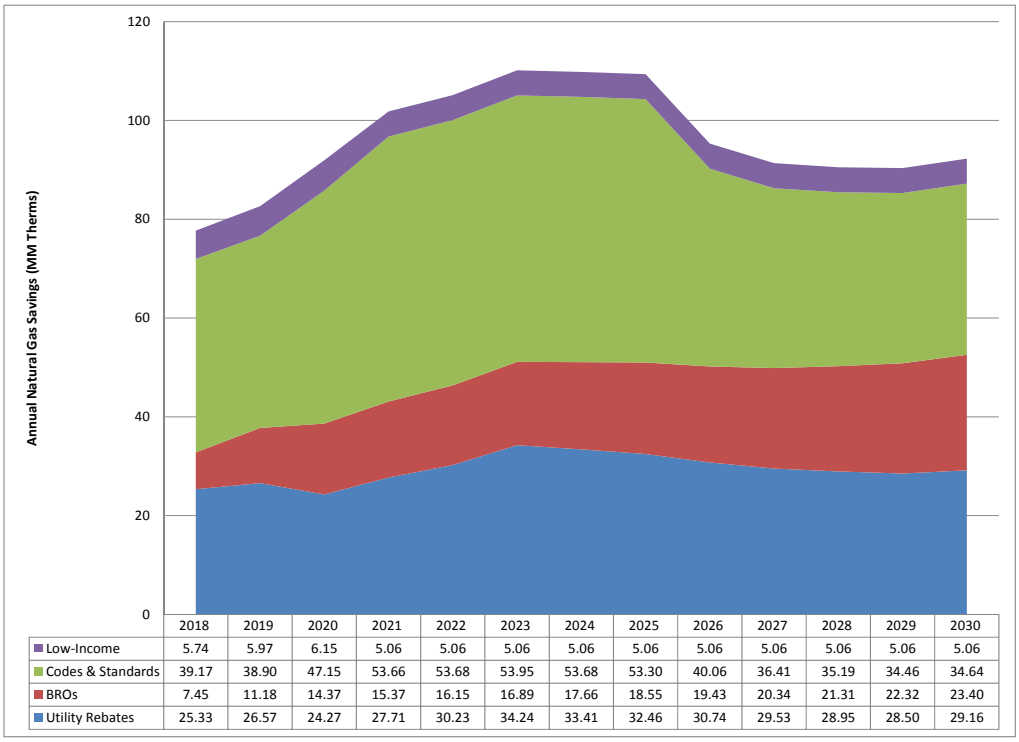
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low-Income	56.84	57.25	57.02	32.71	32.71	32.71	32.71	32.71	32.71	32.71	32.71	32.71	32.71
Codes & Standards	1211.68	1257.16	1266.36	1304.24	1268.84	1406.21	1347.36	1298.72	1217.84	1173.46	1066.83	965.96	864.26
BROs	213.33	269.76	301.93	337.66	363.39	388.18	414.03	451.06	482.13	514.40	547.41	581.75	612.92
Utility Rebates	662.89	729.44	702.51	772.27	781.24	796.75	837.68	849.07	848.03	850.04	855.29	855.12	852.54

Source: CPUC/Navigant. *Energy Efficiency Potential and Goals Study for 2018 and Beyond - Final Public Report*. August 2017. http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M194/K614/194614840.PDF.

Figure 10: Annual Natural Gas Savings – mTRC (GHG Adder #1) Reference Scenario

40 Retrocommissioning is a process to improve energy efficiency of an existing building's equipment and systems that involves a systematic evaluation of opportunities to resolve problems during design and construction, or address problems that have developed throughout the building's life as equipment has aged, or as building usage changes..

(MMTherms)



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low-Income	5.74	5.97	6.15	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06
Codes & Standards	39.17	38.90	47.15	53.66	53.68	53.95	53.68	53.30	40.06	36.41	35.19	34.46	34.64
BROs	7.45	11.18	14.37	15.37	16.15	16.89	17.66	18.55	19.43	20.34	21.31	22.32	23.40
Utility Rebates	25.33	26.57	24.27	27.71	30.23	34.24	33.41	32.46	30.74	29.53	28.95	28.50	29.16

Source: CPUC/Navigant. *Energy Efficiency Potential and Goals Study for 2018 and Beyond - Final Public Report*. August 2017. http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M194/K614/194614840.PDF.

Adjustments to CPUC Savings Projections

For setting IOU targets under SB 350, the Energy Commission proposes specific adjustments to the savings projections presented in the mTRC – GHG Adder #1 scenario of the *2018 IOU Potential and Goals Study* that will help streamline accounting and tracking of savings. These are the following:

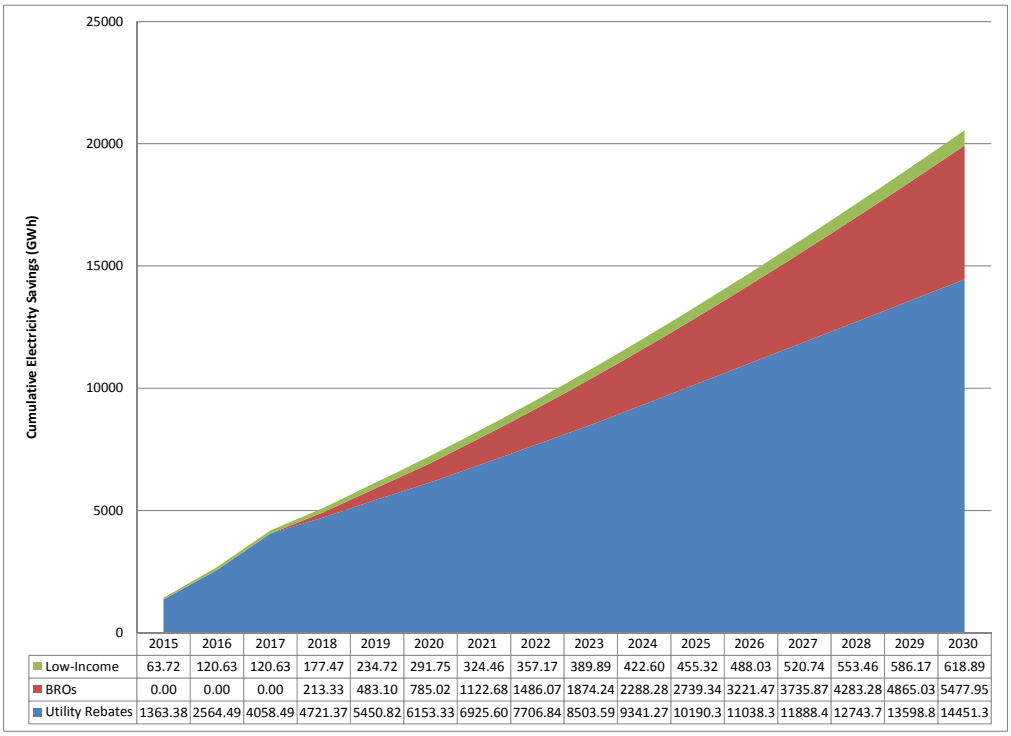
- Excluding the savings projections for codes and standards from the utility projected savings and accounted for under nonutility programs.
- Adding in historical savings for 2015-2017 to reflect 2015 base year for consistency with SB 350.[41]
- Selecting cumulative savings projections to meet the requirement of SB 350 that the statewide doubling goal be cumulative.

Figure 11 shows cumulative electricity savings projections and **Figure 12** shows cumulative natural gas savings projections using the mTRC – GHG Adder #1 scenario.

Figure 11: Electricity Savings – mTRC (GHG Adder #1) Reference Scenario by Program Type

41 The *2018 IOU Potential and Goals Study* reported only from 2018 through 2030.

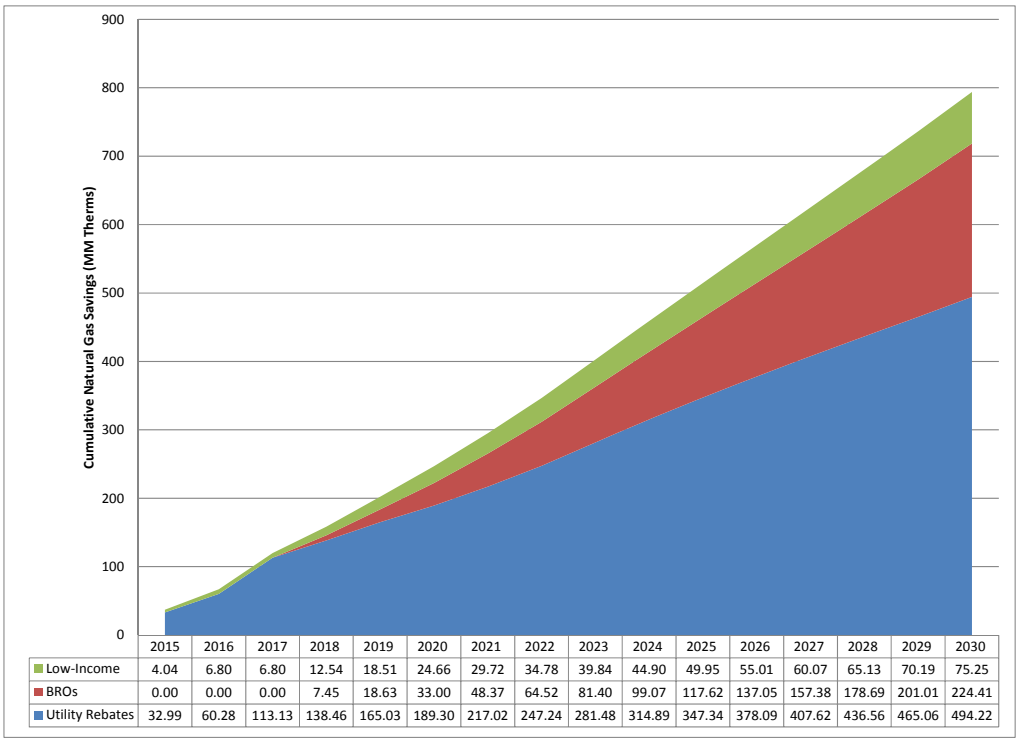
(Excluding Codes and Standards) (GWh)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low-Income	63.72	120.63	120.63	177.47	234.72	291.75	324.46	357.17	389.89	422.60	455.32	488.03	520.74	553.46	586.17	618.89
BROs	0.00	0.00	0.00	213.33	483.10	785.02	1122.68	1486.07	1874.24	2288.28	2739.34	3221.47	3735.87	4283.28	4865.03	5477.95
Utility Rebates	1363.38	2564.49	4058.49	4721.37	5450.82	6153.33	6925.60	7706.84	8503.59	9341.27	10190.3	11038.3	11888.4	12743.7	13598.8	14451.3

Source: CPUC/Navigant. *Energy Efficiency Potential and Goals Study for 2018 and Beyond - Final Public Report*. August 2017. http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M194/K614/194614840.PDF.

Figure 12: Natural Gas Savings – mTRC (GHG Adder #1) Reference Scenario by Program Type (Excluding Codes and Standards) (MM Therms)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low-Income	4.04	6.80	6.80	12.54	18.51	24.66	29.72	34.78	39.84	44.90	49.95	55.01	60.07	65.13	70.19	75.25
BROs	0.00	0.00	0.00	7.45	18.63	33.00	48.37	64.52	81.40	99.07	117.62	137.05	157.38	178.69	201.01	224.41
Utility Rebates	32.99	60.28	113.13	138.46	165.03	189.30	217.02	247.24	281.48	314.89	347.34	378.09	407.62	436.56	465.06	494.22

Source: CPUC/Navigant. *Energy Efficiency Potential and Goals Study for 2018 and Beyond - Final Public Report*. August 2017. http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M194/K614/194614840.PDF.

CHAPTER 4:
Publicly Owned Utility Energy Efficiency

California's POU are vertically integrated utilities regulated by local governing boards and that vary by size, customer base, and resource portfolios. POU electricity savings programs provide subsidies and incentives for energy efficiency to the final end users. POU incentive programs range from cash rebates for the purchase of higher-efficiency products and home energy upgrades to customized financial incentives and awareness and education campaigns that improve customer energy use behavior. Only a few small POUs provide natural gas service to end-use customers, which is a small fraction of the scale of natural gas service provided by IOUs to end users across the state.[42] Thus, natural gas savings from energy efficiency measures presented in Chapter 3 are largely a result of CPUC-supervised IOU activities. Additional POU natural gas savings have not been included in the SB 350 targets.

POU incentives for electricity savings can be designed for customers or can be directed further upstream in larger consumer market supply chains to encourage manufacturers, retailers, contractors, and builders to influence how consumers pick building designs, choose operating methods, or buy home appliances. POUs also administer load management programs that provide technical assistance and customer incentives to install automated demand response equipment, undertake voluntarily scheduled load reduction, and manage peak-day and time-of-use consumption patterns.

Historical Energy Efficiency Savings

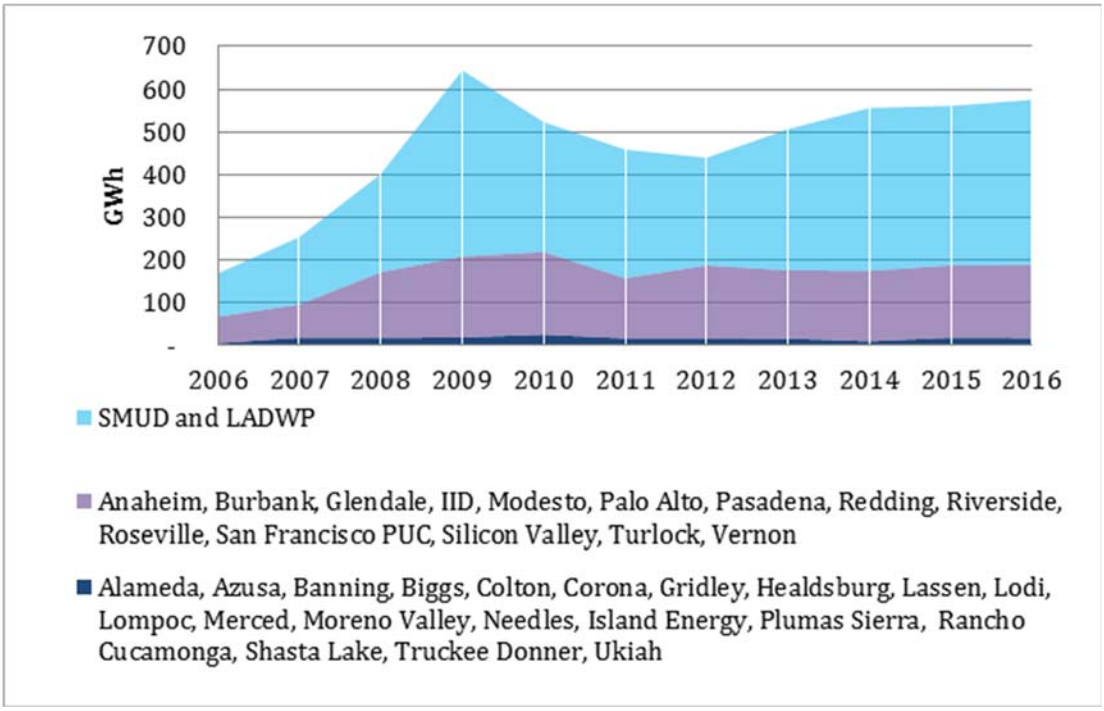
The POU electricity savings accomplishments are shown in **Figure 13**. POU net electricity savings from first-year efficiency measure installations totaled around 575 GWh in 2016, a slight increase of 2 percent over 2015. In March of each year, CMUA submits an annual report on energy efficiency savings.[43] Cumulatively, POUs reported more than 5,000 GWh in net electricity savings for the past 10 years. POUs' electricity savings have been steadily increasing since 2012.

The POU electricity savings by end use in both residential and nonresidential sectors are shown in **Figure 14**. Two of the largest end uses – lighting and heating, ventilation, and air-conditioning (HVAC) equipment – account for the majority of savings.

42 The City of Palo Alto provides both electricity and natural gas service to end-use customers and offers energy efficiency programs. Only very limited data and program descriptions of these programs were available for the *POU Potential and Goals Study.*

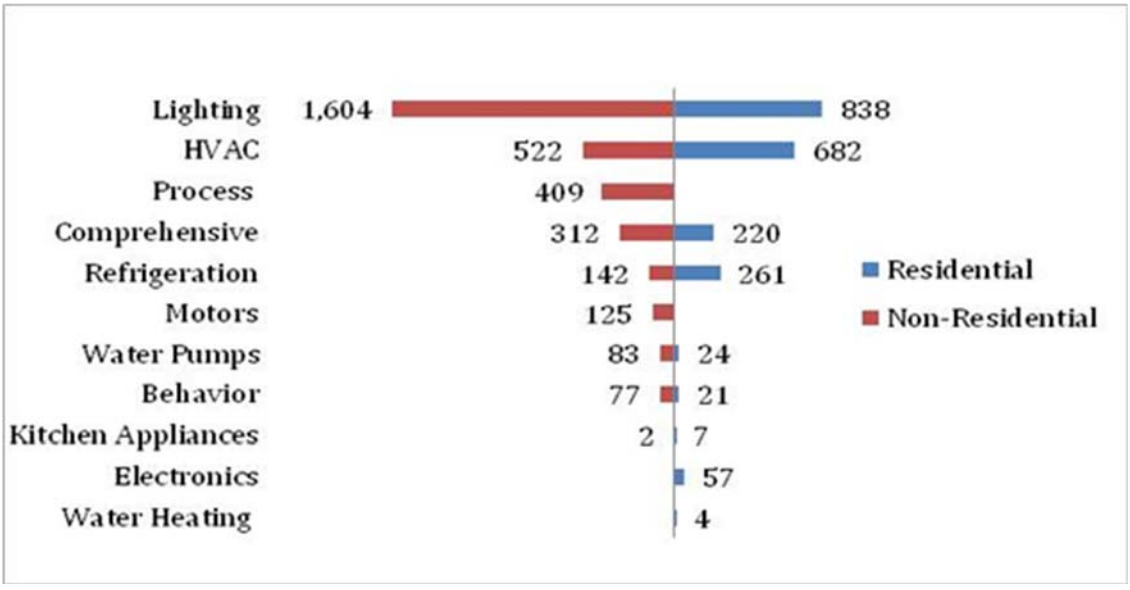
43 *Energy Efficiency in California's Public Power Sector Status Reports, Appendix B* http://www.ncpa.com/policy/reports/energy-efficiency/.

Figure 13: POU Reported Electricity Savings (GWh)



Source: California Energy Commission staff, July 2017, based on *Energy Efficiency in California's Public Power Sector Status Reports*, Appendix B http://www.ncpa.com/policy/reports/energy-efficiency/.

Figure 14: Combined (2006-2016) POU Reported Electricity Savings by End Use (GWh)



Source: California Energy Commission staff, July 2017, based on *Energy Efficiency in California's Public Power Sector Status Reports*, Appendix B http://www.ncpa.com/policy/reports/energy-efficiency/.

POU Energy Efficiency Potential and Goals Studies

POUs are required to identify on a four-year cycle all feasible and cost-effective energy efficiency savings and establish 10-year annual goals.[44] In addition, they are required to provide to their customers and the Energy Commission the results of evaluation studies that measure and verify claimed demand reduction and energy savings. The CMUA, in partnership with the Northern California Power Agency (NCPA) and the SCPPA, collaborated on developing POU 10-year electricity savings projections to establish electricity savings goals. CMUA used the contractor Navigant to perform the technical assessment used by the POUs in establishing the 10-year targets.[45]

The POUs' 2017 report on energy efficiency potential and goals (*POU Potential and Goals Study*) was submitted in March 2017. The study uses the Navigant's Electricity Resource Assessment Model (ELRAM) to calculate technical, economic, market-maximum, and market-adjusted electricity savings projections. ELRAM is substantially similar to the Navigant model used by the CPUC to establish energy efficiency goals for the IOUs. The *POU Potential and Goals Study* presents a base set of projections of electricity savings and demand reduction as a function of projected electricity sales. Each POU then directed CMUA/Navigant to modify estimates using alternative assumptions, or other changes, for its own portion of the overall POU savings projection. The *POU Potential and Goals Study* contains the results of the adjustments to the base analysis identified by each POU, so there is no uniform set of assumptions common to all POUs, nor have any alternative scenarios been prepared.

The POUs generally use the levelized cost of energy efficiency measures as the most useful metric for evaluating cost-effectiveness and for making comparisons to generation resources.[46] ELRAM estimates economic potential as the amount of technical potential that is cost-effective, as defined in this case by the results of the TRC test.[47] POUs use the TRC test as a cost-benefit analysis of relevant energy efficiency measures, excluding market barriers such as lack of consumer knowledge. Benefits include the avoided costs of generation, transmission, and distribution investments; avoided fuel costs; and other benefits that may accrue to participants or to the utility or both. Costs vary by economic test but may include incremental technology cost, incentives, administrative costs, or lost revenue.

For the *POU Potential and Goals Study*, *technical potential* is defined as the complete penetration of all available energy efficiency measures. It is a product of the electricity savings per unit of a measure, the quantity of applicable efficiency units in each facility, and the number of facilities in a utility service territory. The quantity of applicable units per year

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44 Assembly Bill 2021 (Levine, Chapter 734, Statutes of 2006) required 10-year efficiency targets to be set every three years. Assembly Bill 2227 (Bradford, Chapter 606, Statutes of 2012) changed the frequency of target setting to every four years.

45 *Energy Efficiency in California's Public Power Sector: 11th Edition* – 2017. March 15, 2017. http://www.ncpa.com/wp-content/uploads/2015/02/2017_POU_EE_Reportv2.pdf.

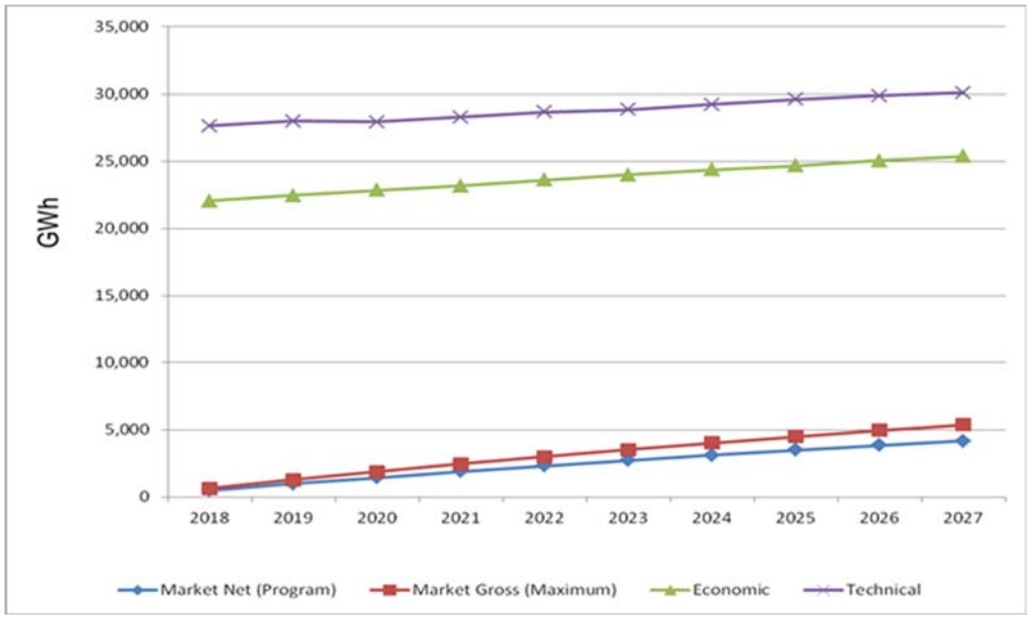
46 *Energy Efficiency in California's Public Power Sector: 11th Edition.* 2017. P. 18.

47 *Energy Efficiency Potential Forecasting for California's Publicly Owned Utilities.* Prepared by Navigant for CMUA. February 2017. P. 12. http://ncpasharepointservice20161117100057.azurewebsites.net/api/document?uri=https://ncpapwr.sharepoint.com/sites/publicdocs/Compliance/2017_Energy_Efficiency_Report.pdf.

is determined by the effective useful life of the measure. *Economic potential* represents a portion of the technical potential if a utility installs measures that meet the cost-effectiveness screening, which uses both the TRC and PAC tests. POU market potential is estimated in response to specific levels of incentives, program design, the magnitude of utility rebates, and assumptions about policies, market influences, and market barriers. Gross and net market potentials are estimated incrementally and cumulatively. Some of the POU-specific methods differ in whether the estimates are considered net of naturally occurring efficiency or free riders.

Figure 15 provides savings potential using the ELRAM projections for the composite of all POUs. Technical and economic potentials are relatively constant through time, reflecting the definition of these concepts described above. Market potential and net program savings projections grow through time as year-by-year savings accumulate. However, by the end of the 10-year period, only limited amounts of economic potential have been achieved.

Figure 15: POU Ten-Year Cumulative Savings Potential (GWh)



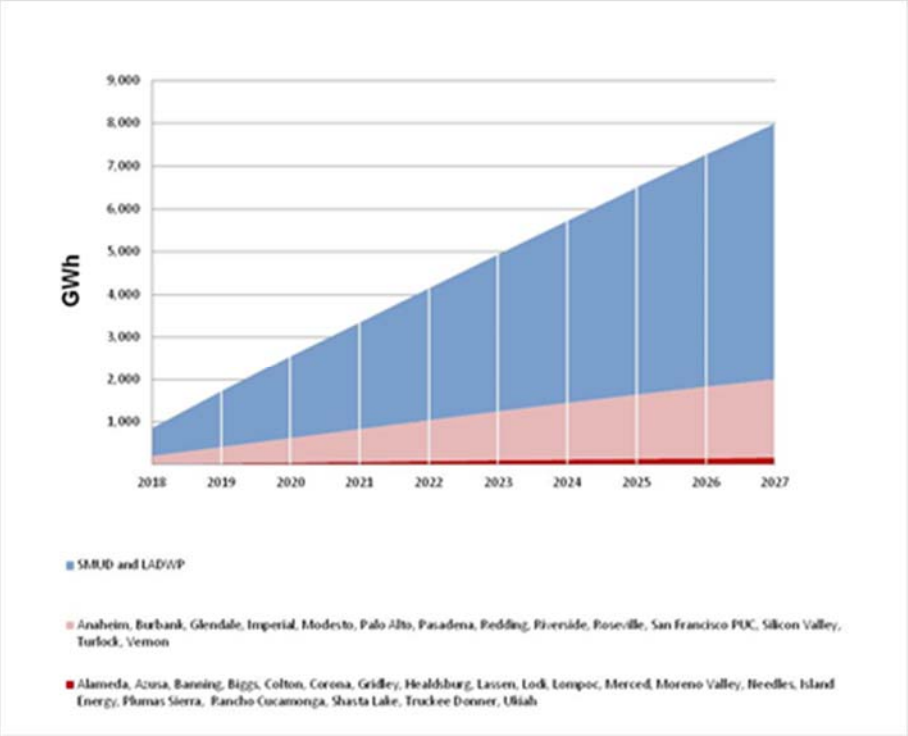
Source: CMUA, *POU Potential and Goals Study,* March 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217680_20170522T124015_Energy_Efficiency_in_California's_Public_Power_Sector_11th_Edit.pdf.

POU Energy Efficiency Goals

As described above, each POU used different assumptions to arrive at its respective goals. **Figure 16** provides a view of cumulative 10-year savings for all POUs combined into three size groups. The Los Angeles Department of Water and Power (LADWP) and the Sacramento Municipal Utility District (SMUD) alone account for much more than half of total cumulative savings. The 14 medium-sized POUs account for about a quarter of the cumulative savings.[48] The remaining POUs collectively account for a very small share of composite POU savings.

48 The large and medium-sized POUs are the 16 utilities for which the integrated resource planning requirements of SB 350 are applicable. These are the 16 POUs for which historical energy sales are 700 GWh per year or larger.

Figure 16: Ten-Year Cumulative Savings Goals by POU Group (GWh)



Source: CMUA, *POU Potential and Goals Study,* March 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217680_20170522T124015_Energy_Efficiency_in_California's_Public_Power_Sector_11th_Edit.pdf.

Adjusted POU Energy Efficiency Projections

Since each POU customizes the final projections of goals that were submitted to the Energy Commission, the composite projections shown above do not use a uniform basis for developing future savings projections. To partially address this problem for SB 350 and the energy demand forecast, Energy Commission has adjusted the savings estimates presented in the *POU Potential and Goals Study*.

Three adjustments were made to some or all POU projections to put them on a uniform basis.

- Where appropriate, shift from gross to net savings for specific POUs. As discussed in Chapter 1, energy efficiency savings can be reported as either net, gross, or both metrics. The *POU Potential and Goals Study* reported both metrics, but POUs generally selected net savings estimates rather than gross savings. However, several POUs directed CMUA/Navigant to use gross savings for setting goals in the *POU Potential and Goals Study*.

- Where appropriate, exclude savings from codes and standards, as was done for the IOUs. Those savings have been accounted for in nonutility program savings projections.[49, 50]
- For all POUs add historical savings from 2015-2017 and extrapolate savings from 2027 through 2029.

Table 2 provides a listing of which utilities required one or both of the first two adjustments. All POUs were adjusted as described in Item 3 above.

Table 2: Adjustments to POU-Submitted Targets for the 16 Large and Medium-Sized POU

POU	Adjust for Net	Adjust for C&S
LADWP	✓	✓
SMUD	✓	✓
Imperial		✓
Anaheim	✓	✓
Riverside	✓	
Pasadena	✓	
Turlock		✓
Santa Clara		
Glendale		✓
Burbank	✓	
Modesto		
Roseville	✓	
Palo Alto		
Vernon		✓
Redding	✓	
San Francisco PUC		

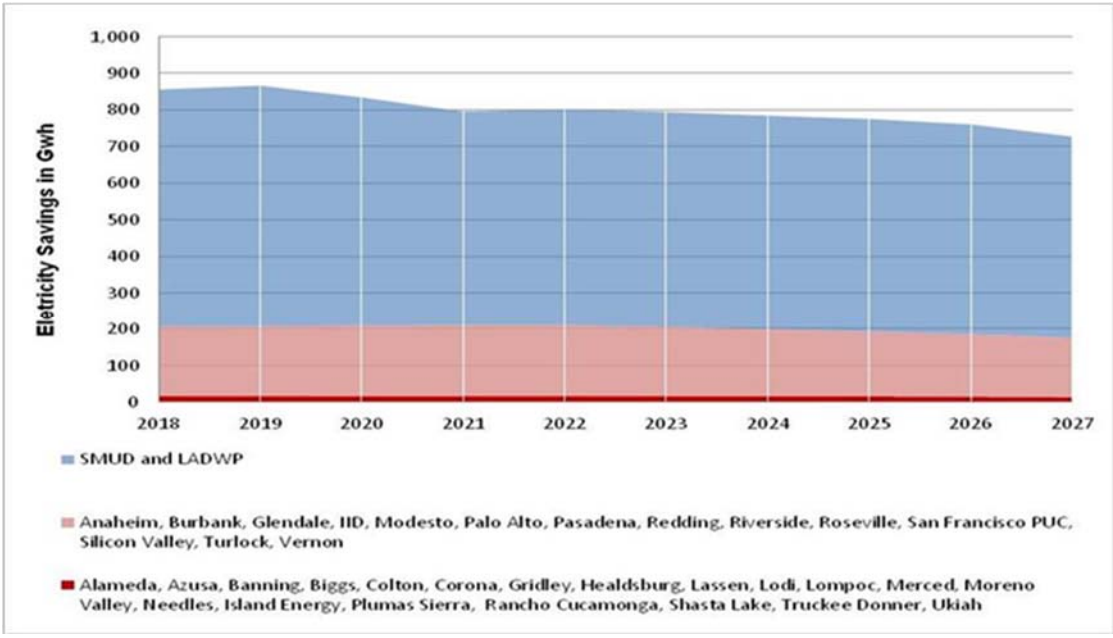
Source: California Energy Commission staff, Demand Analysis Office, July 2017.

The effect of these adjustments on the three aggregate groups of POUs can be seen by comparing **Figure 17** and **Figure 18**. Both figures report annual incremental savings and generally report reductions in annual savings going forward in time. The most important difference between the two figures is that **Figure 17** begins in 2018, while **Figure 18** begins in 2015. This difference reflects the requirement of SB 350 to use 2015 as the base year. The second important difference is that all the annual incremental values in **Figure 18** are scaled down about 200 GWh per year compared to the corresponding values in **Figure 17**. This difference reflects the exclusion of codes and standards savings and the replacement of gross savings by net savings.

49 Appendix B – *2018-2027 Annual Targets*. All POUs. Excel Spreadsheet. May 8, 2017. CMUA. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217215_20170420T151450_SB_350_2030_EE_Savings_Doubling_Goal.xlsx .

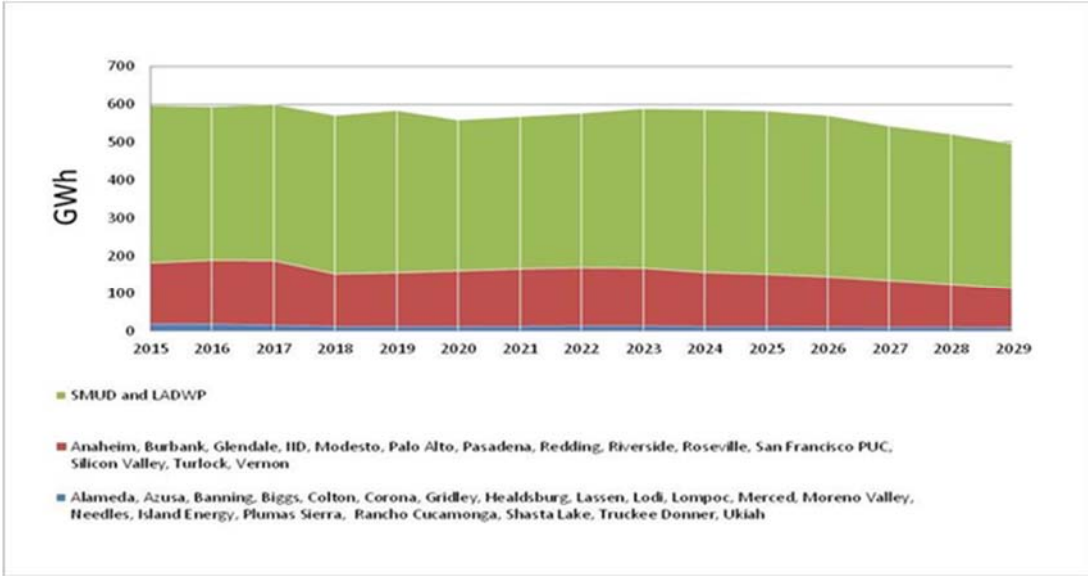
50 *POU Responses to the California Energy Commission Questions*. May 8, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217483_20170508T153257_POU's_Response_to_California_Energy_Commission's_Questions.pdf.

Figure 17: POU Annual Incremental Electricity Savings Goals (GWh)



Source: CMUA, *POU Potential and Goals Study,* March 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217680_20170522T124015_Energy_Efficiency_in_California's_Public_Power_Sector_11th_Edit.pdf.

Figure 18: POU Annual Goals With Adjustments (GWh)

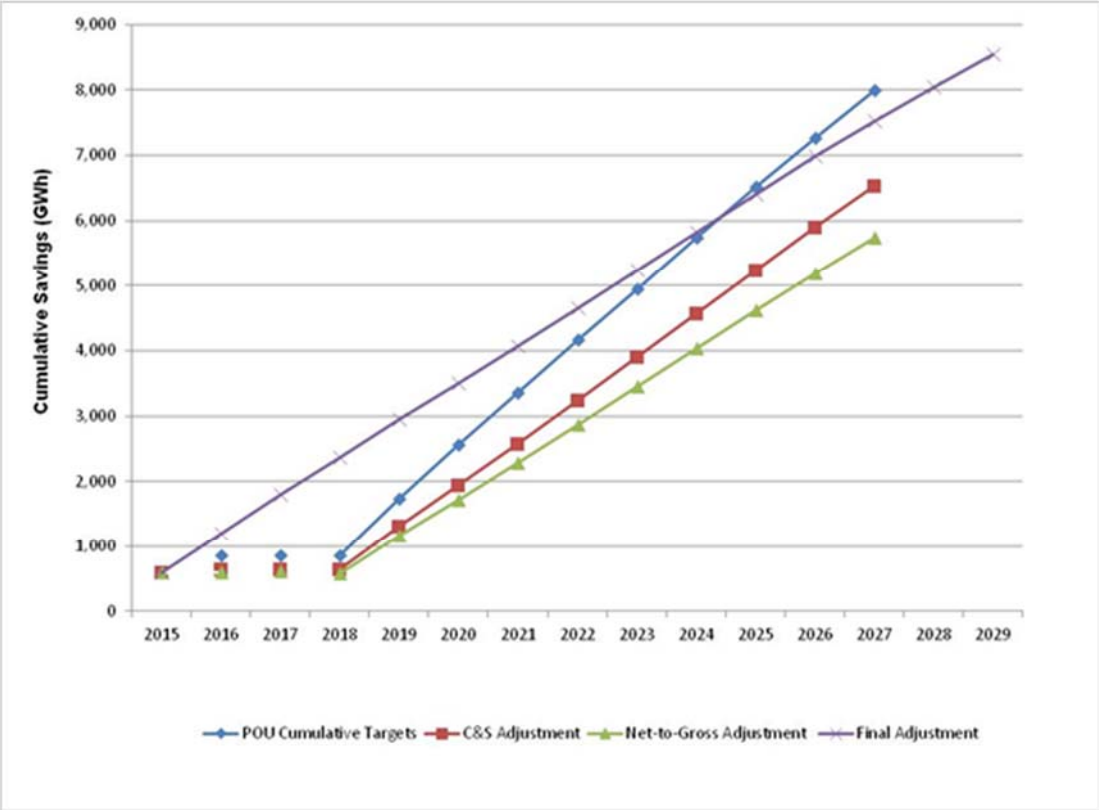


Source: Energy Commission staff, Energy Assessments Division, July 2017. Based on CMUA, *POU Potential and Goals Study,* March 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217680_20170522T124015_Energy_Efficiency_in_California's_Public_Power_Sector_11th_Edit.pdf.

Figure 19 depicts the cumulative effect of these proposed adjustments on the original POU projections as submitted in March 2017. The blue line represents the cumulative savings for all POUs for the period submitted within the CMUA report – 2018 to 2027. The red line indicates the adjustment to remove codes and standards savings – all annual values on the red line are lower in each year than those for the blue line. The green line represents the effect of replacing gross savings with net savings. As with the first adjustment, all green line

values are lower in each year than the corresponding red line values. Finally, the purple line represents the results of adding savings in the historical years of 2015 and 2016 (and estimated savings for current year 2017), so the value for each year is always higher in 2018 to 2027, reflecting adding a constant value to the original POU projections.

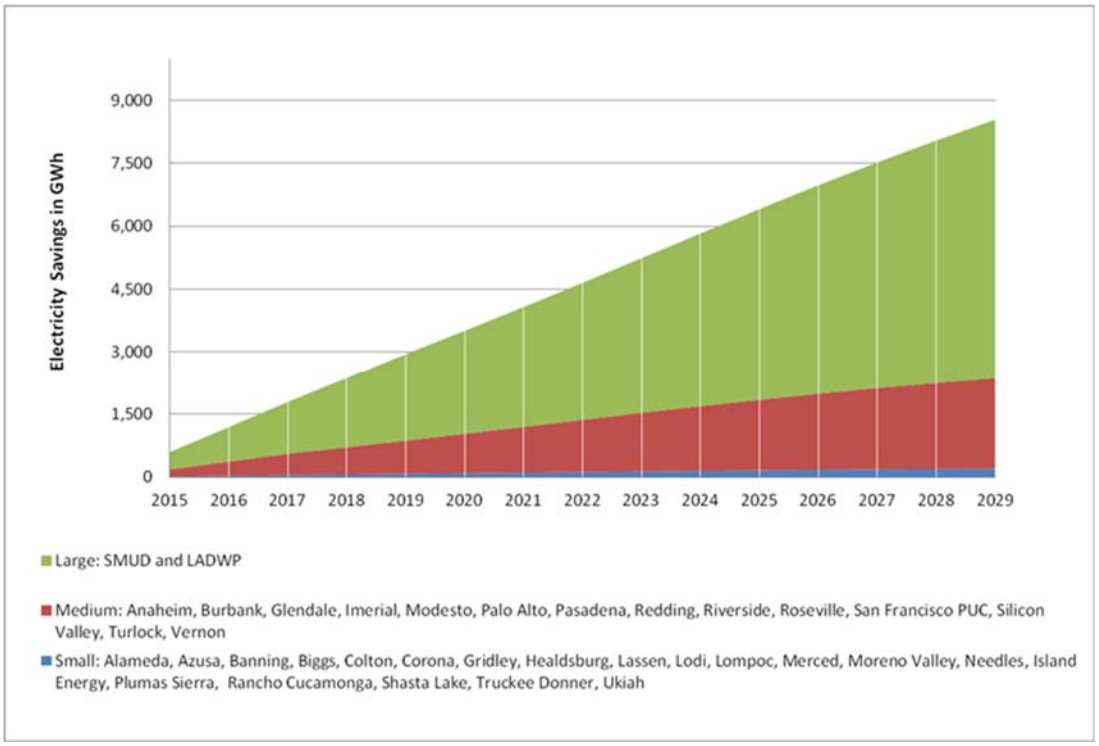
Figure 19: Effect of Adjustments to POU Cumulative Savings (GWh)



Source: California Energy Commission staff, Energy Assessments Division, July 2017. Based on CMUA, *POU Potential and Goals Study,* March 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217680_20170522T124015_Energy_Efficiency_in_California's_Public_Power_Sector_11th_Edit.pdf.

Figure 20, using the same format as **Figure 16,** represents the adjusted cumulative savings by the three POU size groups. Targets by POU are presented in Appendix A.

Figure 20: Proposed POU Adjusted Cumulative Subtargets (GWh)



Source: California Energy Commission staff, Energy Assessments Division, July 2017.

POU Comments on Proposed SB 350 Doubling Subtargets

Both SMUD and the joint POUs filed comments expressing concern about the proposed target-setting process for publicly owned utilities (POUs).[51] For example, the joint POUs state that "the reference to establishing targets for IRP utilities should be reframed as it implies that the CEC staff targets preempt the POU targets adopted by local governing boards, and that POUs subject to the IRP will be expected to incorporate the Energy Commission targets instead of their own adopted targets into their IRP filings; neither of which is within the scope of the CEC's authority to direct."[52] Similarly, SMUD states, "The exclusive authority to establish POU-specific energy efficiency targets rests with the POUs' governing boards."[53] SMUD also states, "SB 350 continues the previous Commission authority to establish statewide efficiency targets that were established via SB 1037 in 2005, while providing direction to the Commission that the new statewide targets established this year be aimed at a cumulative doubling of energy efficiency by 2030.[54] SB 350 also continues the longstanding policy in Public Utilities Code Section 9505(b) that it is POUs' governing boards that must

51 Joint Publicly Owned Utilities Comments on Draft Staff Papers on SB 350 Energy Efficiency Savings Doubling Targets. Docket Number 17-IEPR-06. August 3, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220545_20170803T165754_Jonathan_Changus_Comments_CMUA_NCPA_and_SCPPA_Joint_Comments_on.pdf .

52 Ibid. P. 9.

53 Comments of the Sacramento Municipal Utility District on Senate Bill 350 Energy Efficiency Target Setting for Utility Programs. Docket Number 17-IEPR-06. P. 2. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220539_20170803T145417_Lourdes_JimenezPrice_Comments_Comments_of_the_Sacramento_Munici.pdf.

54 Ibid. P.2.

adopt energy efficiency targets, continuing to indicate that these targets should be 'consistent with' the statewide targets established by the Commission."[55]

SMUD and the joint POUs misconstrue the Energy Commission's role in this proceeding. The Energy Commission has never stated that the POU targets that it identifies as part of the SB 350 process should supplant the POUs' own targets or that the POUs would be obligated to incorporate these targets as their own. Rather, the Energy Commission targets reflect the POU-adopted targets with adjustments that are necessary to ensure a uniform basis for developing savings projections. In fact, the Energy Commission agrees that POUs can continue to set their own targets, even if those targets are developed using different methods than those adopted by the Energy Commission.

However, the Energy Commission has an affirmative obligation to recommend improvements that "can be made in either the level of a local publicly owned electric utility's annual targets to achieve all cost-effective, reliable, and feasible energy savings and demand reductions and enable local publicly owned electric utilities, in the aggregate, to achieve statewide targets established pursuant to Section 25310."[56] The Energy Commission also has an obligation to assess "the effect of energy efficiency savings on electricity demand statewide, in local service territories, and on an hourly and seasonal basis"[57]

In meeting these legislative mandates, the Energy Commission has determined that using inconsistent methods of accounting for savings is confusing at best and misleading at worst. In fact, the Energy Commission can neither establish targets that will achieve the cumulative doubling target through energy efficiency savings and demand reduction resulting from a variety of programs nor track savings from these programs without accounting for program savings consistently across programs. While POUS may use their own approach in developing their targets, the Energy Commission's responsibility is broader – it must ensure that the targets it establishes are both "based on" the POUs' targets and consistent with the legislative targets for a statewide doubling of energy efficiency savings.

55 Ibid. Pp. 1-2.

56 Public Resources Code Section 25305.2.

57 Public Resources Code Section 25310(e)(1).

CHAPTER 5:
Potential Energy Efficiency Programs Needing Additional Analysis

Several other programs have the potential to deliver significant energy savings toward meeting the SB 350 goals. Issues related to utility fuel substitution and conservation voltage reduction (CVR) programs are discussed in this chapter. Estimates of savings from nonutility fuel substitution are presented in Chapter 6 and Appendix B. Estimates of nonutility agricultural and industrial energy efficiency savings potential are presented in this chapter. The Energy Commission will need additional data and analysis to fully understand the potential savings that might be counted toward the SB 350 doubling target. The Energy Commission intends to reexamine these programs and measures in future update cycles. These programs are discussed below.

Fuel Substitution Programs

SB 350 allows programs that save energy in final end uses by using cleaner fuels to reduce GHG emissions from the provision of energy services.[58] The Energy Commission defines *fuel substitution* as a measure involving the substitution of one utility-supplied or interconnected energy source for another, such as electricity and natural gas.[59] For example, advances in heat pump technology have made substituting electricity for natural gas for heating systems more viable and offer increased efficiency compared to traditional resistance heating devices such as electric clothes dryers.[60] The vast majority of buildings in California use natural gas for water and space heating. Substituting natural gas with heat pumps for space and water heating could reduce both energy consumption and GHG emissions.[61]

The savings from non-utility fuel substitution are shown as part of the market transformation program category in **Figure 27** and **Figure 28** in Chapter 6 and detailed in Appendix B. Estimated potential savings from this type of electrification were assessed as part of the nonutility programs. As Palo Alto notes in its comments, there is significant potential through voluntary fuel substitution in new and existing buildings, so energy savings from fuel substitution should not be attributed exclusively to future local building code mandates. The Energy Commission did not intend to specifically exclude these measures; it simply assessed fuel substitution measures as part of the nonutility programs

58 Public Resources Code Section 25310(d)(10).

59 *Fuel switching* involves shifting from an energy source that is not utility-supplied or interconnected, for example petroleum, to a utility-supplied or interconnected energy source. Fuel switching measures are not counted toward SB 350 energy efficiency savings targets because the statute defines "energy efficiency savings" to mean reduced *electricity* or *natural gas*. (Public Resources Code Section 25310(a)(2), emphasis added.)

60 "Heat Pump Systems." U.S. Department of Energy. Accessed June 12, 2017. https://energy.gov/energysaver/heat-pump-systems.

61 "Heat Pump Water Heaters." U.S. Department of Energy. Accessed June 12, 2017. https://energy.gov/energysaver/heat-pump-water-heaters.

because these measures were not evaluated as part of the utility potential and goals studies.[62]

Two POUs already have fuel substitution programs. In its comments, the City of Palo Alto notes that rather than mandating electric heat pump water heating and space heating as part of its green building code, it decided to rely on education and incentive programs to increase customer awareness and adoption of heat pump water heating and heat pump space heating products.[63] This effort included engaging with equipment makers and installers to lower supply market barriers. For more than a year, the City of Palo Alto has been implementing a pilot that offers a rebate of up to $1,500 to residents for replacing gas water heaters with heat pump hot water heating. Customer and contractor outreach has been a key component of this pilot program. SMUD also has two fuel substitution programs in operation, one for heat pump water heaters and one for all-electric homes, and plans to expand those programs and add new fuel substitution programs that may be used to meet the state's energy savings and GHG goals.[64]

The following discusses issues related to fuel substitution savings and measures that might be pursued by utilities.

Determining Energy Savings and GHG Emission Reductions

SB 350 requires that fuel substitution result in both energy savings and associated GHG emission reductions.[65] Previous efforts to assess the impacts of fuel substitution programs have introduced two key terms – *site* and *source*.[66] *Site* refers to the location of the end user consuming energy to obtain an energy service. *Source* refers to the location(s) of the production or generation of the fuel consumed at the end user's site. In most applications, site energy consumption for specific program participants is unambiguous. However, the complexities of electric generation mean that source energy and accompanying emissions that provide electric energy to the end user introduce numerous analytic uncertainties.

To satisfy the site requirement for energy savings, the end-use energy consumed at a given site must be lower while maintaining the same level of service. For example, the end-use site energy consumed by an electric appliance must be lower than the energy consumed by a natural gas appliance that performs the same level of service.[67] An analysis that relied upon a decrease in source energy as the basis for determining if there is an energy reduction, given

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62 City of Palo Alto Comments on Framework for Doubling Energy Efficiency Savings. Docket Number 17-IEPR-06. September 21, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN221287_20170921T143137_City_of_Palo_Alto_Comments_On_Framework_for_Doubling_Energy_Eff.pdf.

63 Ibid.

64 Comments of the Sacramento Municipal Utility District on Senate Bill 350 Doubling Energy Efficiency Savings by 2030 Draft Commission Report. Docket Number 17-IEPR-06. September 22, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN221289_20170921T150221_Lourdes_JimenezPrice_Comments_Comments_on_Draft_Commission_Repo.pdf.

65 Public Resources Code Section 25310(d).

66 For example, CPUC D.05-04-051, pp. 16-17. See http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/45783.PDF.

67 Reducing energy usage at the site generally refers to electric heat pump technologies replacing technologies that directly combust natural gas.

the large-scale shift to renewable generation through time, could mistakenly infer a site energy reduction when only energy consumed in generation, transmission, and distribution was reduced.[68]

Satisfying the source requirements for emission reductions will involve comparing, for example, GHG emissions from natural gas combustion at the site with the average GHG emissions of the electricity resource mix serving the end use. Natural gas end-use source GHG emissions are only slightly higher than natural gas site GHG emissions and change only with the efficiency of end-user combustion.[69] As noted, for electric end uses, the source GHG emissions will change through time as the resource mix shifts toward renewable generation and away from generating technologies that produce GHG emissions.

Cost Considerations

It appears that the majority of fuel substitution may occur within the four IOU service areas. Therefore, it is logical to consider the CPUC cost-effectiveness requirements for fuel substitution and then consider additional or different criteria needed to meet the requirements of SB 350. One or more fully developed fuel substitution programs are needed to evaluate whether the SB 350 requirement for energy savings and GHG reductions are sufficient to satisfy the CPUC's three-prong test and to determine where there are differences in outcome.[70]

The interactions among different types of utilities and other energy providers raise complexities that involve financial interests that may be difficult to sort. The CPUC has historically addressed fuel substitution in cases of competing interests between SCE and Southern California Gas Company (SoCalGas) through the three-prong test. More widespread fuel substitution could cause load shifting within and between CPUC jurisdictional entities. There is also the potential for load to shift from a gas company to a POU. These complexities will need to be addressed if it appears that more widespread fuel substitution is being pursued. Some parties have raised concerns about barriers to fuel substitution presented by the cost-effectiveness method based on using a TDV metric.

Comments on Fuel Substitution

Several parties provided comments on fuel substitution issues. SCE and Pacific Gas and Electric (PG&E) recommend further development of rules, guidelines, or clarifications to the

68 Converting energy consumption for electric and natural gas appliances to BTUs will allow the comparison of technologies to determine whether end use consumption at the site is reduced.

69 The difference between site and source GHG emissions from end-user consumption is distribution losses. This has historically been estimated at about 2 percent of annual usage.

70 The three prong test for fuel substitution requires that a measure or program not increase source-BTU consumption, have a TRC and PAC benefit-cost ratio of 1 or greater, and not adversely impact the environment.

proposed treatment of fuel substitution to remove current policy impediments.[71, 72] SCE and SoCalGas encourage use of the CPUC's established rules for fuel substitution (the three-prong test) and caution against modifying the test in a way that would compromise the associated screening role to ensure technologies are energy-efficient, provide net resource value to ratepayers, and maintain customer choice.[73] SMUD generally supports the need for demonstrable savings from fuel substitution but argues against use of the CPUC's test since it is under review and may be modified.[74] SMUD believes the utility responsible for implementing the fuel substitution measure should receive the savings credit. It supports a simulation dispatch for assessing marginal natural gas values but believes that rather than using the statewide energy mix utilities, it should be allowed to use its own resource mix.[75] The Natural Resources Defense Council's (NRDC) comments called for clarification that the Energy Commission is proposing to develop estimates of a long-run marginal electric fuel mix, rather than short-run marginal emissions.[76], [77] The Energy Commission proposes that using the long-run marginal statewide energy mix is the appropriate way to account for GHG emissions from fuel substitution. This issue can be further addressed as the Energy Commission works with the CPUC, IOUs, POUs, and various parties to establish an appropriate framework and protocols for fuel substitution programs.

The NRDC suggests that methane emissions associated with the production, transmission, distribution, and on-site use of natural gas should be included in any method to determine fuel substitution savings since methane has a high global warming potential.[78] SoCalGas cautions that including electrification of final end uses as a strategy to reduce energy consumption may preclude adoption other lower carbon energy sources and decelerate

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71 Southern California Edison Company's Comments on Draft Staff Papers on Senate Bill (SB) 350 Energy Efficiency Savings Doubling Targets. Docket Number 17-IEPR-06. August 3, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220538_20170803T140140_Catherine_Hackney_Comments_SCE_Comments_on_Draft_Staff_Papers_o.pdf.

72 Pacific Gas and Electric Comments on Draft Staff Papers Regarding 2030 Energy Efficiency Doubling Targets. Docket Number 17-IEPR-06. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220541_20170803T155809_Pacific_Gas_and_Electric_Comments_Pacific_Gas_and_Electric_Comp.pdf.

73 Southern California Gas Company, Comments on CEC Staff's Two Draft Papers on SB 350 Energy Efficiency Savings Doubling Targets. Docket Number 17-IEPR-06. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220542_20170803T162655_Jennifer_Morris_Comments_SoCalGas_Comments_on_SB_350_Energy_Eff.pdf.

74 Comments of the Sacramento Municipal Utility District on Senate Bill 350 Energy Efficiency Target Setting for Utility Programs. Docket Number 17-IEPR-06. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220539_20170803T145417_Lourdes_JimenezPrice_Comments_Comments_of_the_Sacramento_Munici.pdf.

75 A simulation dispatch is performed as part production cost modeling, wherein generation resources are called on to meet system load at the lowest cost, subject to transmission and reliability constraints.

76 Comments of the Natural Resources Defense Council on the 2017 Integrated Energy Policy Report Staff Workshop on Methodologies for 2013 Energy Efficiency Target Setting (September 7, 2017). Docket Number 17-IEPR-06. September 21, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN221291_20170921T164333_Mohit_Chhabra_Comments_Comments_of_the_Natural_Resources_Defens.pdf

77 Short run marginal emissions are the emissions associated with a kW of electricity generated to meet the next increment of demand on the electricity system. Currently short run marginal emissions are generally based on those from natural gas fired generation. For long run marginal fuel mix, the emissions are based on the total portfolio of electricity resources used to meet electricity demand at a given point in the future. In the long run, the fuel mix in California is expected to shift from natural gas to renewable resources, which will have lower emissions.

78 Comments of Natural Resources Defense Council (NRDC) on the *2017 Integrated Energy Policy Report (IEPR)* Draft Staff Papers on SB 350 Energy Efficiency Savings Doubling Targets. Docket Number 17-IEPR-06. August 3, 2017. Pp 2-4. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220546_20170803T170248_Natural_Resources_Defense_Council_Comments_NRDC_CommentsDraft_S.pdf.

achievement of the state's climate goals.[79] It notes that the use of renewable gas to reduce methane emissions is a strategy relied upon by the California Air Resources Board's *Short-Lived Climate Pollutant Reduction Plan and Scoping Plan*.[80] In comments filed by the Sierra Club, it indicated its support of NRDC's August 3, 2017, comments, which argued to properly account for the GHG emissions of gas appliances, the Energy Commission should include fugitive methane emissions from production, processing, distribution, storage, and on-site end use. In future updates cycles, the Energy Commission will assess the impacts of energy efficiency on methane emissions.[81]

The Energy Commission has identified a recommendation and next steps to address outstanding issues related to fuel substitution in Chapter 7.

Conservation Voltage Reduction

Conservation voltage reduction (CVR) is a proven technology for reducing energy use and peak demand. CVR improves the efficiency of the distribution system by optimizing voltage. The key principle of CVR operation is that the standard voltage band between 114 and 126 volts can be compressed using regulation to the lower half (114–120 volts) instead of the upper half (120–126 volts),[82] producing considerable energy savings at low cost and without harm to consumer appliances.[83] Sensors detect distribution voltages, and when voltages exceed preset limits, voltage regulation equipment is triggered. The benefits from reduced energy consumption (metered end-user usage and distribution losses) and avoided equipment damage through time must exceed the investment and operating costs for CVR to make sense economically.

Distribution utilities implement these activities, not the end user, so there are no programs that either attract or provide incentives for end users. It is expected that energy procurement will be reduced because of such activities, with a portion of the savings occurring as metered energy usage reductions by end users and another portion as reductions in distribution losses by the distribution utility.

The fundamental question of both IOU distribution utilities and POUs is whether investments in more sophisticated distribution equipment are less expensive than the present value of

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79 Southern California Gas Company, Comments on CEC Staff's Two Draft Papers on SB 350 Energy Efficiency Savings Doubling Targets. Docket Number 17-IEPR-06. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220542_20170803T162655_Jennifer_Morris_Comments_SoCalGas_Comments_on_SB_350_Energy_Eff.pdf.

80 Ibid.

81 Sierra Club Comments on 2017 Integrated Energy Policy Report (IEPR) Framework for Doubling Energy Efficiency Savings. Docket Number 17-IEPR-06. September 21, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN221294_20170921T164758_Rachel_Golden_Comments_Sierra_Club_Comments_on_SB350_Doubling_EE.pdf.

82 In the United States, regulations require that voltage be made available to consumers at 120 volts (V) plus or minus 5 percent, yielding a range of 126V to 114V.

83 Electrical equipment including air conditioning, refrigeration, appliances, and lighting is designed to operate most efficiently at 114V. Power delivered at higher voltage wastes energy as heat.

the reduction in energy consumption. If a distribution utility is not also providing generation services to some or all of the end users receiving distribution services, then the distribution utility will be less able to recover CVR investments through charges for energy consumed. Given the evolving role of nonutility energy entities under the CPUC's jurisdiction, determining the cost-effectiveness of such activities is growing more complex. POUs do not face this challenge because they are vertically integrated and have not unbundled the services they offer to customers.

Several research/demonstration projects in California utility service areas were funded by U.S. Department of Energy through the American Recovery and Reinvestment Act of 2009 (ARRA) program in the late 2000s. Among them were CVR projects at Glendale Water and Power and SMUD that were part of distribution system improvement efforts. Palo Alto undertook a self-funded project more specifically oriented to using CVR as an end-user energy savings project. These efforts will help identify opportunities for utilities to use CVR.

Additional details on CVR are provided in Appendix A.

Comments on Conservation Voltage Reduction

The California Efficiency and Demand Management Council (CEDMC) support the inclusion of CVR as an energy-saving measure under SB 350.[84] However, it disagrees with the characterization that CVR is an emerging technology. CEDMC notes that CVR has been demonstrated to be cost-effective in saving energy by regulatory agencies and utilities around the country. It believes that CVR and advanced voltage technologies deserve increased attention, including potential studies by IOUs and POUs, consideration of incentives to support deployment of technologies and addressing lost revenue, and inclusion in IOU energy efficiency business plans. Honeywell also provided comments indicating interest in participating in studying the merits of CVR as a CVR technology provider.[85] Future efforts will be necessary to identify ways to implement societally cost-effective CVR.

Agricultural and Industrial Sector Energy Efficiency

California is home to the nation's largest and most diversified agricultural and food processing sector. California's agricultural abundance includes more than 400 commodities, which are grown on 77,500 farms and ranches and were collectively valued at about $47 billion in 2015. The state's largest irrigated crops by acreage are nuts (almonds, pistachios, and walnuts), grapes, tomatoes, broccoli, and lettuce. Although food processing occurs throughout the state, these industries are concentrated in the Central Valley. The valley is home to more than 3,000 factory sites, including the world's largest facility for processing milk, milk powder, and butter (California Dairies, Inc.); cheese (Hilmar Cheese Company); wine (E & J Gallo); and poultry (Foster Farms). There are common loads that are likely to lend

84 California Efficiency + Demand Management Council Comments on the Draft Staff Papers on Senate Bill 350 Energy Efficiency Targets. Docket Number 17-IEPR-06. August 3, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220498_20170802T075328_Senate_Bill_350_Energy_Efficiency_Target_Setting_for_Utility_Pr.pdf.

85 RE: *Senate Bill 350 Energy Efficiency Target Setting for Utility Programs.* Honeywell. August 2, 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220498_20170802T075328_Senate_Bill_350_Energy_Efficiency_Target_Setting_for_Utility_Pr.pdf.

themselves to efficiency improvements, such as refrigeration. Statewide, the agricultural sector (including water pumping) uses slightly less than 7 percent of electricity and about 1 percent of natural gas.

In 2016, California became the sixth largest economy in the world. Manufacturing and other industrial production play a major part in maintaining California's economic success, contributing nearly 10 percent of the state's gross domestic product. California leads the nation in such market segments as electronics and computer manufacturing.[86] The industrial sector has diverse customer types, sizes, and operations. Industries in this sector include oil refineries, oil and gas extraction industries, printing plants, plastic injection molding facilities, component fabrication plants, lumber and paper mills, cement plants and quarries, metal processing plants, chemical industries, assembly plants, water and wastewater treatment plants, and food processing, among others.

Over the past two decades, the composition of industry in California has been changing with a decrease in heavy manufacturing and energy-consuming industries, and the rise of light manufacturing and less energy-intensive industries.[87] In spite of the decrease in heavy industry, the industrial sector still consumes a significant amount of energy in the state. California's industrial sector uses about 15 percent of electricity and 28 percent of natural gas.[88] This sector has significant untapped potential for energy savings. A central challenge in tapping those savings is that each industry has unique situations and proprietary information.

Projections for agricultural and industrial sector energy savings for electricity and natural gas are shown in **Figure 21** and **Figure 22,** respectively. The methodology and analyses for estimating these savings are detailed in Appendix B. These preliminary estimates will be revisited through collaboration with agricultural groups to develop better estimates of energy savings potential in future update cycles.

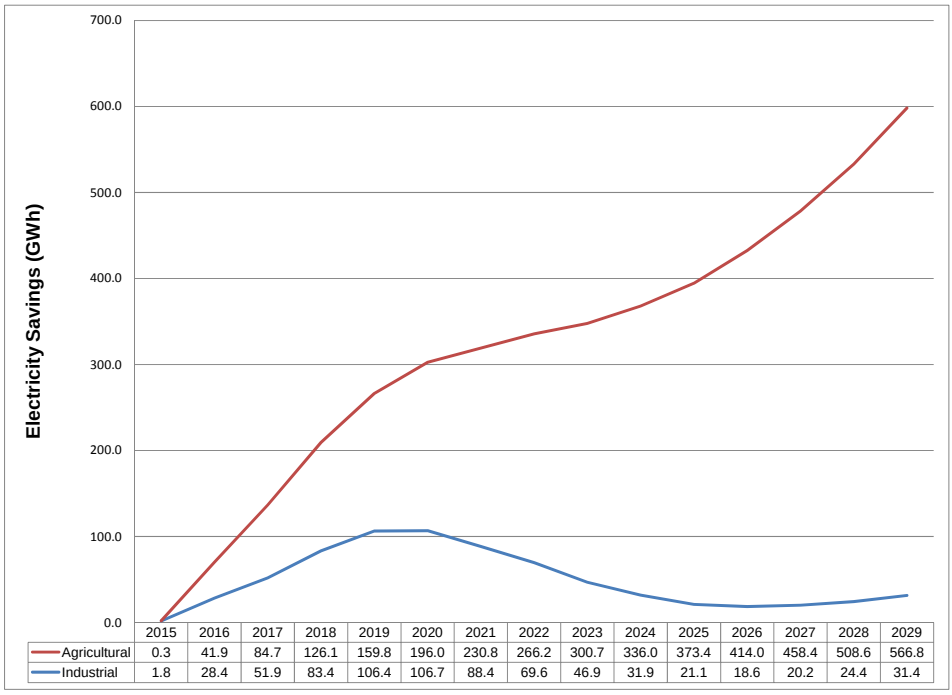
Figure 21: Projected Electricity Savings Estimates for Agricultural and Industrial Programs

86 Pacific Gas and Electric Company. *Energy Efficiency Business Plan 2018-2025.* January 2017.

87 De la Rue du Can, Stephane, Ali Hasanbeigi, and Jayant Sathaye. Lawrence Berkeley National. *2011 ACEEE Summer Study on Energy Efficiency in Industry*. http://aceee.org/files/proceedings/2011/data/papers/0085-000057.pdf.

88 Energy Consumption Data Management System. 2017. California Energy Commission. Staff communication.

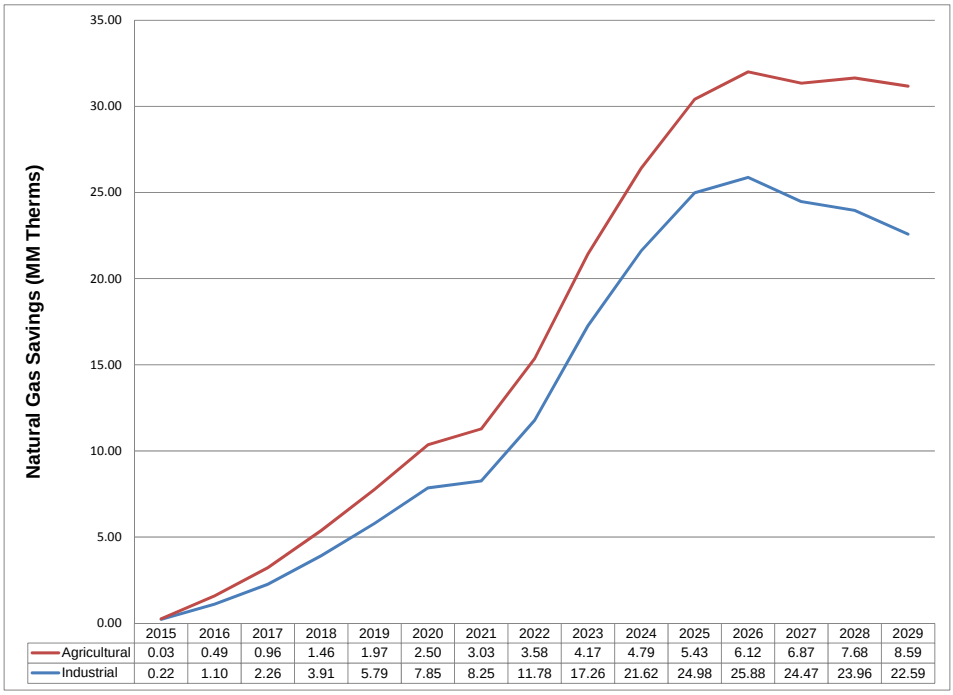
(GWh)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Agricultural	0.3	41.9	84.7	126.1	159.8	196.0	230.8	266.2	300.7	336.0	373.4	414.0	458.4	508.6	566.8
Industrial	1.8	28.4	51.9	83.4	106.4	106.7	88.4	69.6	46.9	31.9	21.1	18.6	20.2	24.4	31.4

Source: California Energy Commission staff, Efficiency Division, August 2017.

Figure 22: Projected Natural Gas Savings Estimates for Agricultural and Industrial Programs (MM Therms)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Agricultural	0.03	0.49	0.96	1.46	1.97	2.50	3.03	3.58	4.17	4.79	5.43	6.12	6.87	7.68	8.59
Industrial	0.22	1.10	2.26	3.91	5.79	7.85	8.25	11.78	17.26	21.62	24.98	25.88	24.47	23.96	22.59

Source: California Energy Commission staff, Efficiency Division, August 2017.

CHAPTER 6:
Nonutility Energy Efficiency Programs

There are a variety of nonutility energy efficiency programs that will contribute to meeting the state's doubling target, which are grouped into the following categories: codes and standards, financing programs that are behavioral, and market transformation programs. This chapter identifies potential sources for nonutility program savings, including programs at the Energy Commission, other state agencies, local governments, and other local entities. There are many other programs saving energy across the state that are important to the state's goals. But without available information indicating that the program would expand beyond pre-2015 levels, these savings are included in the demand forecast baseline. The following sections discuss projected electricity savings and natural gas savings and the proposed targets for the programs. In each category, subtargets have been proposed for the programs based on these savings estimates. Specific methods for estimating of projected savings for nonutility programs are detailed in Appendix B.

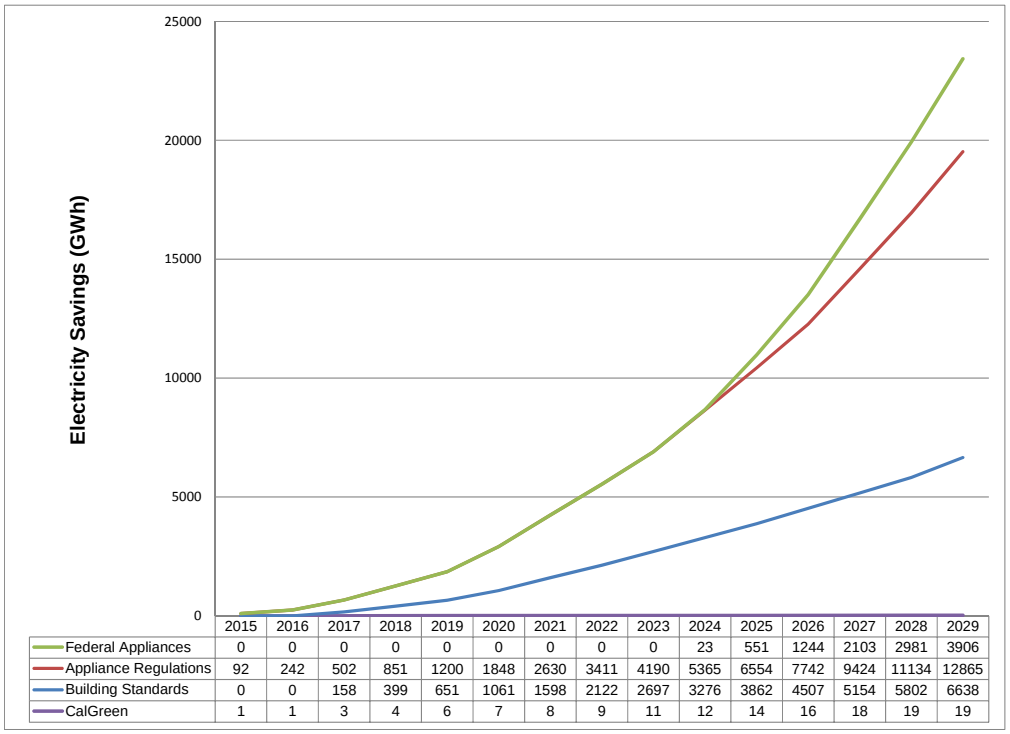
Energy Savings From Codes and Standards

Since the 1970s, the Energy Commission has been responsible for establishing standards for buildings and appliances that conserve electricity and natural gas. Specific programs within the codes and standards category that contribute future energy savings to meet the SB 350 doubling target include Title 24 *Building Energy Efficiency Standards* (building standards), the *California Green Building Standards Code* (CALGreen),[89] Title 20 state *Appliance Efficiency Regulations* (appliance regulations), and federal appliance standards.

Figure 23 shows projected electricity savings, and **Figure 24** shows the projected natural gas savings from codes and standards discussed in the following sections. Projected savings from the building standards up to the 2019 cycle for new construction only and the appliance regulations up to 2019 (with a few adopted in 2023 and 2024) are included in the *2018 IOU Potential and Goals Study*, discussed in Chapter 3. Discussions with CPUC staff indicate that any potential overlap from codes and standards identified in nonutility programs addressed below and IOU rebate programs included in the utility programs (discussed in Chapter 3) is likely to be small and difficult to separate in the short run before evaluation of IOU programs generates updated information. For POU programs, discussions with POUs and CMUA indicated that only savings from the 2016 building standards were included in the *POU Potential and Goals Study;* therefore, no overlap was identified.

89 CALGreen provides a set of voluntary specifications that can be used as model ordinances that allow a city or county or both to easily establish more stringent building efficiency standards based on local climatic, geological, or topographical conditions.

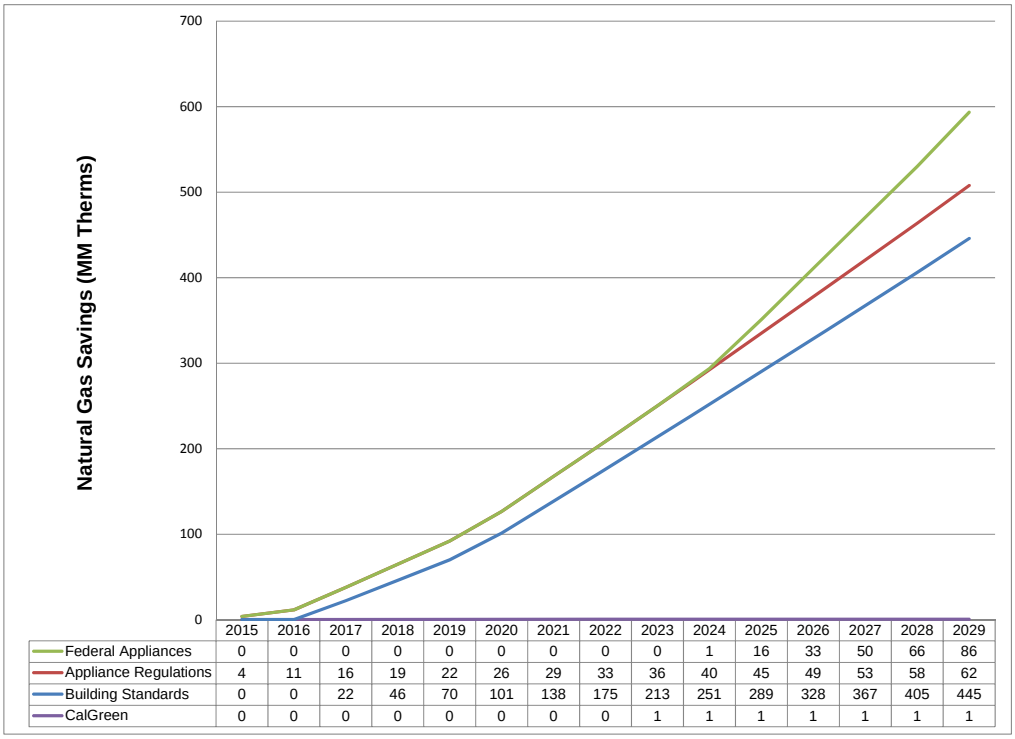
Figure 23: Projected Electricity Savings Estimates for Future Codes and Standards (GWh)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Federal Appliances	0	0	0	0	0	0	0	0	0	23	551	1244	2103	2981	3906
Appliance Regulations	92	242	502	851	1200	1848	2630	3411	4190	5365	6554	7742	9424	11134	12865
Building Standards	0	0	158	399	651	1061	1598	2122	2697	3276	3862	4507	5154	5802	6638
CalGreen	1	1	3	4	6	7	8	9	11	12	14	16	18	19	19

Source: California Energy Commission staff, Efficiency Division. Based on work in Appendix B by NORESCO August 2017.

Figure 24: Projected Natural Gas Savings Estimates for Future Codes and Standards (MM Therms)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Federal Appliances	0	0	0	0	0	0	0	0	0	1	16	33	50	66	86
Appliance Regulations	4	11	16	19	22	26	29	33	36	40	45	49	53	58	62
Building Standards	0	0	22	46	70	101	138	175	213	251	289	328	367	405	445
CalGreen	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1

Source: California Energy Commission staff, Efficiency Division. Based on work in Appendix B by NORESCO. August 2017.

Title 24 State Building Energy Efficiency Standards

The Energy Commission's building standards set energy and water design standards for residential and nonresidential buildings. The building standards include cost-effective energy efficiency requirements for newly constructed buildings, additions to existing buildings, and alterations to existing buildings. These standards are part of the California Building Codes, which are updated triennially, expected to occur in 2019, 2022, 2025, and 2028.[90] For each update of the building standards, proposed new efficiency measures and improvements to existing measures are evaluated.[91]

Projected savings from the 2019 building standards for new construction are already included in the baseline forecast. Projected savings from the 2016 and 2019 new construction and 2019 building standards for additions and alterations are included in the estimates for nonutility programs and begin delivering savings in 2020, once they have gone into effect. Older vintages of the building standards are removed from estimates since they are assumed to be in the baseline. Energy savings projections presented in this section include the 2016 (new construction), 2019, 2022, 2025, and 2028 building standards. In accordance with Governor Brown's 2020 and 2030 zero-net-energy goals, the 2019 and 2028 standards will include consideration of new zero-net-energy requirements for residential and nonresidential buildings. The 2022 standards will examine low-rise and high-rise multifamily buildings and the potential for establishing efficiency measures specific to multifamily buildings, distinct from other residential and nonresidential buildings. Local ordinances adopted under CALGreen complement the statewide standards and ensure California consumers fully realize the benefits of advancements in energy efficiency.[92] As discussed in Chapter 3, projected energy savings for codes and standards

Federal Appliance Standards

The federal appliance standards are implemented at the manufacturing stage and affect any market sector where the products are installed or used. Federal appliance standards, based on mandatory deadlines in the federal appliance law, have a preemptive effect on state standards, with some exceptions.[93] As a result, California cannot set standards for products already covered under the federal appliance standards.[94] California typically participates in federal rulemakings to ensure that stringent standards that save Californians money on the utility bill are adopted. Savings estimates for appliance regulations from the 2015 AAEE and

90 The California Building Code (Title 24, California Code of Regulations) is a collection of codes covering various elements such as electrical, mechanical, plumbing, fire, historic buildings, and so forth. They also include the Energy Commission's *Building Energy Efficiency Standards* (California Energy Code, Title 24, Part 6) and the California Green Building Standards (Title 24, Part 11).

91 Public Resources Code Section 25402(b)(1).

92 Findings of the local condition(s) and the adopted local building standard(s) must be filed with the California Building Standards Commission to become effective, and cost-effectiveness must be demonstrated to the Energy Commission before they can be enforced.

93 The federal Energy Policy and Conservation Act of 1975, as amended by the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007.

94 Under the general rules of federal preemption, states that had set standards prior to federal enactment may enforce their state standards until the federal standards become effective. States that have not set standards for a product category that is now enforced by the federal government are subject to the federal standard immediately.

for new measures from 2017 through 2029, as well as any measures that can be updated to provide additional incremental savings, were included.

Future savings from new federal standards are focused on high-energy-consumption appliances, including heating, HVAC, domestic hot water systems, battery chargers, commercial clothes washers, and lighting.[95]

Title 20 State Appliance Regulations

The Energy Commission has responsibility for establishing and enforcing *Appliance Efficiency Regulations* (appliance regulations) that set minimum efficiency standards and test procedure, marking, and disclosure requirements for both federally and nonfederally regulated appliances.[96] The appliance regulations include the requirement that a regulated appliance may not be sold or offered for sale in California unless it is certified to comply with the standards. Well-designed mandatory energy efficiency standards transform markets by removing inefficient products to increase the overall economic welfare of most consumers without seriously limiting their choice of products.

Energy Savings From Financing Programs

Several financing mechanisms for energy efficiency investments have emerged in recent years. These programs not funded through utility rates are major contributors to projected energy savings. Financing programs include the Property Assessed Clean Energy (PACE) program, the Local Government Challenge, Proposition 39, the Energy Conservation Assistance Act (ECAA), the Low-Income Weatherization Program, the Water-Energy Grant Program; and California Department of General Services -operated Energy Savings Program (DGS-Energy Savings). In addition, some IOUs have indicated that they intend to shift their programs from rebates toward more financing programs.[97] It is unclear at this time whether this could create double-counting with the analysis prepared for these programs by NORESCO and other contractors to the Energy Commission, or whether this is an issue for the future. Staff estimated overlap with utility programs to be about 4 percent of savings in cases where it was clear utility rebates or incentives were used in conjunction with a specific financing program. Savings projections from these programs are shown in

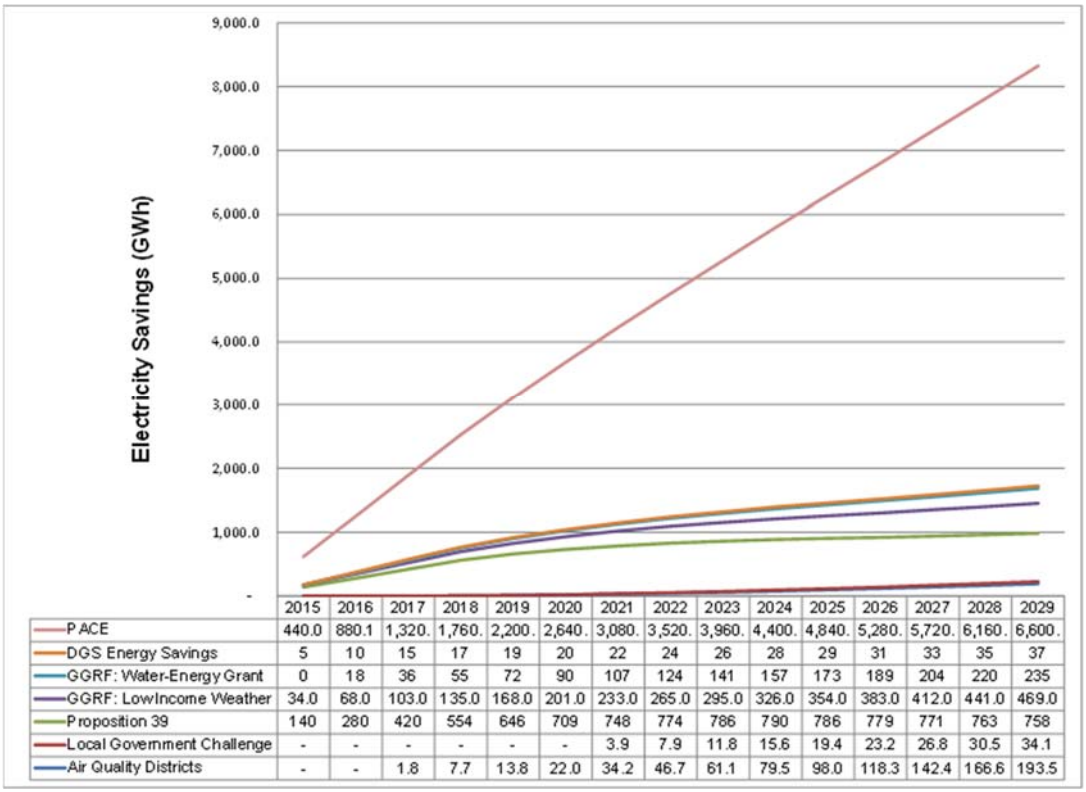
Figure 25 for electricity and **Figure 26** for natural gas.

95 The analysis of California and federal appliance standards was coordinated to eliminate potential overlap especially for emerging technologies and appliances not federally regulated.

96 Title 24, Sections 1601-1609, California Code of Regulations.

97 Pacific Gas and Electric, *Application of Pacific Gas and Electric Company (U 39 M) for Approval of 2018-2025 Rolling Portfolio Energy Efficiency Business Plan and Budget.* January 17, 2017. P. 10.

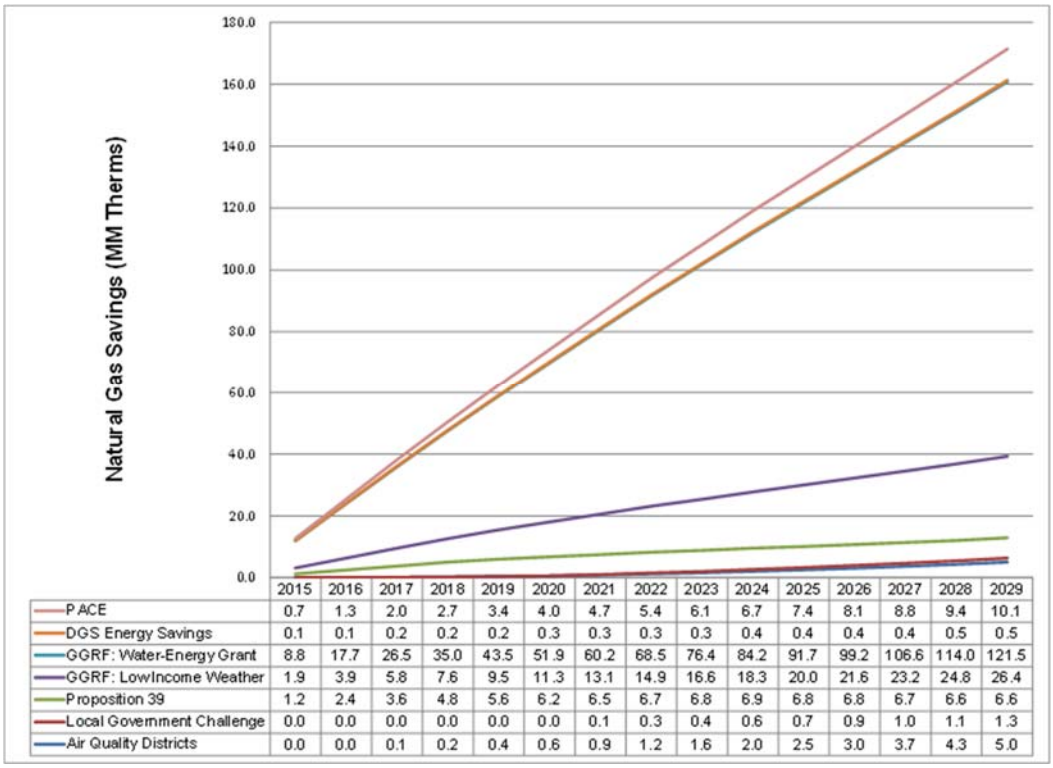
Figure 25: Projected Electricity Savings Estimates for Financing Programs (GWh)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
PACE	440.0	880.1	1,320.	1,760.	2,200.	2,640.	3,080.	3,520.	3,960.	4,400.	4,840.	5,280.	5,720.	6,160.	6,600.
DGS Energy Savings	5	10	15	17	19	20	22	24	26	28	29	31	33	35	37
GGRF: Water-Energy Grant	0	18	36	55	72	90	107	124	141	157	173	189	204	220	235
GGRF: LowIncome Weather	34.0	68.0	103.0	135.0	168.0	201.0	233.0	265.0	295.0	326.0	354.0	383.0	412.0	441.0	469.0
Proposition 39	140	280	420	554	646	709	748	774	786	790	786	779	771	763	758
Local Government Challenge	-	-	-	-	-	-	3.9	7.9	11.8	15.6	19.4	23.2	26.8	30.5	34.1
Air Quality Districts	-	-	1.8	7.7	13.8	22.0	34.2	46.7	61.1	79.5	98.0	118.3	142.4	166.6	193.5

Source: California Energy Commission staff, Efficiency Division. Based on work in Appendix B by NORESCO. August 2017.

Figure 26: Projected Natural Gas Savings Estimates for Financing Programs (MM Therms)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
PACE	0.7	1.3	2.0	2.7	3.4	4.0	4.7	5.4	6.1	6.7	7.4	8.1	8.8	9.4	10.1
DGS Energy Savings	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5
GGRF: Water-Energy Grant	8.8	17.7	26.5	35.0	43.5	51.9	60.2	68.5	76.4	84.2	91.7	99.2	106.6	114.0	121.5
GGRF: LowIncome Weather	1.9	3.9	5.8	7.6	9.5	11.3	13.1	14.9	16.6	18.3	20.0	21.6	23.2	24.8	26.4
Proposition 39	1.2	2.4	3.6	4.8	5.6	6.2	6.5	6.7	6.8	6.9	6.8	6.8	6.7	6.6	6.6
Local Government Challenge	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.6	0.7	0.9	1.0	1.1	1.3
Air Quality Districts	0.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.5	3.0	3.7	4.3	5.0

California Energy Commission staff, Efficiency Division. Based On Work in Appendix B by NORESCO. August 2017.

Property Assessed Clean Energy

Since 2007, PACE programs, offered by private lenders, have been allowed in California.[98] Property owners of residential and commercial buildings can fund energy efficiency, water efficiency, or renewable energy projects with limited upfront capital using PACE loans. PACE financing is offered primarily to residential building owners, largely due to the simplicity in ownership for residential buildings.[99] PACE loans rely on the existing framework of residential property taxes by allowing property owners to repay the entire loan for a project through a special tax assessment made on the property.[100] Loan payments can be amortized for a period of up to 20 years, with an option to extend the payback period as necessary.[101] Some common measures include building envelope,[102] attic insulation, HVAC equipment and controls, lighting equipment and controls, and cool roofs.

Local Government Challenge

The Local Government Challenge (LGC) is a grant program designed to help the state meet the targets set by SB 350 and Assembly Bill 802 (Williams, Chapter 590, Statutes of 2015). The LGC uses funds remaining from ARRA to encourage local jurisdictions to implement new energy efficiency projects, update climate action plans, and address other energy/climate issues. The projects funded by LGC are proposed to reduce statewide electricity consumption, increase self-generation capacity, and improve the conditions of facilities and equipment. The program is divided into two parts: the Small Government Leadership Challenge and the Energy Innovation Challenge. Depending on the awardee of the grant, various building sectors will be affected.

Proposition 39: Clean Energy Jobs Act

The Clean Energy Jobs Act, also known as Proposition 39, provides funding for planning and installing energy efficiency upgrades and clean energy generation at schools. The initiative changed California's corporate income tax code and allocates projected revenue to the general fund and the Clean Energy Job Creation Fund for five fiscal years (2013-2014 to 2017-2018).[103] The funds are awarded to local educational agencies, including K-12 school districts, county offices of education, charter schools, and state special schools, and California community colleges to upgrade existing facilities. The types of energy efficiency

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98 Assembly Bill 811 (Levine, Chapter 159, Statutes of 2008).

99 The complexity of commercial buildings that may arise from the variation in owners, investors, lease holders, lease terms, and other factors can inhibit the adoption of PACE financing for improvement projects.

100 PACE programs are limited to participating districts where the private lenders have legal agreements with cities and counties that allow repayment of the loans through property taxes.

101 According to several PACE providers, the following features represent the key benefits of the program: long-term, fixed-rate financing; no down payment; financing terms independent of credit history; nonrecourse, no financial covenants; easy credit approval; fully transferable and assignable upon sale; treated as an operating expense and available for pass-through to tenant.

102 The building envelope is the physical separator between the interior and exterior of a building, Common components includes walls, floors, roofs, windows, and skylights.

103 Senate Bill 110 (Committee on Budget and Fiscal Review, Chapter 55, Statutes of 2017) has modified the Proposition 39 program and extended it. This bill also allocated an additional $100 million of unspent Prop. 39 money to ECAA-Ed. The bill also made ECAA-Ed competitive.

upgrades that can be done to a building vary greatly. Some examples of the measures include building envelope, insulation, HVAC, and cool roofs.[104]

Energy Conservation Assistance Act

The Energy Conservation Assistance Act (ECAA) loan program administered by the Energy Commission delivers revolving loans to schools, cities, counties, and special districts to finance projects with proven energy demand and/or cost savings. Funds for ECAA loans come from repayment of previous funds with additional infusions from allocations by the Legislature and ARRA funds.[105] The ECAA financing program is designed to ease the adoption of energy projects through a simple process that does not involve credit approval, collateral, or fees. There are two types of loans offered through this program. Education facilities, except universities, qualify for a 0 percent interest loan, whereas cities, counties, and colleges and universities qualify for a 1 percent interest loan. Loans are often used to upgrade the building envelope, electrical systems, HVAC, or lighting or a combination thereof.

Greenhouse Gas Reduction Fund

The Greenhouse Gas Reduction Fund (GGRF) was set up by three statutes that direct the proceeds from the California Cap-and-Trade Program into the GGRF.[106] A portion of the GGRF budget is used to fund programs that save energy through installation of more energy-efficient appliances and weatherization of low-income homeowners' properties. Two elements of the GGRE are expected to result in energy savings: the Low-Income Weatherization Program (LIWP) and the Water-Energy Grant Program.

In addition to GGRF funds, the LIWP is funded by the federal weatherization program. The program, administered by the Department of Community Services and Development, is targeted at different subsets of low-income households in disadvantaged communities.[107] The Single Family/Small Multi-Family EE and Solar Water Heating subprogram provides single-family and small multifamily low-income homes with weatherization and energy efficiency measures.[108] The Large Multi-Family EE and Renewables subprogram provides multifamily, low-income properties with technical assistance and incentives for weatherization and energy efficiency measures. Program participants receive a home energy assessment to generate a list of recommended measures to improve the energy efficiency of the home. Energy savings from lighting, ceiling fans, appliances, insulation, and microwaves

104 A cool roof is one that has been designed to reflect more sunlight and absorb less heat than a standard roof. They can be made of a highly reflective type of paint, a sheet covering, or highly reflective tiles or shingles.

105 The 1 percent loan was developed separately as ECCA-Ed funds. Proposition 39: *California Clean Energy Jobs Act, K-12 Program and Energy Conservation Assistance Act 2015-2016 Progress Report*, California Energy Commission, 2016.

106 Assembly Bill 1532 (Pérez, Chapter 807, Statutes of 2012), Senate Bill 535 (De León, Chapter 830, Statutes of 2012), and Senate Bill 1018 (Budget and Fiscal Review Committee, Chapter 39, Statutes of 2012).

107 The three programs include (1) Single Family/Small Multi-Family EE and Solar Water Heating; (2) Single-Family Solar Photovoltaics; and (3) Large Multi-Family EE and Renewables.

108 The Department of Community Services and Development's Low-Income Weatherization Program serves low-income homes. Specifically, it seeks to help households in disadvantaged communities as identified by CalEnviroScreen 2.0, which calculates if someone qualifies as disadvantaged or low-income in the state.

installed because of this program are expected to deliver energy savings that will contribute to meeting SB 350 targets.

Water-energy grants administered by the Department of Water Resources are used to improve the water and energy efficiency and reduce GHG emissions of residential and commercial buildings through measures such as clothes washers, dryers, and dishwashers. Energy savings are captured primarily by installing measures to reduce hot water use, which then decreases the energy needed to heat water.

Energy Savings Program

The Energy Savings Program operated by the Department of General Services (DGS) uses energy service companies to implement energy upgrades in state buildings. Projects are funded by loans taken out by the state agency that are paid back by the realized savings from the retrofit. The common types of measures funded by the loan include upgrading lighting, installing energy-efficient HVAC systems, and retrocommissioning. An initial $25 million payment from the Energy Commission provided the seed money to begin the EE Retrofit Revolving loan program.

Air Quality Management District Programs

California air quality management districts (AQMDs) may require or encourage lead agencies under the California Environmental Quality Act (CEQA) to address environmental impacts of air pollution from building projects. Energy efficiency measures that reduce energy consumption at the building level that are being considered by AQMDs and air pollution control districts (APCDs) include exceeding the building standards by installing programmable thermostat timers, upgrading lighting, and installing energy-efficient appliances.[109] Other mitigation could include the use energy efficiency measures, such as HVAC retrofits, retrocommissioning, envelope upgrades, and other whole-building measures on existing buildings. Although there are no current programs, these types of programs have the potential to capture energy savings and GHG reductions by 2030.

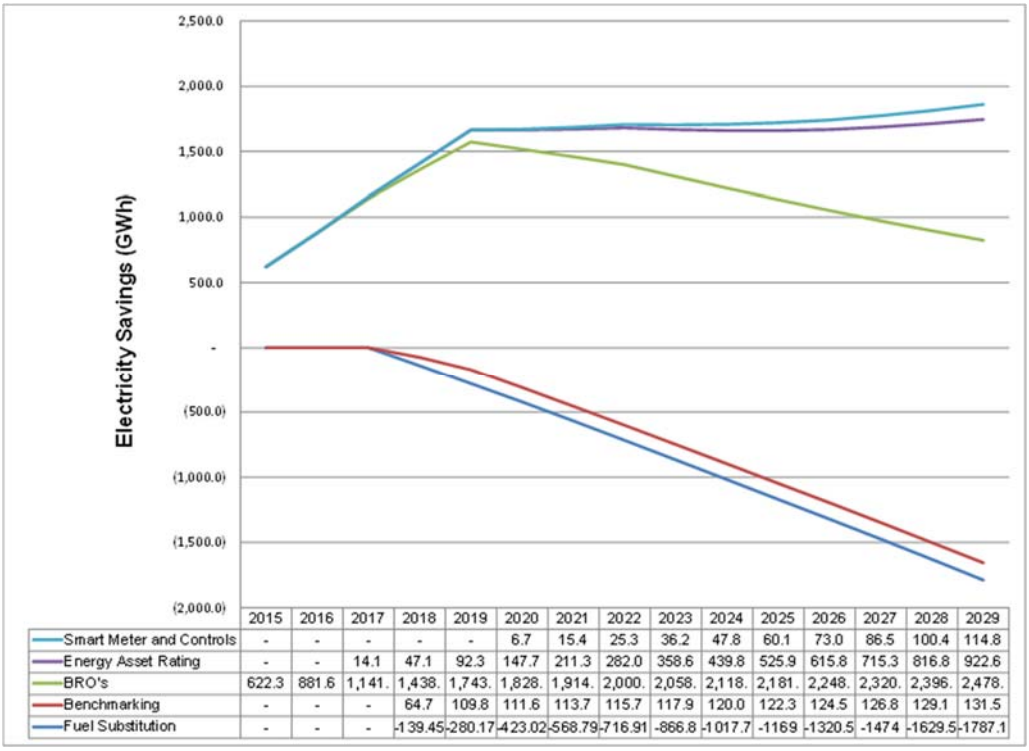
Energy Savings From Behavioral and Market Transformation

There are additional energy efficiency savings that can result from behavioral and market transformation changes as opposed to installing a physical measure like new lighting or HVAC. These include behavioral, retrocommissioning, and operational (BROs) changes that are initiated by informing the customer or building owner of energy usage. Other programs include fuel substitution, benchmarking, energy asset ratings, and computer applications using smart meter data (smart meter and controls), among others. Energy savings can also be realized through market transformation efforts for measures that are on the cusp of widespread adoption but need additional public education or funding. An example of market transformation is the automation of appliances through the *Internet of Things,* which is the

109 California Air Pollution Control Officers Association. *Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emission Reductions From Greenhouse Gas Mitigation Measures.* August 2010. https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/capcoa_quantifying_ghg_measures.pdf.

communication between devices using the Internet, connected to a customer's smart meter. Many of the programs described here do not yet have firm funding but are considered likely to occur. Electricity and natural gas savings from these programs are shown **Figure 27** and **Figure 28**, respectively.

Figure 27: Projected Electricity Savings Estimates for Behavioral and Market Transformation Programs (GWh)

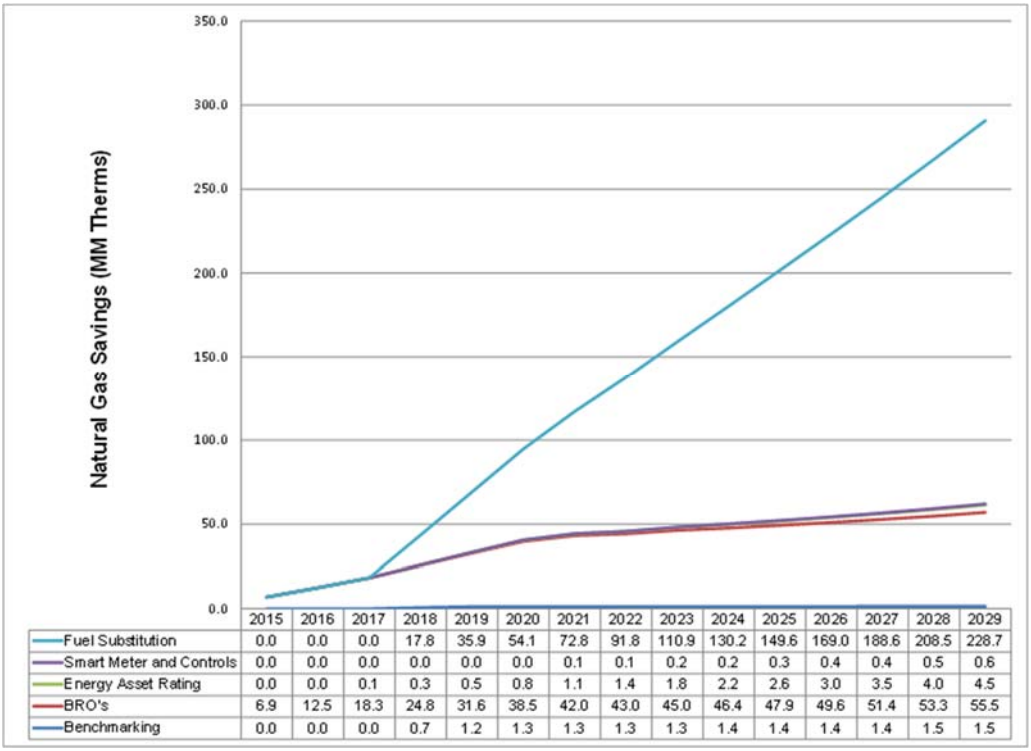


	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Smart Meter and Controls	-	-	-	-	-	6.7	15.4	25.3	36.2	47.8	60.1	73.0	86.5	100.4	114.8
Energy Asset Rating	-	-	14.1	47.1	92.3	147.7	211.3	282.0	358.6	439.8	525.9	615.8	715.3	816.8	922.6
BRO's	622.3	881.6	1,141.	1,438.	1,743.	1,828.	1,914.	2,000.	2,058.	2,118.	2,181.	2,248.	2,320.	2,396.	2,478.
Benchmarking	-	-	-	64.7	109.8	111.6	113.7	115.7	117.9	120.0	122.3	124.5	126.8	129.1	131.5
Fuel Substitution	-	-	-	-139.45	-280.17	-423.02	-568.79	-716.91	-866.8	-1017.7	-1169	-1320.5	-1474	-1629.5	-1787.1

California Energy Commission staff, Efficiency Division. Based On Work in Appendix B by NORESCO. August 2017.

Figure 28: Projected Natural Gas Savings Estimates for Behavioral and Market Transformation

Programs (MM Therms)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Fuel Substitution	0.0	0.0	0.0	17.8	35.9	54.1	72.8	91.8	110.9	130.2	149.6	169.0	188.6	208.5	228.7
Smart Meter and Controls	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6
Energy Asset Rating	0.0	0.0	0.1	0.3	0.5	0.8	1.1	1.4	1.8	2.2	2.6	3.0	3.5	4.0	4.5
BRO's	6.9	12.5	18.3	24.8	31.6	38.5	42.0	43.0	45.0	46.4	47.9	49.6	51.4	53.3	55.5
Benchmarking	0.0	0.0	0.0	0.7	1.2	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.5

California Energy Commission staff, Efficiency Division. Based on work in Appendix B by NORESCO. August 2017.

Benchmarking

AB 802 directs the Energy Commission to create a mandatory benchmarking and public disclosure program for certain commercial and multifamily residential buildings, as well as making certain building-level energy-use information available to building owners, agents, and operators upon request.[110] The Energy Commission has proposed regulations that would implement the benchmarking and public disclosure provisions of AB 802. Specifically, the regulations would require the owners of most commercial and residential buildings larger than 50,000 square feet to report building-level energy performance information to the Energy Commission annually, with commercial buildings beginning in 2018 and residential buildings beginning in 2019. The Energy Commission will publish this information on a public website. The program will assist in achieving energy savings by providing better information about buildings to prospective buyers or lessees, allowing policy makers and planners to be better informed and helping energy service companies target their services. As local ordinances with requirements exceeding the statewide requirements (for example, by requiring audits or retrocommissioning, or by including smaller buildings) become more common, energy efficiency savings can continue to increase.[111]

110 An earlier benchmarking program established under of Assembly Bill 1103 (Saldaña, Chapter 533, Statutes of 2007) required the owner or operator of a nonresidential building to disclose the benchmarking information of that building to a prospective buyer, lessee, or lender.

111 At this time, the cities of San Francisco, Berkeley, and Los Angeles have local ordinances requiring benchmarking, reporting, and audits. The increased access to building-level energy use information provided by AB 802 will make it easier for more jurisdictions to create local ordinances.

Energy Asset Rating

The Energy Commission EBEE Action Plan calls for standardized energy asset ratings for both residential and nonresidential buildings.[112] An *asset rating* is a method of quantifying the efficiency potential of a building itself, independent of the number of occupants and their behavioral choices. By including an asset rating as part of real estate listings or information for a building owner, one can factor the behavior-independent energy costs of a building into their decision making and amend their behavior to achieve the full potential energy efficiency. The factors affecting underlying efficiency potential include the envelope, heating, cooling, ventilation, and hot water systems of the building, along with the installed lighting and major appliances, as well as any offsetting electrical power produced by on-site renewable systems. Energy savings that can be directly attributed to an energy asset rating are behavioral, whereas any measures implemented due to knowing and acting on the rating is attributable to that specific program.

Behavioral, Retrocommissioning, and Operational Savings

The idea behind BROs savings is to give energy customers greater accessibility to their energy data for a greater understanding of their energy usage to influence them to become more energy-efficient. Energy customers can accomplish this through energy efficiency improvements, such as purchasing more efficient technologies or by changing behavior that affects building energy usage, including shifting appliance and equipment use to off-peak hours and turning off energy measures when not needed. Changes in behavior have been shown to provide quantifiable effects on energy consumption.

Retrocommissioning is checking that equipment was installed correctly, like the ducts of an HVAC system. It helps discover ways to capture energy savings in existing buildings. Operational savings improve the operation of the equipment of a building by offering certifications and training. Effective building operations have significant affected energy use for multifamily and commercial buildings

Smart Meters and Controls

Utilities have begun deploying advanced metering infrastructure (AMI) to enable two-way communications with their customers. There are numerous aspects of AMI that can contribute to energy savings, including what are referred to as *smart meters*. The smart meter may be able to communicate through the Internet with devices in the building that are connected as part of Internet of Things. For example, the air conditioner can be sent a signal to operate minimally when the electricity rates are above a threshold, or the clothes dryer can be set to run as soon as the electricity rate drops below a desired level. This communication would result in both load shifting and energy savings. Although smart meters have been widely installed across California, they have not been the focus of specific

112 California Energy Commission. *2016 Existing Buildings Energy Efficiency Action Plan Update - Final. Strategy 1.4, Adopt Uniform Asset Ratings to Compare Building Properties.* December 2016. http://docketpublic.energy.ca.gov/PublicDocuments/16-EBP-01/TN214801_20161214T155117_Existing_Building_Energy_Efficency_Plan_Update_Deceber_2016_Thi.pdf.

energy efficiency programs, and much of the potential of these devices remains unrealized.[113] Most of the energy savings from using smart meter data are captured in the previous category of behavioral and market transformation programs. The focus of this section is the automation of appliances and other loads in a building by communicating with a smart meter.

Fuel Substitution

In Chapter 5, issues surrounding fuel substitution were addressed. As noted, there are very few utility fuel substitution programs, but fuel substitution programs could apply to a wide range of residential and nonresidential buildings. Fuel substitution can include measures for space heating, water heating, clothes dryers, and possibly additional nonresidential measures. The requirements of SB 350 allow measures such as *appliance electrification*, which is substituting a natural gas appliance with an electric appliance. Advances in heat pump technology have made substituting natural gas with electricity for heating systems more viable and offer increased efficiency compared to traditional resistance heating devices such as electric clothes dryers. The vast majority of buildings in California use natural gas for water and space heating. Substituting natural gas with heat pumps for space and water heating could reduce both energy consumption and GHG emissions.

113 Mooney, Chris. "Why 50 Million Smart Meters Still Haven't Fixed America's Energy Habits," *The Washington Post,* 2015. Accessed June 12, 2017. https://www.washingtonpost.com/news/energy-environment/wp/2015/01/29/americans-are-this-close-to-finally-understanding-their-electricity-bills/?utm_term=.18f33f7d09e2.

CHAPTER 7: Recommendations

Several actions must be taken to meet the SB 350 doubling targets. Efficiency programs, especially financing programs, are assumed to be funded through 2029, yet many of them do not have an ongoing funding source or are expected to end before then. Ensuring adequate funding for energy efficiency programs will be important in meeting the SB 350 targets. As California moves forward, it is essential to closely examine how programs are performing and make adjustments that will maximize the savings achieved. Sufficient data must be collected from numerous parties to adequately track progress in meeting the SB 350 doubling targets. There must be an ongoing effort to look for innovative ways to create program designs. The following discusses proposed recommendations and next steps to address these issues.

Fund and Improve Energy Efficiency Programs

Since the energy efficiency projections for many of the nonutility programs assume that the funding remains constant through 2029, any loss of funding will increase the energy savings gap that exists between current subtargets and the SB 350 doubling targets. In addition, to maximize the full potential of energy efficiency equipment and appliances, they must be installed correctly, consistent with the *Low-Income Barriers Report* and the EBEE Action Plan. The projection of energy savings for the building standards and appliance regulations assumes that there is 100 percent compliance to show the full potential impact. For this assumption to be realized, there needs to be increased compliance across the state. The following recommendations will need to be implemented.

- Maintain or expand current levels of funding of financing programs, including the Water Energy Grant, LIWP, and Proposition 39, and others. Coordinate with state and local agencies that deliver energy efficiency programs and stakeholders.
- Develop and reward programs that most effectively attract and leverage private capital, simplify and reduce the cost of program participation, and provide incentives for real-world performance.
- Increase the funding of the ECAA program to allow more access to schools, cities, counties, and special districts for energy efficiency projects.
- Improve code compliance by increasing interagency collaboration, stakeholder engagement, and funding for outreach and education at the local level, especially for local building permit offices and the contractor communities.

Achieve Additional Energy Efficiency Savings

To meet the SB 350 electricity doubling target, it will be necessary to develop new programs or expand existing ones. As utilities have noted, expansion of utility programs may be

difficult to do in a manner that honors the requirement that utility programs be cost-effective and feasible and not adversely impact health and safety.[114] Any changes in IOU programs requirements must be done through a CPUC proceeding. At the September 7, 2017 workshop on the SB 350, representatives from the energy efficiency industry encouraged the Energy Commission to continue the work needed to realize the energy savings targets. In particular, they suggested that specific action steps and timelines should be established with responsible entities to realize significant increases in the energy efficiency savings. In addition, efforts underway to reduce carbon emissions associated with California's food processing energy needs are important in meeting the SB 350 targets, and could be replicated for other major industrial processes in the state. Identifying cost-effective and feasible energy and demand reductions, along with emission reductions from fuel substitution, in industrial facilities will be a focus in the next update to the SB 350 doubling targets. The following recommendations and next steps must be undertaken:

- Create new energy efficiency programs that capture additional savings in collaboration with utilities, state and local governments, and stakeholders.
- Establish specific action steps and timelines for responsible entities to realize significant increases in energy savings derived from energy efficiency through ongoing collaborations with the CPUC, other state and local governments, stakeholders as part the required update of the *Existing Buildings Energy Efficiency Action Plan*.
- Expand workforce training to improve the quality of energy efficiency equipment installation, consistent with recommendations from the Low-Income Barriers Report and the EBEE Action Plan.
- Develop a comprehensive framework to implement of fuel substitution programs that maximizes efficiency savings and GHG emission reductions in collaboration with CPUC, California Air Resources Board (CARB), utilities, and stakeholders. Next steps include the following:
    - Convene a working group to review SB 1383 and CARB's *Short-Lived Climate Reduction Pollutant Reduction Strategy* and provide recommendations about complementary or competing roles of substituting electricity for natural gas and replacing natural gas with renewable gas as strategies for reducing GHG emissions.
    - Establish a joint effort between Energy Commission and CPUC to coordinate SB 350 fuel substitution requirements, including opportunities for fuel substitution in industrial facilities.
- Continue ongoing partnership with the CPUC, ARB, California Department of Food and Agriculture, the Treasurer's Office, and food processing industry members to

114 Joint Publicly Owned Utilities Comments on Draft Staff Papers on SB 350 Energy Efficiency Savings Doubling Targets. CMUA, NCPA, and SCPPA. Docket #17-IEPR-06. August 3, 2017. P. 7. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220545_20170803T165754_Jonathan_Changus_Comments_CMUA_NCPA_and_SCPPA_Joint_Comments_on.pdf .

examine issues and identify strategies that will assist food processors reduce energy use and GHG emissions.

Enhance Reporting and Estimating Energy Efficiency Savings

As discussed, SB 350 requires the Energy Commission to report to the Legislature every two years on progress toward achieving the energy efficiency savings doubling targets. It also requires an assessment of the impact of such savings on hourly and seasonal electricity demand patterns in local utility service territories and on disadvantaged communities. Neither of these two legislatively mandated evaluation criteria is supported by existing reporting requirements. To determine that progress is being achieved, the Energy Commission will need to collect additional data from utilities and other responsible entities. Through such information, the Energy Commission will be able to determine how programs are performing and whether further legislative action may be needed to authorize new energy efficiency implementation authority to achieve the SB 350 doubling target.

Standardized Historical Savings Estimates

All utilities provide energy efficiency program savings reports, both the expenditure level for activities and estimated savings, to the Energy Commission, the CPUC, or both. IOUs report level of activity to the CPUC at least quarterly, with nominal savings estimates including hourly data that use approved *ex ante* savings values.[115] The CPUC staff then conducts extent EM&V using contractors.[116] The nature of the current EM&V is that final *ex post* savings estimates, or estimates based on actual results, have lagged two to three years behind reported energy efficiency activity. POUs provide annual reports to the Energy Commission in March of each year for the previous year but do not have hourly data for energy efficiency saving estimates in most cases.[117] The Energy Commission is revising data collection regulations and proposes to collect hourly data from the IOUs and the two large POUs, LADWP and SMUD.[118] The following recommendations will need to be implemented.

- Ensure that sufficient disaggregated data, including hourly and seasonal, is available on historical energy consumption and efficiency savings estimates in coordination with the CPUC, IOUs, and POUs. Next steps include the following:
    - The Energy Commission and CPUC should collaborate to reduce the time currently required to produce analytically rigorous savings estimates.

115 Ex ante is a process that estimates the potential energy savings for an energy efficiency measure before it is installed, based on predictions of typical operating conditions and baseline usage.

116 The EM&V process to determine final *ex post* savings means estimates lag 2-3 years behind reported energy efficiency activity. Incomplete and/or preliminary versions of many variables are available earlier but will ultimately be revised once *ex post* values are complete.

117 The EE Reporting Tool used by POUs has been simplified to eliminate some of the information that is now needed by the Energy Commission to develop the impacts the Legislature mandated. The simplification from 8,760 hourly measure savings profiles down to just 6 TOU periods, while making reporting easier for POUs, is now a barrier to developing 8,760 hourly projections of impacts.

118 Energy Commission Order Instituting Rulemaking (Docket No. 16-OIR-03, In the Matter of Developing Regulations, Guidelines and Policies for Implementing SB 350 and AB 802, Title 20 Data Collection Regulations to Support New Analytical Needs.

    - The Energy Commission and POUs should coordinate to ensure that each POU provides appropriately documented estimates of net and gross savings and of savings from codes and standards.
- Ensure access to additional energy savings data from nonutility programs in coordination with energy efficiency program deliverers, including other state, regional, and local agencies. Next steps include the following:
    - Incorporate appropriate requirements for data on energy efficiency program savings, not currently available from PACE providers and other sources, needed for target setting in the Energy Commission's update of data collection regulations (Phase II of Title 20 Data Collection Regulations).
    - Work with nonutility program deliverers, including PACE program administrators, to voluntarily report energy savings while data collection regulations are being developed.
    - Work with new responsible entities not now implementing formal EM&V to help establish a credible basis for estimating historical and projected energy efficiency savings for the energy efficiency activities of each.

Reporting on Disadvantaged Communities

Some utility service areas include many disadvantaged communities, while others may have few or none. Disaggregated energy savings estimates will be necessary to identify impacts in disadvantaged communities from those of the utility's other participating customers. This disaggregation will require utilities to geocode, or provide geographical coordinates for, their customers, or at least those customers participating in energy efficiency programs, and begin reporting historical savings for each of these two subsets separately. The following recommendation will need to be implemented.

- Work with utilities to determine and apply the best methods to ensure adequate reporting of energy efficiency impacts in disadvantaged communities, including whether simplified methods should be used initially while more definitive methods are developed and implemented.

Reporting Hourly and Seasonal Impacts

Historically hourly impact data have not been provided on a measured basis. Instead, estimates have been developed and applied generically across utilities for those applications requiring hourly impacts.[119] Operational issues are pushing utilities and system operators to better understand hourly impacts of high penetrations of renewable generation, behind-the-meter PV systems, and energy efficiency savings. The Legislature, in establishing mandates for higher reliance upon energy efficiency, recognized the importance of measured hourly

119 The CPUC-administered Database of Energy Efficiency Resources (DEER) process periodically develops updated generic hourly load shapes for energy efficiency measures.

impacts of energy efficiency to improve demand forecasting and support system planning and operations.

- Determine and apply the best methods to improve estimation of hourly impacts of energy efficiency savings for each utility in cooperation with the CPUC, investor-owned utilities, and publicly owned utilities.
    - The Energy Commission should form a working group to determine appropriate sources for measuring savings hourly profiles and for satisfying SB 350 hourly demand impacts for the *2019 IEPR* cycle.
    - The Energy Commission should incorporate appropriate regulatory requirements in its update of data collection regulations (Phase II of Title 20 Data Collection Regulations).

Evaluation, Measurement, and Verification

Although there will be continuing uncertainty in savings projections that are the basis for SB 350 targets and sub-targets, the state must focus improvements to EM&V in two areas. This focus would ensure that there is a full understanding of savings achieved from each year's energy efficiency programs and market activities and how these savings accumulate through time toward the 2030 targets. Establishing cumulative targets places the focus on actual savings persisting over time, whereas incremental targets place the emphasis on accomplishing near-term targets. Additional research and analysis are needed to better understand persistence of savings through time and emphasize measures and customer education that increase expected savings over time. Savings from codes and standards and the related attribution to utility programs or to the agency promulgating the standards are an area requiring additional work. The following recommendations will need to be implemented.

- Establish formal EM&V activities at the Energy Commission to measure savings projections for target setting for Energy Commission Title 24 and Title 20 standards, and to use as the basis for improvement in compliance and enforcement.
    - Work with CPUC and POU representatives to fully understand existing codes and standards programs and develop mutually agreeable methods and tools to determine the effect of codes and standards.
    - The Demand Analysis Working Group and the Demand Forecast Expert Panel should review the Energy Commission's forecasting models for treatment of codes and standards, as well as the CPUC's evaluation methods and tools for codes and standards, and offer recommendations for changes that would reduce discrepancies.
- Place a high priority on understanding energy efficiency savings decay to obtain a better understanding of this topic for use in improving projections of cumulative savings.
    - The Energy Commission, CPUC's EM&V team, IOUs, and POUs should review methods used to determine savings decay and replacement and develop a

program to coordinate assumptions between energy efficiency savings potential models and Energy Commission demand forecasting models.

- The CPUC should develop a method for calculating cumulative energy efficiency goals at the earliest date compatible with its use of energy efficiency savings projections in various proceedings.

Projecting Energy Efficiency Savings

The Energy Commission will implement the SB 350 energy efficiency doubling targets based on periodic revisions of the subtargets established for each responsible entity while establishing the doubling target only once. This means that utilities and other responsible entities will need to periodically provide projections of program savings that will flow through the target-setting process multiple times before January 1, 2030. As noted, the potential and goals studies done by the CPUC and POUs have inconsistent accounting conventions and assumptions.

- Ensure that the next round of potential and goals studies support SB 350 implementation by using consistent reporting conventions and assumptions for target-setting and tracking in collaboration with the CPUC and POUs.
  - Work with the CPUC and POUs to undertake behavioral studies appropriate to each major customer sector to improve potential studies that assume existing nonparticipants will behave like recent program participants.
  - The Energy Commission's Energy Research and Development Division, the CPUC, and major utilities should initiate experiments to determine whether behavioral barriers can be overcome by new program designs.
  - Based upon behavioral research results, the Energy Commission, CPUC, and POUs should work to adapt potential models to more fully include behavioral barriers to high-energy efficiency adoption.
  - The Energy Commission will work with the POUs to establish uniform saving projection conventions for use in the next cycle of POU potential studies.[120]
  - Work with the CPUC and POUs to establish improved methods for measuring energy efficiency program savings in recent and current years to improve projections of cumulative savings to 2030.
- Develop improved methods of estimating additional savings potential beyond existing programs from the agricultural and industrial sectors and their contribution to the SB 350 doubling targets in collaboration with utilities and agricultural and industrial stakeholders.
  - Review utility agricultural and industrial programs and methods for projecting savings in the 2018 – 2028 CPUC potential study.

120 For example, whether projected savings are estimated using an AB 802 "existing" baseline or a "to code" baseline.

- Collaborate with agriculture stakeholders to better understand opportunities for energy savings and develop program designs and funding mechanisms to ensure their contribution to achieving the SB 350 doubling targets.
- Collaborate with industry stakeholders to better understand opportunities for energy savings and develop program designs to ensure their contribution to achieving the SB 350 doubling targets.

Establish Aggregate Electricity and Natural Gas Targets

SB 350 provides the authority for the Energy Commission to aggregate, or combine, electricity and natural gas savings projections when establishing targets. To aggregate target the Energy Commission must, "in a public process that allows input from other stakeholders, adopt a methodology for aggregating electricity and natural gas final end-use energy efficiency savings in a consistent manner based on source of energy reduction and other relevant factors."[121] The Energy Commission has not yet exercised this authority, as doing so implies considering relative cost-effectiveness of electricity versus natural gas savings potential, relative contribution of electricity versus natural gas in reducing GHG emissions, and the relationship of this authority to potential fuel substitution programs allowed by SB 350. Stakeholders have asserted, however, that an aggregated target is the best method to guide decisions about fuel substitution of natural gas to electricity versus natural gas efficiency programs.[122] To address this:

- Develop one or more proposed specific aggregation methods for consideration in the next cycle of target setting during the *2019 Integrated Energy Policy Report* in collaboration with the CPUC, IOUs, POUs, and other stakeholders.

121 Public Resources Code Section 25310(c)(2).

122 Southern California Edison Company's Comments on Draft Staff Papers on Senate Bill (SB) 350 Energy Efficiency Savings Doubling Targets. Docket Number 17-IEPR-06. August 3, 2017. P. 3. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN220538_20170803T140140_Catherine_Hackney_Comments_SCE_Comments_on_Draft_Staff_Papers_o.pdf.

ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Original Term
AAEE	Additional Achievable Energy Efficiency
AB 802	Assembly Bill 802 (Williams, Chapter 590, Statutes of 2015)
AB 2021	Assembly Bill 2021 (Levine, Chapter 734, Statutes of 2006)
AMI	Advanced metering infrastructure
APCDs	Air pollution control districts
APCR	Allowance price containment reserve
AQMDs	Air quality management districts
ARRA	American Recovery and Reinvestment Act
BROs	Behavioral, Retrocommissioning, and Operational Programs
BTU	British thermal unit
C&S	Codes and standards
California ISO	California Independent System Operator
CARB	California Air Resources Board
CCA	Community choice aggregators
C-E	Cost-effectiveness
CMUA	California Municipal Utilities Association
CMUA/Navigant	Publicly Owned Utility *Energy Efficiency Potential and Goals Study*
CPUC	California Public Utilities Commission
CPUC/Navigant	Investor-Owned Utility *Energy Efficiency Potential and Goals Study for 2018 and Beyond*
CVR	Conservation voltage reduction
DEER	Database of Energy Efficiency Resources
DER	Distributed energy resource
DGS	Department of General Services
DOE	U.S. Department of Energy
EBEE Action Plan	*Existing Buildings Energy Efficiency Action Plan*

ECAA	Energy Conservation Assistance Act
ELRAM	Electric Resource Assessment Model
EM&V	Evaluation, measurement, and verification
Energy Commission	California Energy Commission
Framework Paper	*Framework for Establishing the Senate Bill 350 Energy Efficiency Savings Doubling Targets*
GGRF	Greenhouse Gas Reduction Fund
GHG	Greenhouse gas
GWh	Gigawatt-hour
GWP	Glendale Water and Power
HVAC	Heating, ventilation, and air conditioning
IEPR	*Integrated Energy Policy Report*
IOU	Investor-owned utility
IRP	Integrated resource planning
kWh	Kilowatt-hour
LADWP	Los Angeles Department of Water and Power
LEA	Local education agency
LGC	Local Government Challenge
LIWP	Low-Income Weatherization Program
MM Therms	Million therms
mTRC	Modified total resource cost
Navigant	Navigant Consulting
NCPA	Northern California Power Agency
NRDC	Natural Resources Defense Council
P&G	Potential and goal
PA	Program administrator
PAC	Program administrator cost
PACE	Property Assessed Clean Energy
PCT	Participant Cost Test

PG&E	Pacific Gas and Electric Company
POU	Publicly owned utility
PRC	Public Resources Code
PUC	Public Utilities Code
Quad BTU	Quadrillion British thermal units
RIM	Ratepayer Impact Measure Test
SB 1037	Senate Bill 1037 (Kehoe, Chapter 366, Statutes of 2005)
SB 350	Clean Energy and Pollution Reduction Act (Senate Bill 350) De León, Chapter 547, Statutes of 2015)
SCE	Southern California Edison Company
SoCal Gas	Southern California Gas Company
SCPPA	Southern California Public Power Authority
SCT	Societal Cost Test
SDG&E	San Diego Gas & Electric Company
SMUD	Sacramento Municipal Utility District
TRC	Total Resource Cost

APPENDIX A:
Utility Savings Technical Issues and Assessment

Two important studies of energy efficiency savings potential are relied upon for establishing subtargets for utility programs.[123] The California Public Utilities Commission (CPUC) worked with Navigant Consulting (Navigant) to prepare *Energy Efficiency Potential and Goals Study for 2018 and Beyond* [124] (2018 IOU Potential and Goals Study), adhering to the method established in previous work. The study objective was to adapt the 2015 potential and goals to the requirements of AB 802 and SB 350, resulting in IOU programs using an "existing conditions" baseline as opposed to a "code baseline." Even though the 2018 IOU Potential and Goals Study did not attempt to double IOU savings, SB 350 directed that goals not be set based on past studies. Consequently, the 2018 IOU Potential and Goals Study used a combination of different calibration and scenarios.

The POUs, through the California Municipal Utilities Association (CMUA), also contracted with Navigant, producing *Energy Efficiency Potential Forecasting for California's Publicly Owned Utilities*[125] (POU Potential and Goals Study.) Using an approach similar to the CPUC study, the POU Potential and Goals Study identified 10-year energy efficiency savings projections for each POU. These projections were submitted to the Energy Commission in March 2017 as required by the Public Resources Code (PRC) 25310(b).

Table A-1 summarizes the differences between POU and IOU characteristics that influence energy efficiency planning.

Table A-1: Comparison of POU and IOU Characteristics in California

	POU	IOU
Ownership	Locally owned by municipal government body, an independent district, or customers/members of the rural cooperative utility residing within the local service area.	Privately owned by shareholders or stockholders. Not limited to the service area.

123 The information presented in this appendix related to IOUs is based on the draft 2018 IOU Potential and Goals Study. The appendix will be updated to reflect the final report released on August 25, 2017.

124 California Public Utilities Commission. *Energy Efficiency Potential and Goals Study for 2018 and Beyond.* August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619.

125 *Energy Efficiency Potential Forecasting for California's Publicly Owned Utilities.* Prepared by Navigant for CMUA. February 2017. P. 12. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217680_20170522T124015_Energy_Efficiency_in_California's_Public_Power_Sector_11th_Edit.pdf.

	POU	IOU
Structure/ Management	Nonprofit public entity managed by locally elected officials/ public employees.	Shareholder-elected board appoints management team of private sector employees.
Rate Setting	Customer rates are set by each utility's governing body or city council in a local public forum.	For profit means investors receive rate of return adding a cost element different from POUs. Customer rates are set and regulated by California Public Utilities Commission (CPUC) through a general rate case proceeding that includes some customer participation, especially through customer advocacy groups.
Mission/Goals	Optimize benefits for local customers, usually in the form of lower energy rates.	Optimize return on investment for shareholders, subject to policy goals set by the Legislature and/or CPUC.
Financing	Public utilities have access to tax-free bonds and co-ops have access to low-interest loans usually at the local level.	Shareholders (investors), the sale of bonds and bank borrowing help finance the utility's operations. Allows recovery through rate structure.
Profit/Net Revenue	Rates are set to recover costs and earn additional return to maintain bond ratings and invest in new facilities.	Utility rates are set to recover costs and earn a reasonable return as profits for shareholders in return for the risk they bear for investing in new facilities.
Size/Heterogeneity	Although POUs dramatically differ in geographical size and number of customers, most are small or midsized with the exception of LADWP and SMUD.	Very large in size and number of customers. Complex, heterogeneous customer mix.
Planning and Procurement of Power Generation Resources	POUs develop plans to meet resource requirements and then either develop or contract for new supplies. Operate their own generation facilities or purchase power through contracts.	A combination of CPUC-centric and IOU planning. A biennial LTPP proceeding to evaluate the utilities' need for new generation resources and establish rules for rate recovery of procurement transactions. Under SB 350, an integrated resource planning process will replace the long-term program plan approach.

	POU	IOU
Transmission	Some larger POUs, like LADWP, SMUD, Imperial, and Turlock Irrigation District own, control, and manage their own transmission grids are balancing authorities. Smaller POUs are part of IOU planning areas.	IOUs own transmission lines, but the Independent System Operator controls and manages the IOUs' transmission lines as a single open-access grid system. IOU generation has no more access to the system than competing generators and marketers.
Retail Service	Some POUs, such as Silicon Valley Power, cities of Corona, Lompoc, Colton, and Plumas-Sierra Rural Electric provide direct access[126] load within city limits.	All IOUs provide direct access and bundled service, which includes all aspects of service—electricity generation, sales, administration, and deliveries.

Source: *2018 IOU Potential and Goals Study*, August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619

Investor-Owned Utilities' Potential and Goals Study

Decision 15-10-028 ordered CPUC staff to conduct a potential and goals study that assesses all the technologies and measures that the utilities could use to make up their energy efficiency portfolios.

Technical, Economic, and Market 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. The technical potential represents the total energy savings available each year that is above the baseline established by Title 20 and Title 24 codes and federal appliance standards.

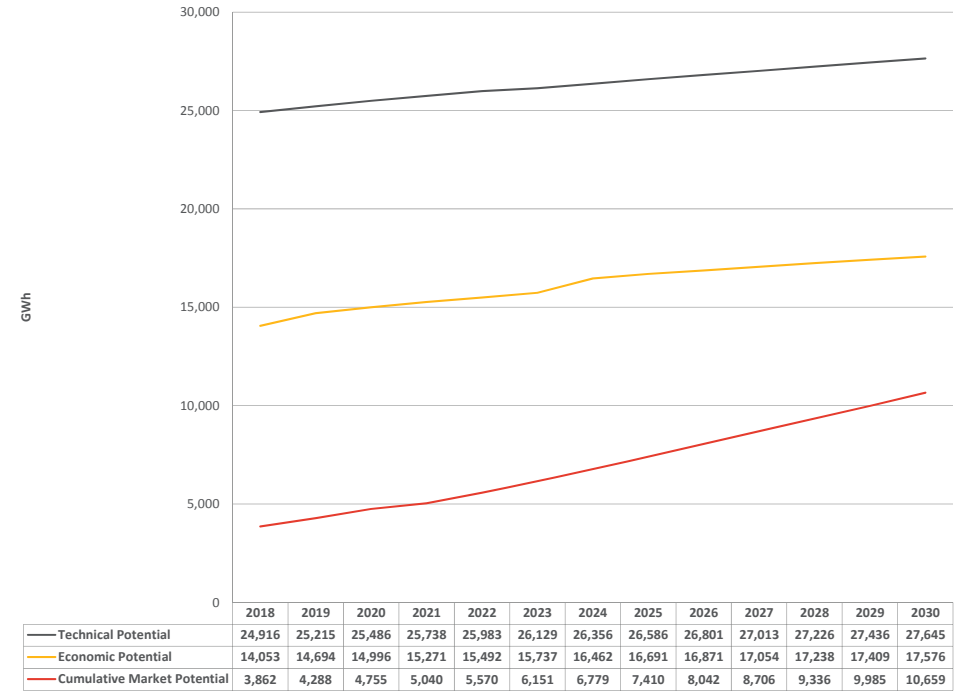
As shown in **Figure A-1** and

126 *Direct access* means the ability of a retail customer to purchase electricity or other energy sources directly from an energy supplier other than utility.

Figure A-2, 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. Both technical and economic potential, as presented in the CPUC studies, are "instantaneous," not "annualized." Assumptions about stock turnover rates are not applied annually to these categories of efficiency potential. Instead, efficiency improvements are assumed to be applied to all applicable equipment and systems in the first year that those improvements are available.

The final output of the *2018 IOU Potential and Goals 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 market influences and barriers. All components of market potential are a subset of economic potential. Some studies also refer to this as "maximum achievable potential." One significant difference between market potential and both technical and economic potential is that the former is annualized, whereas the latter two are instantaneous. The CPUC uses market potential to establish the IOUs' energy efficiency goals.[127]

Figure A-1: Electricity Technical, Economic, and Market Potential for IOUs Using mTRC (GHG Adder #1) Reference Scenario (GWh)

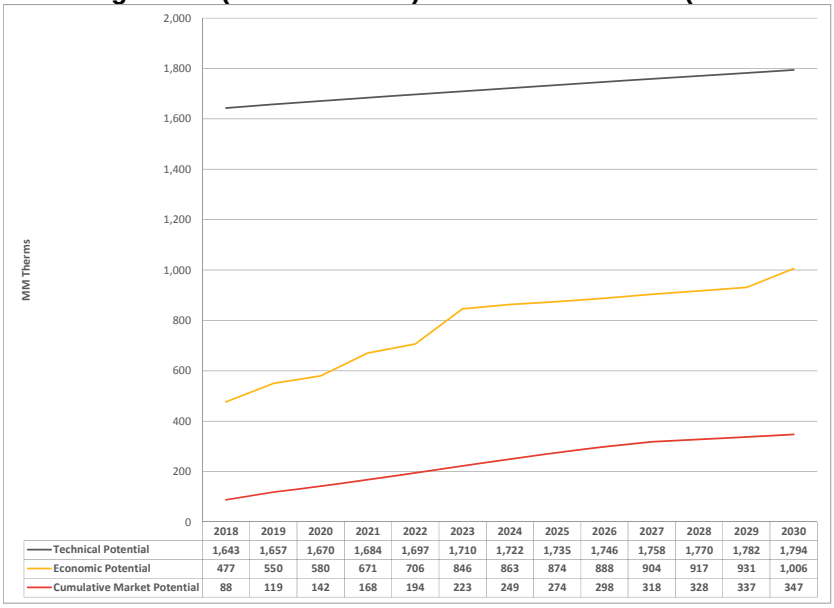


	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Technical Potential	24,916	25,215	25,486	25,738	25,983	26,129	26,356	26,586	26,801	27,013	27,226	27,436	27,645
Economic Potential	14,053	14,694	14,996	15,271	15,492	15,737	16,462	16,691	16,871	17,054	17,238	17,409	17,576
Cumulative Market Potential	3,862	4,288	4,755	5,040	5,570	6,151	6,779	7,410	8,042	8,706	9,336	9,985	10,659

Source: California Energy Commission staff, Energy Assessments Division, August 2017. Based on *2018 IOU Potential and Goals Study,* August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619

127 California Public Utilities Commission. *2018 IOU Potential and Goals Study.* August 2017.

Figure A-2: Natural Gas Technical, Economic, and Market Potential for IOUs Using mTRC (GHG Adder #1) Reference Scenario (MM Therms)



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Technical Potential	1,643	1,657	1,670	1,684	1,697	1,710	1,722	1,735	1,746	1,758	1,770	1,782	1,794
Economic Potential	477	550	580	671	706	846	863	874	888	904	917	931	1,006
Cumulative Market Potential	88	119	142	168	194	223	249	274	298	318	328	337	347

Source: California Energy Commission staff, Energy Assessments Division. August 2017. Based on *2018 IOU Potential and Goals Study*. August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619

Incremental Market Potential

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. Assumptions do not include 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 a year of energy efficiency programs will produce. This has been the basis for IOU program goals.[128]

In the 2011, 2013, and 2015 potential and goals studies, a single forecast of energy efficiency potential was produced for informing IOU goals. This forecast was calibrated to historical program activity. In these past studies, alternate scenarios were considered only in the AAEE forecast used by the Energy Commission. The AAEE scenarios were developed after the CPUC had established goals and were primarily driven by the needs of the Energy Commission. The 2018 potential and goals study considers multiple scenarios to inform goal setting.

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. CPUC 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. The *2018 IOU Potential and Goals Study* considers scenarios primarily built around policies and program decisions that are under the control of the CPUC and IOUs collectively; these scenarios are

128 California Public Utilities Commission. *2018 IOU Potential and Goals Study for 2018 and Beyond*. August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619.

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 over which CPUC and IOUs collectively have no control. A list of example internally and externally influenced variables can be found in **Table A-2**.

Table A-2: 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

Source: *2018 IOU Potential and Goals Study*, August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619

Potential and Goals Study Scenarios

CPUC staff worked with Navigant to develop scenarios for consideration in the goal-setting process. Each of the internally influenced variables in **Table A-2** is expected to affect the forecast of energy efficiency potential. The combined effect of these variables represents a scenario.

CPUC staff considered the following when advising Navigant on the scenarios:

- CPUC staff followed closely the developments in the integrated distributed energy resources (IDER) proceeding. These developments informed the alternative cost-effective tests to consider.
- In February 2017, CPUC staff released a societal cost test (SCT) white paper with recommendations for parameters to support a SCT, as well as potential modifications to the currently used TRC and PAC tests.[129]
- In April 2017, CPUC 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 runs of the RESOLVE model in the IRP.[130]
- In the comments to the proposed interim GHG adder, the joint IOUs proposed an alternative GHG adder curve based on the allowance price containment reserve (APCR).[131] This curve is an extrapolation of preliminary values released by the California Air Resources Board (CARB) during development of the CARB *AB 32 Scoping Plan Update*. Although the proposed allowance prices are not final and are subject to

129 http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M175/K295/175295886.PDF.

130 http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M182/K363/182363230.PDF.

131 *Joint Opening GHG Adder Comments*. P. 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. https://www.arb.ca.gov/regact/2016/capandtrade16/appc.pdf.

change, CPUC 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.

CPUC 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 were proposed and are listed in
Table A-3.

Table A-3: Scenarios for Energy Efficiency Potential – Summary

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

Source: *2018 IOU Potential and Goals Study*, August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619

The "TRC | Reference" scenario represents "business as usual" and continues 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. **Figure A-3** and **Figure A-4** show the five scenarios.

The following tests were used to help develop the scenarios:

Total Resource Cost Test (TRC)—The *California Standard Practice Manual* defines the *TRC test* as the measurement of the net benefits and costs that accrue to society (the program administrator and all its customers).[132] 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.

Modified TRC Test (mTRC)—The mTRC test builds upon the TRC test by including a GHG adder along with the avoided cost of electricity and natural gas.

- GHG Adder #1—IOU Proposal for GHG Adder (CARB APCR price)
- GHG Adder #2—CPUC Staff Proposal for GHG Adder (based on preliminary RESOLVE model runs in the IRP proceeding)

Program Administrator Cost Test (PAC)—The *California Standard Practice Manual* defines the PAC test as the measurement of the net benefits and costs that accrue to program

132 CPUC. *California Standard Practice Manual.* 2001. http://www.cpuc.ca.gov/egyefficiency/

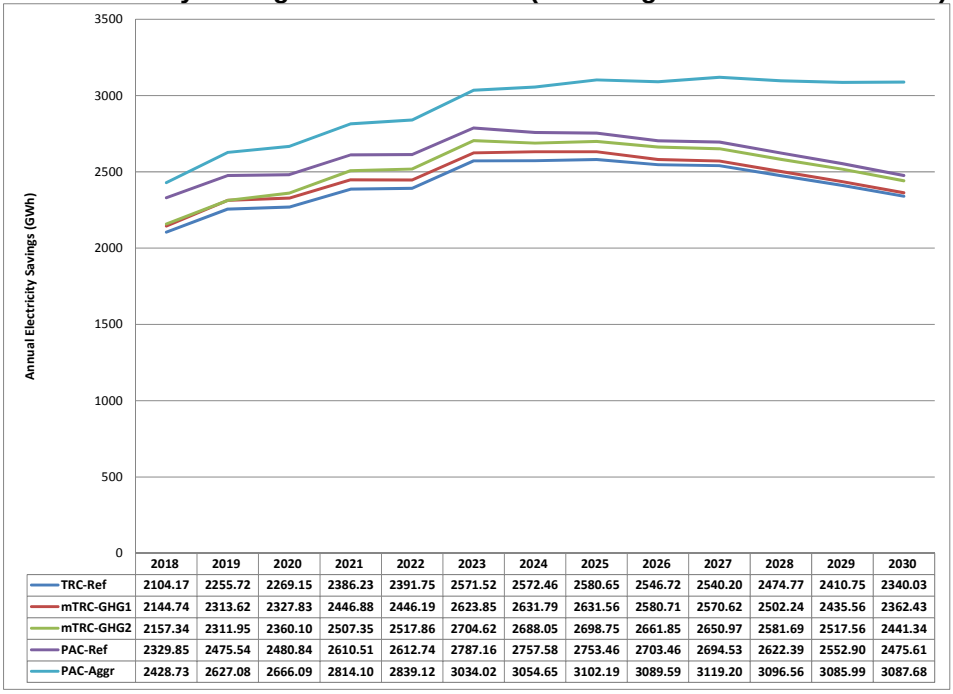
administrator. It compares the benefits, which are the avoided cost of generating electricity and supplying natural gas, with the total costs, which include program administration and incentive costs. The PAC does not include the out-of-pocket costs paid by customers.

- Reference—Existing Programs
- Aggressive—Existing Programs + Enhanced/Expanded Programs

California Public Utilities Commission Goals Adoption Process

The *2018 IOU Potential and Goals Study* was released on June 15, 2017, and a workshop was held June 20, 2017. Comments were due July 7, 2017, and reply comments were due July 14, 2017. The CPUC posted the final potential study in August 2017. The CPUC released Decision 17-09-025 in late September 2017, with the IOU energy efficiency goals for 2018 to 2030.These goals were adopted by the CPUC commissioners on September 28, 2017, and were based on mTRC (GHG Adder #1) reference

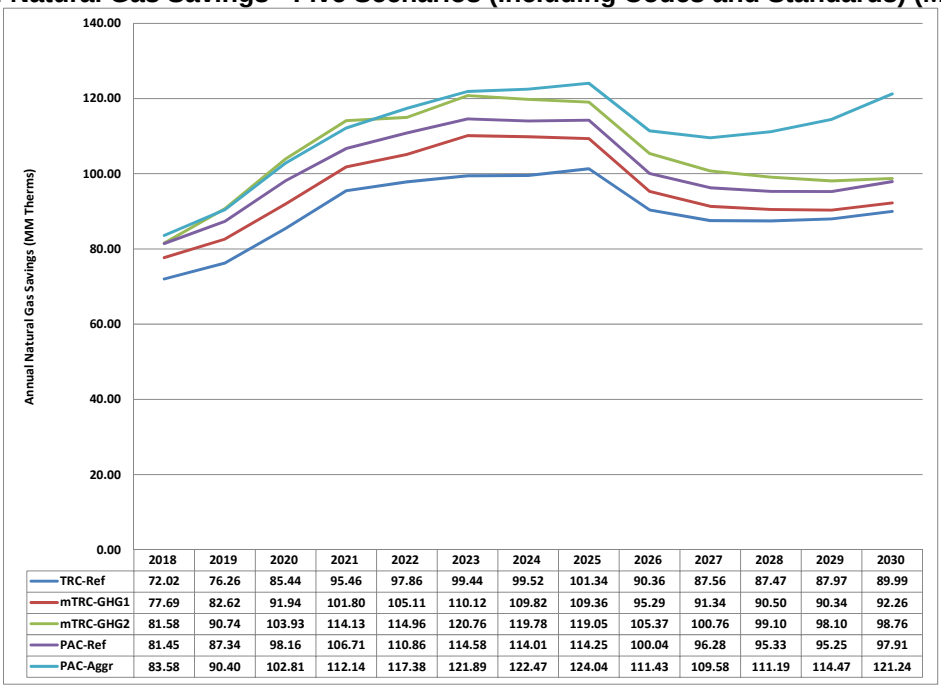
Figure A-3: Electricity Savings – Five Scenarios (Including Codes and Standards) (GWh)



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
TRC-Ref	2104.17	2255.72	2269.15	2386.23	2391.75	2571.52	2572.46	2580.65	2546.72	2540.20	2474.77	2410.75	2340.03
mTRC-GHG1	2144.74	2313.62	2327.83	2446.88	2446.19	2623.85	2631.79	2631.56	2580.71	2570.62	2502.24	2435.56	2362.43
mTRC-GHG2	2157.34	2311.95	2360.10	2507.35	2517.86	2704.62	2688.05	2698.75	2661.85	2650.97	2581.69	2517.56	2441.34
PAC-Ref	2329.85	2475.54	2480.84	2610.51	2612.74	2787.16	2757.58	2753.46	2703.46	2694.53	2622.39	2552.90	2475.61
PAC-Aggr	2428.73	2627.08	2666.09	2814.10	2839.12	3034.02	3054.65	3102.19	3089.59	3119.20	3096.56	3085.99	3087.68

Source: California Energy Commission staff, Energy Assessments Division. August 2017. Based on *2018 IOU Potential and Goals Study,* August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619

Figure A-4: Natural Gas Savings - Five Scenarios (Including Codes and Standards) (MM Therms)



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
TRC-Ref	72.02	76.26	85.44	95.46	97.86	99.44	99.52	101.34	90.36	87.56	87.47	87.97	89.99
mTRC-GHG1	77.69	82.62	91.94	101.80	105.11	110.12	109.82	109.36	95.29	91.34	90.50	90.34	92.26
mTRC-GHG2	81.58	90.74	103.93	114.13	114.96	120.76	119.78	119.05	105.37	100.76	99.10	98.10	98.76
PAC-Ref	81.45	87.34	98.16	106.71	110.86	114.58	114.01	114.25	100.04	96.28	95.33	95.25	97.91
PAC-Aggr	83.58	90.40	102.81	112.14	117.38	121.89	122.47	124.04	111.43	109.58	111.19	114.47	121.24

Source: California Energy Commission staff, Energy Assessments Division. Based on *2018 IOU Potential and Goals Study,* August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619.

Proposed California Public Utilities Commission – Jurisdictional Savings Targets

This section identifies two adjustments to the projections of the *2018 IOU Potential and Goals Study* that the Energy Commission's Energy Assessments Division proposes in identifying IOU SB 350 savings targets. This section concludes with graphs of cumulative electricity and natural gas savings, using the TRC-Ref scenario as an example pending final CPUC decision, for the total savings from CPUC-jurisdictional entities.[133]

Investor-Owned Utilities Statewide Codes and Standards Program

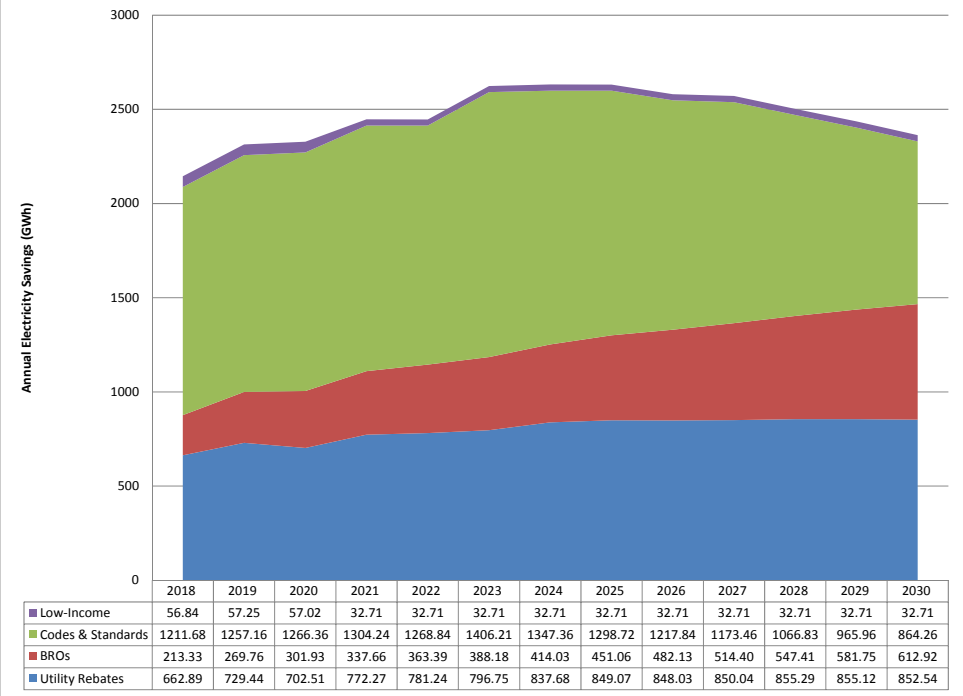
The CPUC adopted a Statewide Codes and Standards Program as part of the original energy efficiency strategic plan in 2008. This program includes several elements – building and appliance standard advocacy for more stringent requirements, compliance improvement, reach codes, and planning and coordination. A substantial budget has been allocated to these efforts, but the benefits are great, since adopting and realizing more stringent standards affect all customers, and there is no direct measure implementation cost to the utility. In D.16-08-019, numerous parties proposed reforms for this program in light of the AB 802 requirements to shift toward use of existing baselines. However, the CPUC decided it was premature to revise

133 All analyses reported here use the IOU distribution utility service area as the basis for analysis. To the extent that the CPUC decides to allow CCAs to undertake an expanded scope of energy efficiency activities through time, then partitioning savings projections appropriate to multiple entities may be appropriate for SB 350.

these programs and instead worked with the Energy Commission in various forums to devise improved methods for code savings quantification.[134]

As shown in **Figure A-5** and **Figure A-6**, using the TRC-Ref scenario as an example, projections of attributable savings from various codes and standards activities are the largest of the four categories of savings in the *2018 IOU Potential and Goals Study*. Now that the Energy Commission is producing its own estimates of savings from future tightening of codes and standards, parties have expressed concern that there is increased potential for double-counting between the *2018 IOU Potential and Goals Study* projections and Energy Commission projections documented in the separate Energy Commission staff paper.[135] Therefore, as an interim accounting mechanism, the Energy Commission is excluding *2018 IOU Potential and Goals Study* attributable codes and standards savings from proposed IOU savings for SB 350. It is expected that this issue will receive explicit attention in later phases of this proceeding and in interagency efforts to prepare for the next cycle of target setting.

Figure A-5: Electricity Savings – mTRC (GHG Adder #1) Reference Scenario With Four Program Types (GWh)



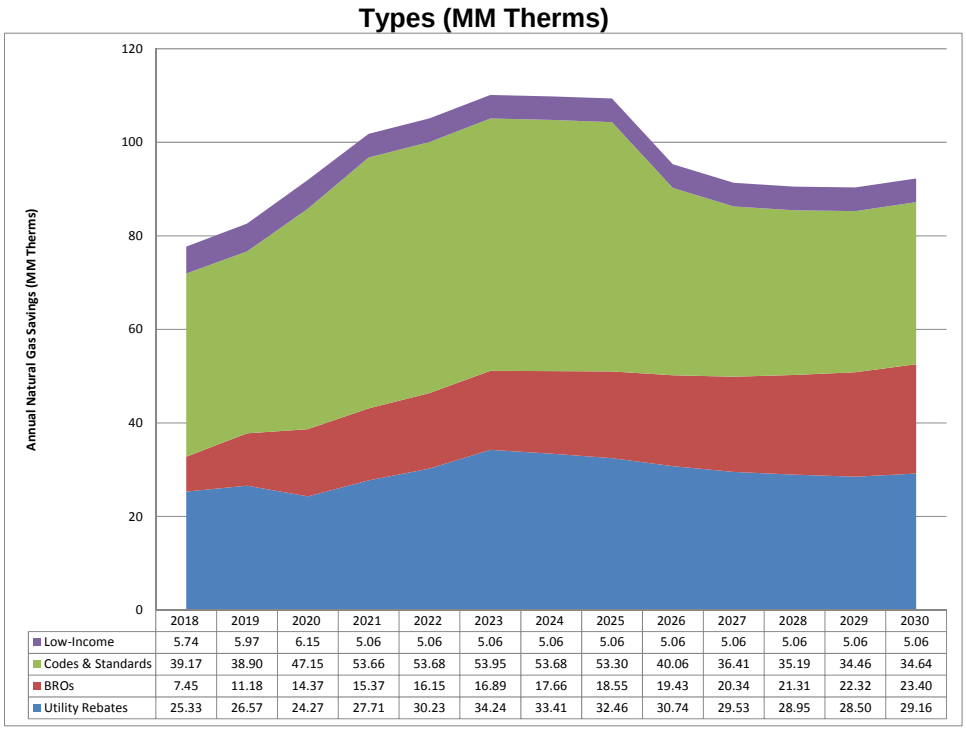
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low-Income	56.84	57.25	57.02	32.71	32.71	32.71	32.71	32.71	32.71	32.71	32.71	32.71	32.71
Codes & Standards	1211.68	1257.16	1266.36	1304.24	1268.84	1406.21	1347.36	1298.72	1217.84	1173.46	1066.83	965.96	864.26
BROs	213.33	269.76	301.93	337.66	363.39	388.18	414.03	451.06	482.13	514.40	547.41	581.75	612.92
Utility Rebates	662.89	729.44	702.51	772.27	781.24	796.75	837.68	849.07	848.03	850.04	855.29	855.12	852.54

Source: California Energy Commission staff, Energy Assessments Division. Based on *2018 IOU Potential and Goals Study*, August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619.

Figure A-6: Natural Gas Savings – mTRC (GHG Adder #1) Reference Scenario With Four Program

134 CPUC, D.16-08-019, p. 31. See http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M166/K232/166232537.PDF.

135 Kenney, Michael, Brian Samuelson, and Manjit Ahuja. 2017. *Senate Bill 350 Energy Efficiency Targets for Programs Not Funded Through Utility Rates*. California Energy Commission. Publication Number: CEC-400-2017-009-SD.



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low-Income	5.74	5.97	6.15	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06
Codes & Standards	39.17	38.90	47.15	53.66	53.68	53.95	53.68	53.30	40.06	36.41	35.19	34.46	34.64
BROs	7.45	11.18	14.37	15.37	16.15	16.89	17.66	18.55	19.43	20.34	21.31	22.32	23.40
Utility Rebates	25.33	26.57	24.27	27.71	30.23	34.24	33.41	32.46	30.74	29.53	28.95	28.50	29.16

Source: California Energy Commission staff, Energy Assessments Division. Based on *2018 IOU Potential and Goals Study.* August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619.

Proposed Adjustments to the Potential Study

The Energy Commission is making two nonsubstantive adjustments to the final CPUC savings projections for the IOUs. Because SB 350 uses 2015 as the base year, the Energy Commission will add 2015, 2016, and 2017 to the 2018-2029 projections to the cumulative savings. Energy Commission will also exclude savings from most codes and standards effective after 2019 to avoid double-counting with independent estimates by the Efficiency Division for future standard impacts.

Energy Efficiency Savings in Historical Years

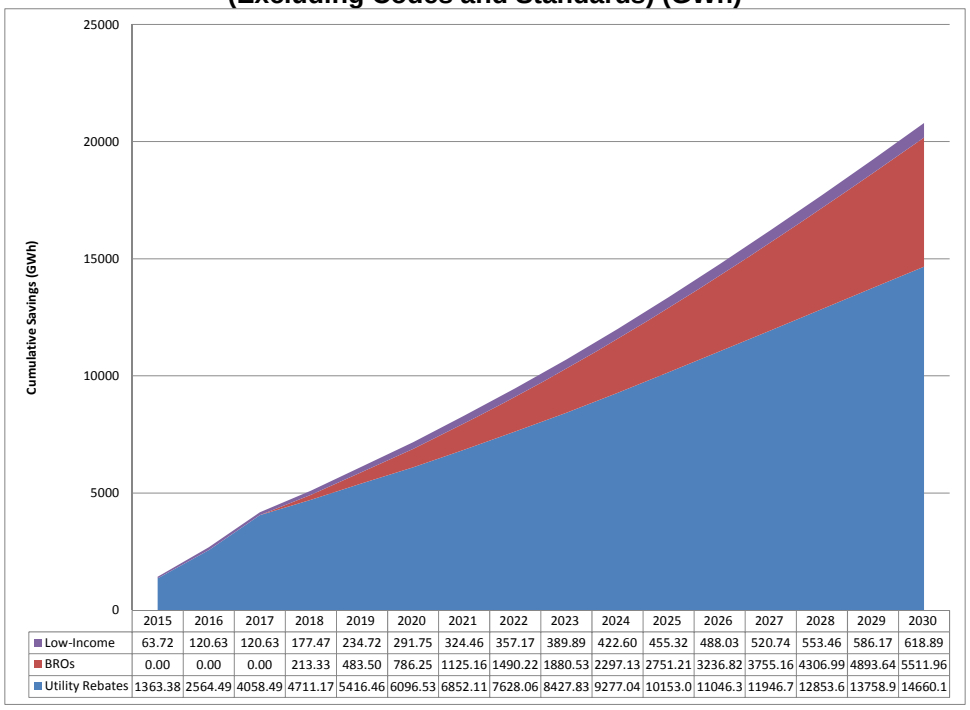
The Energy Commission understands that SB 350 establishes 2015 as the base year for cumulative projections. The *2018 IOU Potential and Goals Study* only reported 2018 to 2030. This means that energy efficiency savings from 2015-2017 must be added to the *2018 IOU Potential and Goals Study* analyses that covered 2028 through 2030. The CPUC has not released final evaluations of program savings for 2015-2016, and 2017 is still unfolding. The Energy Commission developed its own estimates of historical savings for the four program categories as an interim measure. Those values are reported in **Figure A-7** and **Figure A-8**.

Proposed CPUC-Jurisdictional SB 350 Savings Projections

Figure A-7 and **Figure A-8** report proposed combined CPUC-jurisdictional energy efficiency savings from 2015 through 2029 for electricity and natural gas, respectively, using the TRC-Ref scenario for illustration. In contrast to **Figure A-3** and **Figure A-4**, the exclusion of attributable

codes and standards savings reduces the aggregate amounts and shifts the emphasis to utility rebate programs as the dominant source of savings.

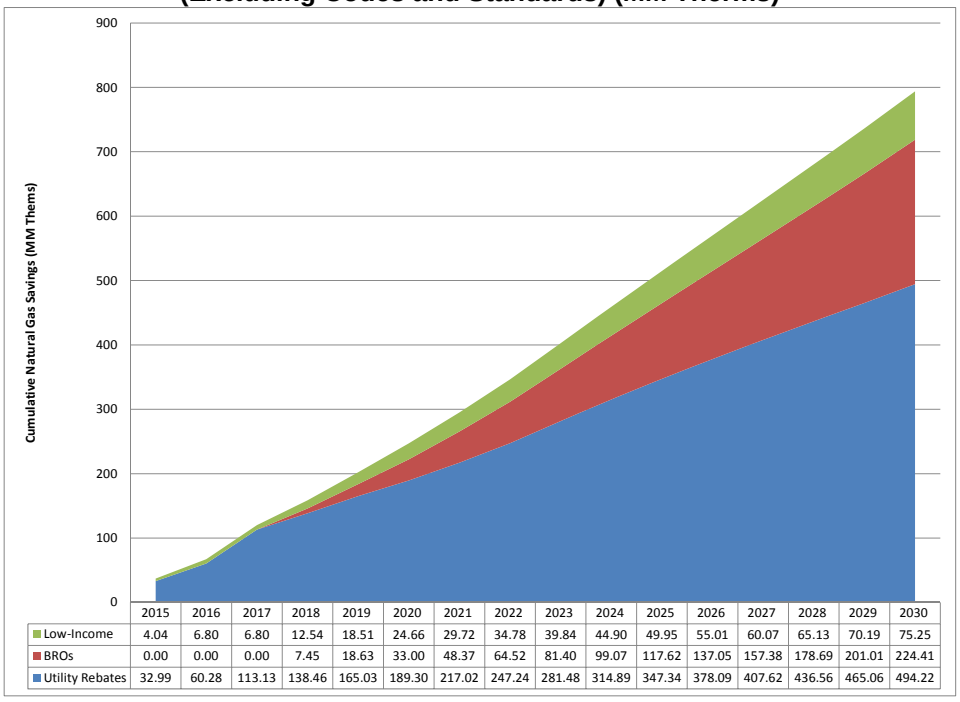
Figure A-7: Electricity Savings – mTRC (GHG Adder #1) Reference Scenario by Program Type (Excluding Codes and Standards) (GWh)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low-Income	63.72	120.63	120.63	177.47	234.72	291.75	324.46	357.17	389.89	422.60	455.32	488.03	520.74	553.46	586.17	618.89
BROs	0.00	0.00	0.00	213.33	483.50	786.25	1125.16	1490.22	1880.53	2297.13	2751.21	3236.82	3755.16	4306.99	4893.64	5511.96
Utility Rebates	1363.38	2564.49	4058.49	4711.17	5416.46	6096.53	6852.11	7628.06	8427.83	9277.04	10153.0	11046.3	11946.7	12853.6	13758.9	14660.1

Source: California Energy Commission staff, Energy Assessments Division. Based on *2018 IOU Potential and Goals Study,* August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619.

Figure A-8: Natural Gas Savings – mTRC (GHG Adder #1) Reference Scenario by Program Type (Excluding Codes and Standards) (MM Therms)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low-Income	4.04	6.80	6.80	12.54	18.51	24.66	29.72	34.78	39.84	44.90	49.95	55.01	60.07	65.13	70.19	75.25
BROs	0.00	0.00	0.00	7.45	18.63	33.00	48.37	64.52	81.40	99.07	117.62	137.05	157.38	178.69	201.01	224.41
Utility Rebates	32.99	60.28	113.13	138.46	165.03	189.30	217.02	247.24	281.48	314.89	347.34	378.09	407.62	436.56	465.06	494.22

Source: California Energy Commission staff, Energy Assessments Division. Based *on 2018 IOU Potential and Goals Study.* August 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619.

Publicly Owned Utility Potential and Goals Study

The POUs, through CMUA, submitted 10-year energy efficiency savings projections, based on an approach similar to the CPUC's, for each POU in the *POU Potential and Goals Study* in March 2017. The POUs used a tool developed by Navigant Consulting called the *Electricity Resource Assessment Model (ELRAM)*. ELRAM is an Excel spreadsheet model designed to estimate technical, economic, and market potentials. ELRAM estimates electricity savings and demand reduction as a function of projected electricity sales. Each POU provided its total baseline system electricity sales projections, and the model compared results after energy efficiency programs implementation assumptions are applied. Adjustments to the model to accommodate each POU's unique set of inputs are common. Since the initial development in 2007, the model has been used by CMUA, its members, and more than 50 electric utilities nationwide.

Table A-4 below provides the savings projection summed for all POUs from their potential studies for the past four cycles. Although the studies resulting from these four versions of ELRAM show increasingly large technical and economic potential, the market gross potential and proposed savings targets have been more stable.

Technical Potential

ELRAM technical potential conceptually is similar to that of the IOU model. As described in Chapter 3, technical potential provides a starting point for determining achievable levels of cost-effective market potential. It is calculated as a product of the electricity savings per unit of a measure, the quantity of applicable efficiency units in each facility, and the number of facilities in a utility service territory. The quantity of applicable units per year is determined by measuring effective useful life. **Table A-4** shows the difference in POU technical potential levels among 10-year periods analyzed in 2007 (2007—2016), in 2010 (2011—2020), in 2013 (2014—2023), and 2017 (2018—2027). The estimate of all 38 POUs technical energy savings potential is 30,117 GWh in 2027. This estimate is 44 percent higher than the 2013 estimate. The list of ELRAM-recognized measure types is provided in below in **Table A-5**.

Table A-4: Comparison of POU 10-Year Forward Potentials (GWh)

	2007	2010	2013	2017
Technical	13,687	10,693	20,950	30,115
Economic	10,553	9,525	15,999	25,374
Market Gross	5,907	6,206	10,952	5,371
Electricity Savings Target	6,630	7,403	7,366	7,969

Source: California Energy Commission staff, Energy Assessments Division, July 2017, based on *Energy Efficiency in California's Public Power Sector* Status Reports, http://www.ncpa.com/policy/reports/energy-efficiency/.

Table A-5: POU Technical Potential Groups of Measures

Measure Group	Description
Replacement on burnout (ROB)	Implementation of an energy-efficient measure after the existing equipment fails.
Retrofit (RET)	Immediate installation of an energy-efficient measure that improves the efficiency of an existing technology. The lifetime of the base technology is not a factor as retrofit measures generally do not replace existing technologies. The energy impact is, therefore, only the amount of improvement to the existing technology.
Dual Baseline (DUB)	The dual-baseline measure type is an early replacement that replaces an existing technology before the end of useful life; however, savings are calculated using a less efficient "as-found condition" baseline for the first part of the remaining useful life (RUL) and a "code condition" for the second portion of the RUL. This results in higher initial energy savings under the first baseline and lower savings under the second baseline once the measure would have reached the end of the effective useful life (EUL). Measure costs are also adjusted to reflect the change in baselines.
Behavioral Programs (BEH)	Programs designed to influence consumer behavior through the provision of training and/or information. As with emerging technologies, achievable potential is calculated using a Bass diffusion model rather than the traditional measure payback.
Low-Income	Measures that are implemented as part of a utility-administered low-income program.
New Construction	Installation of a measure or package of measures at the time of construction.
Demand Response	Strategies specifically designed to reduce peak demand. There are generally very little energy savings associated with these strategies.

Source: Navigant and California Energy Commission, Energy Assessments Division, July 2017.

Economic Potential

Similar to the IOU model, POU economic potential represents a portion of the technical potential if a utility installs measures selected by the results of the cost-effectiveness screening. As described in Chapters 2 and 4, cost-effective measures are those with a test result of 1 or greater of the total resource cost (TRC) and the program administrator cost (PAC). POUs

provide TRC and PAC test results, using a benefit/cost ratio, derived from the E3 Reporting Tool. Descriptions of the ELRAM cost/benefit screening are provided in below in **Table A-6**. Historically, economic potential is around 80 percent of technical potential. The economic potential estimated for the POUs in the 2017-2028 study is 60 percent higher than the 2013 estimate.

Table A-6: Economic Screening of Measures

Test	Description
Total Resource Cost (TRC)	This test includes all quantifiable costs and benefits of an energy efficiency measure that may accrue to participants or the utility. For example, a measure passing the TRC test is cost-effective if the sum of the avoided costs and other benefits accruing to participants or the utility are greater than the sum of the measure costs and the utility's administrative costs.
Program Administrator Cost Test (PAC)	This test measures the costs of an energy efficiency program based on the costs incurred by the utility (including incentive costs) and excluding any net costs incurred by the participant. For example, a measure passing the PAC test is cost-effective if the sum of the avoided costs (costs avoided by energy and demand savings of the measure) and other utility benefits are greater than the utility's costs to promote the measure, including incentives provided to customers.
Ratepayer Impact Measure Test (RIM)	This test measures what happens to a dwelling or business' electric bills or rates due to changes in utility revenue and operating costs caused by the program. For example, a measure passing the RIM test is cost-effective if the avoided costs are greater than the sum of the utility's costs and the "lost revenues" caused by the measure.
Participant Cost Test (PCT)	This test measures the quantifiable benefits and costs to the customer due to participation in the program. For example, a measure passing the PCT test is cost-effective if the reduced electric costs to the participating customer from the measure exceed the after-incentive cost.
Customer Payback	This measurement calculates the incremental technology cost divided by the incentive and the reduction in the electric bill. If multilife benefits and costs are considered, it also includes the PV of future technology costs and future incentives and bill reductions.
Levelized Measure Cost/kWh	This metric multiplies the energy efficiency measure costs by the capital recovery factor and divides by the first-year kWh savings.

Source: California Energy Commission staff, Energy Assessments Division, July 2017

Market Potential

CMUA, in its annual report, formulated a foundational principle for POU energy efficiency efforts that the customer is central to realizing energy savings, implying that a final end user is ultimately responsible for the decision to comply, invest, or otherwise implement an energy efficiency measure. "Customers are ultimately responsible for achieving savings from energy efficiency. To fully realize potential energy savings, policies and programs must aim to remove barriers and encourage voluntary action by customers to reduce energy usage."[136]

Market potential is further limited by such factors as program design, the magnitude of utility incentives, and rebates. Efficiency savings are estimated in response to specific levels of incentives and assumptions about policies, market influences, and market barriers. When the cost-effectiveness screening value at the measure level is less than 1.0, it is common to assess for market feasibility. POU market potential varies significantly based on local policy and program assumptions. Some of the POU-specific methods differ in whether the estimates are considered net of naturally occurring efficiency or free riders. In addition to gross and net estimates, market potentials are estimated incrementally and cumulatively. The gross market potential estimated for the POUs in the 2017-2028 study is 60 percent lower than 2013 estimate.

Natural Gas Savings Potential

Only two POUs, both small, provide natural gas service to end-use customers.[137] The ELRAM tool does not address natural gas savings; thus, savings projections for natural gas are not reported in the main CMUA report submitted in March 2017. The CMUA report, provided to the Energy Commission because of a data request, provides a limited description of natural gas savings projections for the City of Palo Alto. Natural gas service by the two POUs is a small fraction of the scale of natural gas service provided by IOUs to end users across the state; thus, natural gas savings from energy efficiency measures are due to CPUC-supervised IOU activities. Natural gas savings projections for IOUs are discussed in Chapter 3.

Ten-Year Electricity Savings Projections

Table A-7 provides results of the ELRAM projections by POU group. Technical and economic potentials are relatively constant through time, reflecting the definition of these concepts described above. Market potential and net program savings projections grow through time as year-by-year savings accumulate. By the end of the 10-year period, however, only limited amounts of economic potential have been achieved.

136 *Energy Efficiency in California's Public Power Sector: A 2016 Status* Update. P.25.

137 The City of Palo Alto provides both electricity and natural gas service to end-use customers. The City of Long Beach provides natural gas service to end users.

Table A-7: Ten-Year Electricity Savings Potential by POU Group (GWh)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Technical										
LADWP	11,721	11,822	11,781	11,926	12,085	12,141	12,309	12,475	12,589	12,699
SMUD	4,670	4,767	4,858	4,950	5,014	5,103	5,192	5,269	5,348	4,670
Economic										
LADWP	8,854	8,920	9,062	9,168	9,325	9,481	9,602	9,721	9,906	10,020
SMUD	3,737	4,045	4,116	4,261	4,346	4,467	4,548	4,630	4,709	3,737
Market Gross										
LADWP	371	742	1,076	1,409	1,660	1,921	2,171	2,430	2,697	2,947
SMUD	113	208	305	406	517	614	704	781	846	897
Technical										
Midsize[138]	9,694	9,810	9,813	9,916	10,037	10,090	10,191	10,289	10,354	10,415
Economic										
Midsize	8,173	8,291	8,418	8,541	8,679	8,788	8,904	9,000	9,098	9,192
Market Gross										
Midsize	160	304	450	601	755	896	1,029	1,154	1,270	1,372
Technical										
Small POUs[139]	1,564	1,579	1,574	1,590	1,602	1,608	1,623	1,635	1,643	1,653
Economic										
Small POUs	1,307	1,322	1,337	1,349	1,555	1,383	1,403	1,421	1,432	1,452
Market Gross										
Small POUs	16	32	48	64	81	97	113	128	141	154

Source: CMUA, *POU Potential and Goals Study*, March 2017. Compiled from http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217482_20170508T153251_Appendix_B__20182027_Annual_Targets_All_POUs.xlsx.

Table A-8 provides a view of projected cumulative 10-year savings targets for all POUs combined into three size groups. LADWP and SMUD alone account for more than half of total cumulative savings. The 14 medium-sized POUs account for about a quarter of the cumulative savings. The remaining 20 POUs collectively account for a very small share of composite POU savings.

138 Midsize POUs include Anaheim, Burbank, Glendale, IID, Modesto, Palo Alto, Pasadena, Redding, Riverside, Roseville, San Francisco PUC, Silicon Valley, Turlock, and Vernon.

139 Small- POUs include Colton, Lodi, Merced, Moreno Valley, Alameda, Truckee Donner, Shasta Lake, Banning, Healdsburg, Rancho Cucamonga, Lassen, Lompoc, Corona, Pittsburg, Ukiah, Victorville, Plumas-Sierra, Gridley, Needles, Biggs, Trinity, and Azusa.

Table A-8: POU Ten-Year Cumulative Electricity Savings Targets (GWh)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
LADWP	499	1,004	1,464	1,874	2,282	2,684	3,087	3,501	3,918	4,324
SMUD	150	305	469	644	828	1,015	1,196	1,366	1.523	1,669
Imperial	33	67	101	133	164	193	221	247	272	295
Anaheim	28	56	83	109	135	160	184	207	229	249
Riverside	23	46	69	92	115	139	162	186	209	233
Pasadena	14	27	41	54	68	81	95	108	122	135
Turlock	16	31	46	61	75	89	102	113	124	135
Santa Clara	13	26	40	55	70	85	98	110	122	132
Glendale	15	30	44	58	72	86	98	110	121	130
Burbank	11	22	33	46	58	71	85	99	112	124
Modesto	9	19	30	42	55	69	82	96	109	121
Roseville	8	17	26	36	46	56	65	73	81	89
Palo Alto	7	15	22	30	39	47	55	64	73	82
Vernon	5	10	16	22	27	32	37	41	45	48
Redding	4	8	12	17	21	25	29	33	37	40
San Francisco	3	6	8	11	14	16	19	21	23	25
Small[140]	17	34	51	67	84	101	118	133	148	162
All Combined	**852**	**1,716**	**2,548**	**3,341**	**4,139**	**4,932**	**5,713**	**6,486**	**7,244**	**7,969**

Source: CMUA, *POU Potential and Goals Study*, March 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217482_20170508T153251_Appendix_B__20182027_Annual_Targets_All_POUs.xlsx.

Adjustments to POU-Proposed Projections

The Energy Commission proposes to adjust the energy efficiency targets submitted by the POUs in March 2017. As described earlier, the CMUA process that engaged Navigant Consulting to develop an energy efficiency potential study allowed each POU to customize the final targets projections. Many POUs took advantage of this opportunity, and the composite projections described earlier do not use a uniform basis for developing future savings projections. As described in Chapter 4, the Energy Commission does not believe that such customized definitions can be the basis for SB 350 energy efficiency targets, although the decisions that POUs have made can continue to be used for each POUs' own internal planning.

Three types of changes to POU projections as submitted are proposed:

- Exclude code and standard savings from utility targets and include such savings in the nonutility program savings group.
- Shift from gross to net basis for calculating historical and future savings.
- For SB 350, add historical savings for 2015-2017 and extrapolate savings from 2027 through December 31, 2029.

140 Small POUs include Colton, Lodi, Merced, Moreno Valley, Alameda, Truckee Donner, Shasta Lake, Banning, Healdsburg, Rancho Cucamonga, Lassen, Lompoc, Corona, Pittsburg, Ukiah, Victorville, Plumas-Sierra, Gridley, Needles, Biggs, Trinity, and Azusa.

The effect of these adjustments on the three aggregate groups of POUs can be seen by comparing
Table A-8 and **Table A-9**. Both tables show incremental annual electricity savings targets, and generally both tables illustrate reductions in annual savings going forward. The most important difference between the two figures is that **Table A-8** begins in 2018, while **Table A-9** begins in 2015. This difference reflects the requirement of SB 350 to use 2015 as the base year. The second most important difference is that all the annual incremental values in **Table A-9** are scaled down about 200 GWh per year compared to the corresponding values in **Table A-8**. This reflects the exclusion of C&S savings and the replacement of gross by net savings.

Table A-9: POU Ten-Year Incremental Annual Electricity Savings Targets (GWh)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Large										
LADWP	499	504	461	410	408	402	404	414	417	406
SMUD	150	155	164	175	184	187	181	169	158	146
Midsize										
Imperial	33	34	34	32	31	29	28	27	25	22
Anaheim	28	28	27	26	26	25	24	23	22	20
Riverside	23	23	23	23	23	23	23	23	23	24
Pasadena	14	14	14	14	14	14	14	14	14	14
Turlock	16	15	15	15	14	14	13	12	11	10
Santa Clara	13	13	14	15	15	15	13	12	12	11
Glendale	15	15	15	14	14	14	12	12	11	10
Burbank	11	11	11	12	13	13	14	14	13	13
Modesto	9	10	11	12	13	13	14	14	13	12
Roseville	8	9	9	10	10	10	9	9	8	8
Palo Alto	7	7	8	8	8	8	9	9	8	8
Vernon	5	5	6	6	6	5	5	4	4	4
Redding	4	4	4	4	4	4	4	4	4	3
San Francisco	4	4	4	4	4	4	4	3	3	3
Small[141]	13	13	12	13	12	12	13	12	12	11
All Combined	**852**	**864**	**832**	**793**	**798**	**792**	**782**	**773**	**758**	**725**

Source: CMUA, POU Potential and Goals Study, March 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217482_20170508T153251_Appendix_B__20182027_Annual_Targets_All_POUs.xlsx.

141 Small POUs include Colton, Lodi, Merced, Moreno Valley, Alameda, Truckee Donner, Shasta Lake, Banning, Healdsburg, Rancho Cucamonga, Lassen, Lompoc, Corona, Pittsburg, Ukiah, Victorville, Plumas-Sierra, Gridley, Needles, Biggs, Trinity, and Azusa.

Table A-10: POU Annual Electricity Savings Targets with Adjustments (GWh)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
LADWP	255	255	252	320	330	301	297	294	305	317	328	332	323	321	316
SMUD	160	150	160	98	98	97	105	114	116	113	103	94	85	76	67
Imperial	12	13	17	16	16	17	18	18	18	17	17	16	14	12	10
Anaheim	26	25	26	15	16	16	16	17	17	16	16	15	14	13	12
Riverside	21	17	20	21	21	20	19	18	18	16	15	14	13	12	10
Pasadena	17	15	13	13	13	13	13	13	13	12	11	11	10	9	8
Turlock	5	13	13	9	9	10	10	10	10	10	9	8	8	8	8
Santa Clara	12	19	20	13	13	14	15	15	15	13	12	12	11	10	9
Glendale	17	18	12	9	9	9	9	10	10	9	8	8	7	6	6
Burbank	14	12	11	10	10	10	11	11	12	12	12	12	11	11	10
Modesto	14	11	15	9	10	11	12	13	13	14	14	13	12	11	10
Roseville	9	17	8	8	9	9	10	10	10	9	9	8	8	8	7
Palo Alto	6	6	6	8	8	9	9	9	9	8	8	8	8	7	7
Vernon	6	2	4	3	3	3	4	4	3	3	3	3	3	2	2
Redding	2	1	3	3	3	4	4	4	3	3	3	3	3	3	2
San Francisco	2	1	4	3	3	3	3	3	3	2	2	2	2	2	2
Small POUs[142]	19	19	16	13	13	13	13	14	14	13	13	12	11	11	10
All Combined	**597**	**594**	**600**	**571**	**584**	**559**	**568**	**577**	**589**	**587**	**583**	**571**	**543**	**522**	**496**

Source: CMUA, POU Potential and Goals Study, March 2017http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217482_20170508T153251_Appendix_B__20182027_Annual_Targets_All_POUs.xlsx.

142 Small POUs include Colton, Lodi, Merced, Moreno Valley, Alameda, Truckee Donner, Shasta Lake, Banning, Healdsburg, Rancho Cucamonga, Lassen, Lompoc, Corona, Pittsburg, Ukiah, Victorville, Plumas-Sierra, Gridley, Needles, Biggs, Trinity, and Azusa.

Table A-7 depicts the cumulative effect of these proposed adjustments on the original POU projections as submitted in March 2017. Since the annual savings decrease through time (as shown in **Table A-8**), the cumulative numbers add less to the cumulative total in each successive year.

Table A-11: POU Cumulative Electricity Savings Targets With Adjustments (GWh)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
LADWP	255	510	762	1,082	1,412	1,713	2,010	2,304	2,609	2,926	3,254	3,586	3,909	4,230	4,546
SMUD	160	310	470	568	666	763	868	982	1,098	1,211	1,314	1,408	1,493	1,569	1,636
Imperial	12	25	42	58	74	91	109	127	145	162	179	195	209	221	231
Anaheim	26	51	77	92	108	124	140	157	174	190	206	221	235	248	260
Riverside	21	38	58	79	100	120	139	157	175	191	206	220	233	245	255
Pasadena	17	32	45	58	71	84	97	110	123	135	146	157	167	176	184
Turlock	5	18	31	40	49	59	69	79	89	99	108	116	124	132	140
Santa Clara	12	31	51	64	77	91	106	121	136	149	161	173	184	194	203
Glendale	17	35	47	56	65	74	83	93	103	112	120	128	135	141	147
Burbank	14	26	37	47	57	67	78	89	101	113	125	137	148	159	169
Modesto	14	25	40	49	59	70	82	95	108	122	136	149	161	172	182
Roseville	9	26	34	42	51	60	70	80	90	99	108	116	124	132	139
Palo Alto	6	12	18	26	34	43	52	61	70	78	86	94	102	109	116
Vernon	6	8	12	15	18	21	25	29	32	35	38	41	44	46	48
Redding	2	3	6	9	12	16	20	24	27	30	33	36	39	42	44
San Francisco	2	3	7	10	13	16	19	22	25	27	29	31	33	35	37
Small POUs[143]	19	38	54	67	80	93	106	120	134	147	160	172	183	194	204
All Combined	**597**	**1,191**	**1,791**	**2,362**	**2,946**	**3,505**	**4,073**	**4,650**	**5,239**	**5,826**	**6,409**	**6,980**	**7,523**	**8,045**	**8,541**

Source: CMUA, POU Potential and Goals Study, March 2017 http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-06/TN217482_20170508T153251_Appendix_B__20182027_Annual_Targets_All_POUs.xlsx.

143 Small POUs include Colton, Lodi, Merced, Moreno Valley, Alameda, Truckee Donner, Shasta Lake, Banning, Healdsburg, Rancho Cucamonga, Lassen, Lompoc, Corona, Pittsburg, Ukiah, Victorville, Plumas-Sierra, Gridley, Needles, Biggs, Trinity, and Azusa.

Fuel Substitution Programs

Site Energy and Source Greenhouse Gas Emissions

Previous efforts to assess the impacts of fuel substitution programs have introduced two key terms – site and source.[144] *Site* refers to the location of the end user consuming energy to obtain an energy service. *Source* refers to the location(s) of the production or generation of the fuel consumed at the end user's site. In most applications, *site* energy consumption for specific program participants is unambiguous; however, the complexities of electric generation mean that source energy and emissions to provide electric energy to the end user introduce numerous analytic uncertainties. To satisfy the energy savings requirements of PRC 25310(d) (10), the end-use *site* energy consumed for equal energy service delivered must be lower with an electric appliance versus a natural gas appliance. To satisfy the GHG emissions requirement, the site natural gas GHG emissions must exceed the expected electric generation *source* production emissions.[145] Reducing *site* GHG generally implies electric heat pump technologies replacing direct combustion natural gas technologies. Converting energy consumption for electric and natural gas appliances to British thermal units (BTUs) will enable this energy consumption comparison. Reducing *source* GHG emissions means comparing GHG emissions from site natural gas combustion with the GHG emissions characteristics of the electricity resource mix serving the end-use customer. Natural gas end-use *source* GHG emissions are only slightly higher than natural gas *site* GHG emissions and change only with the efficiency of the end-user combustion process.[146] Electric *source* GHG emissions will change through time as the resource mix shifts toward renewable generation and away from generating technologies that produce GHG emissions. Chapter 5 discusses estimated energy savings in electricity and natural gas from fuel substitution programs for 2015 through 2029.

Use of *site* energy as the basis for energy reduction is critical to meet the energy restriction of PRC 25310(d) (10) to require end-user energy savings. An analysis that relied upon a source energy reduction requirement, in the face of a massive shift to renewable generation through time, could mistakenly infer a site energy reduction when only energy consumed in the generation, transmission, and distribution was reduced.

A production simulation model will capture electricity changes in generation, transmission, and distribution losses in the analysis of GHG emission impacts. So, the difference between site and source energy would be captured in this portion of the analysis. Further, a production simulation model explicitly models each hour

144 For example, CPUC D.05-04-051, pp. 16-17. http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/45783.PDF.

145 Natural Resources Defense Council's (NRDC) comments submitted following the January 23, 2017, workshop appear to misunderstand the Framework Paper – both energy savings and projected GHG emission reductions are required by the language of PRC 25310(d)(10).

146 The difference between site and source GHG emissions from end-user consumption is distribution losses. This has historically been estimated at about 2 percent of annual usage.

chronologically so that the projection of electric system emissions will inherently address the specific hours that load would be increased by fuel-substitution impacts and the mix of renewables and GHG-emitting resources that is the least-cost dispatch to satisfy that load increase given an assumed resource mix. The following steps would be needed to estimate net GHG emission reduction requirements:

a) An analysis of the hourly shifts in load from penetration of electricity fuel substitution measures.

b) A production simulation model with proper inputs for performance of renewable generation.

c) A resource mix that accurately matches the end-use customers expected to participate in the fuel substitution program.

Properly constructed, such an analysis would identify how efficient electric heat pump technologies would satisfy the two requirements of PRC 25310(d) (10) in two use cases: (1) replacing existing natural gas appliances and (2) installing electric appliances in new construction.

Interutility Departing Load/Gaining Load Considerations

Historically, the CPUC has been addressing fuel substitution programs where the issues focused on competing interests of SCE and SoCalGas and ultimately resolved them by creating the three-prong test for fuel substitution.[147] The CPUC will continue to have a strong interest in this issue within (PG&E and SDG&E) and between (SCE and SoCalGas, or PG&E versus CCAs) its jurisdictional entities. However, the language of SB 350 as embodied in PRC 25310(d)(10) appears to limit the extent to which fuel substitution programs can be used to satisfy the doubling goal. Further, it is clear that at least some electric-only POUs are interested in fuel-substitution programs in ways they were not two or three decades ago. Since there are five natural gas distribution utilities and more than 50 electric distribution utilities, fuel substitution raises the issue of an IOU natural gas utility losing sales and a wholly separate, financially independent POU electric utility gaining electric sales. Of course, the natural gas utility is expected to lose load through natural gas energy efficiency programs, but unlike traditional energy efficiency programs, fuel substitution causes electric load to increase. When the financial and regulatory issues are confined to a single entity (PG&E, SDG&E, or Palo Alto), a clear-cut assessment is feasible. When two independent organizations are involved – a natural gas utility regulated by the CPUC and an electric utility regulated by its own governing board – then a variety of financial and regulatory complications arise.

147 California Public Utilities Commission. *Energy Efficiency Policy Manual* – Version 5. 2013. Pp. 24-25. See http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/EE_and_Energy_Savings_Assist/EEPolicyManualV5forPDF%20(1).pdf.

Conservation Voltage Reduction

Background and Historical Conservation Voltage Reduction Efforts

Conservation voltage reduction (CVR) is a technique for improving the efficiency of the electrical grid by reducing average voltage on the feeder lines that run from secondary distribution equipment to homes and businesses, saving energy at the point of consumption. By controlling voltage on a distribution circuit to the lower end of the tolerance bands, efficiency benefits can be realized by consumers and the distribution utility. End-user electricity consumption is reduced when certain end-use loads draw less power at lower voltages, and distribution system losses are reduced by the combination of less electricity consumption incurring losses and lower losses per unit of consumption when voltage is regulated in a tighter range. This technology has been around since the 1970s, but is undergoing renewed interest as part of general distribution automation activities.

Utilities implement CVR by installing equipment that seeks to keep voltage in the bottom end of the acceptable range to reduce energy consumption and to avoid high voltage spikes that damage equipment. Sensors detect distribution voltages, and voltage regulation equipment is triggered when voltages exceed preset limits. Several kinds of equipment can be used to control voltage on specific distribution line segments including voltage regulators[148], tap-changing transformers[149], capacitor banks,[150] and dynamic circuit reconfiguration,[151] The benefits from reduced energy consumption (metered end-user usage and distribution losses) and avoided equipment damage through time must exceed the investment and operating costs for CVR to make sense from an economic perspective. CVR is explicitly included within the possible programmatic activities listed in PRC 25310(d) that may be used to satisfy the SB 350 doubling goal.

In the United States, regulations require that voltage be made available to consumers at 120 volts (V) plus or minus 5 percent, yielding a range of 126V to 114V. The key principle of CVR operation is that the standard voltage band between 114 and 126 volts can be compressed via voltage regulation equipment to the lower half (114–120) instead of the upper half (120–126), producing considerable energy savings at low cost and without harm to consumer appliances. Electrical equipment including air conditioning, refrigeration, appliances, and lighting is designed to operate most efficiently at 114V.

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148 A voltage regulator uses electronic or electromechanical devices to control voltage to a constant output level when input voltage fluctuates.

149 A tap changing transformer adjusts the output setting of a step-down transformer to match a preset desired output voltage.

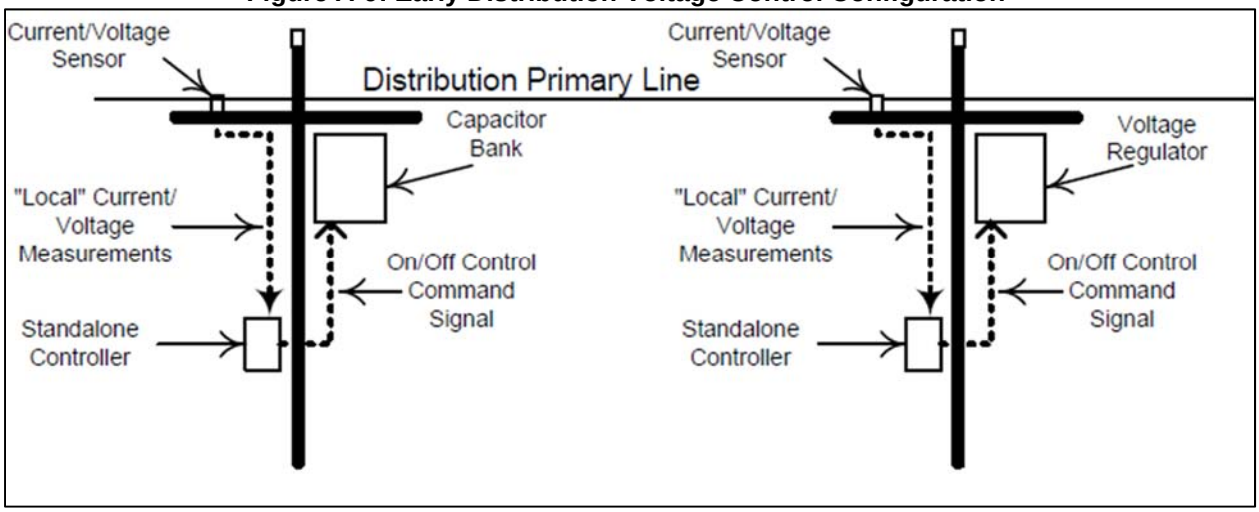
150 A capacity bank rapidly charges or discharges one or capacitors to counteract fluctuating end-use loads and thus keep voltage in a narrower range.

151 Dynamic circuit reconfiguration involves installation of centrally controlled switches that shift which circuit segments are supplied by a specific substation. Voltage is made more uniform by shifting which source supplies fluctuating loads.

Power delivered at higher voltage wastes energy. On feeder lines, voltage on the line gradually decreases as the number of customers (cumulative load) on the line increases, also known as *line drop*. Power is often transmitted at higher voltages to ensure that the voltage at the last house is at least 114V.

CVR was initially popular in the late 1970s and early 1980s as the benefits of this class of distribution equipment were realized. **Figure A-9** (taken from an EPRI Microsoft PowerPoint® presentation)[152] provides a simple schematic of a distribution line segment and the two types of equipment (voltage regulator and capacitor bank) that would respond through preset controllers responding to measured line voltage and current.

Figure A-9: Early Distribution Voltage Control Configuration



Source: EPRI, Uluski PowerPoint presentation, 2011, page 13.

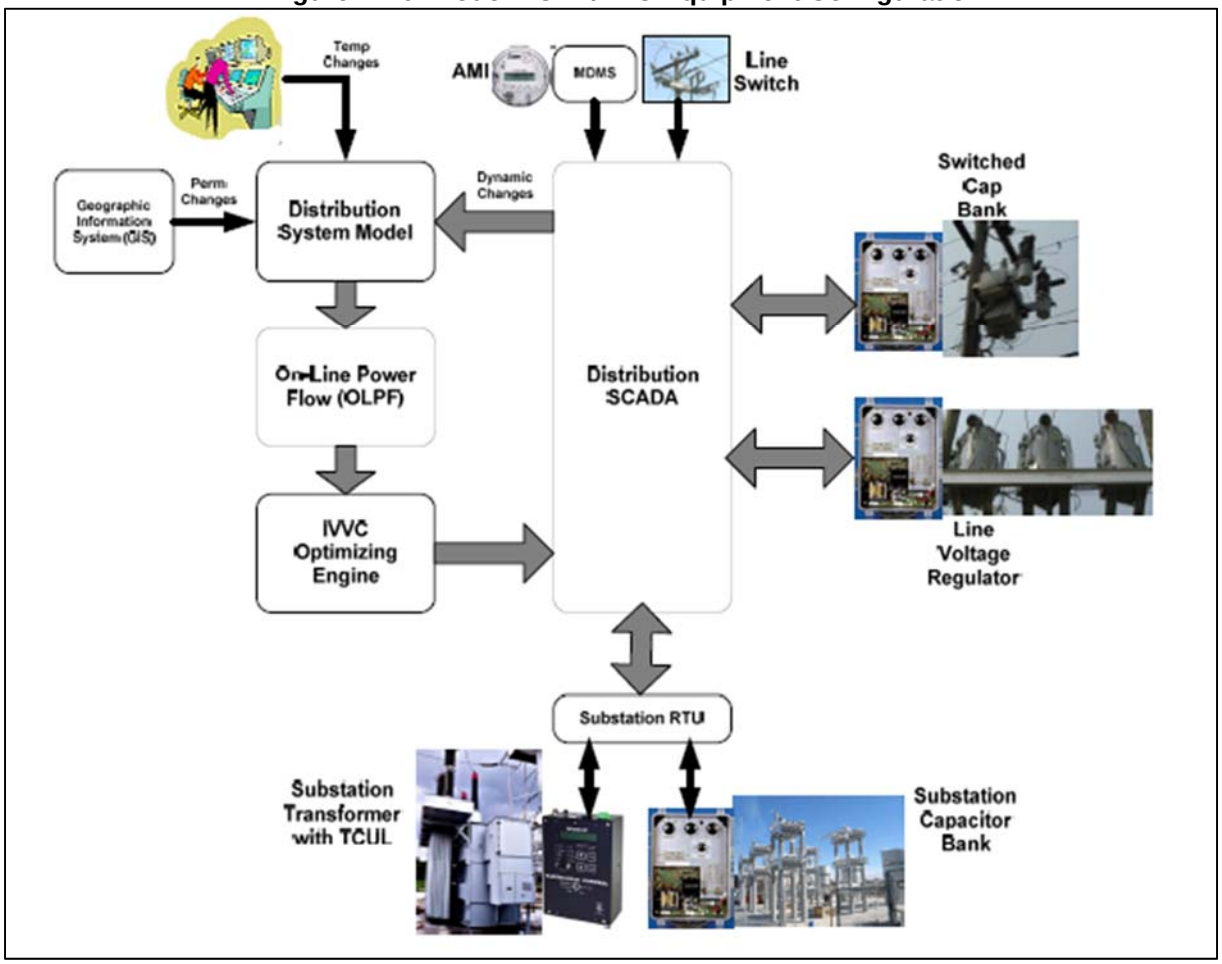
Unfortunately, the limitations of existing equipment at the time were encountered, and only limited penetration took place. The inability to monitor distribution line voltages in real time and to install and operate equipment that responded to dynamic conditions meant that simulations using stylized conditions were used to determine whether net benefits were expected. Of course, this resulted in performance that did not actually match expectations.

Modern CVR Capabilities

Advances in data acquisition capabilities, computer processing, and general sophistication about dynamic, real-time control have fundamentally changed the CVR picture of the 1970s.
Figure A-10 portrays a modern approach to CVR.

152 Electric Power Research Institute, Robert Uluski PowerPoint presentation, "Volt/VAR Control and Optimization Concepts and Issues," 2011.

Figure A-10: Modern CVR/VVO Equipment Configuration



Source: EPRI, Uluski Power Point, 2011, page 33.

Several important changes from **Figure A-10** should be noted. First, a distribution supervisory control and data acquisition (SCADA) system collects real-time, short-interval data about the distribution system and forwards them to a distribution control center for use.[153] This means that control systems can be designed to address near-real-time conditions rather than stylized assumptions. Second, line voltage regulators and switched capacitor banks can respond to signals sent from the distribution control center rather than preset responses to readings from sensors wired to the controller. Third, distribution system models can be developed that integrate readings from many sensors and respond to trends in readings through time (and perhaps anticipated conditions for the near future) to generate signals to send to specific voltage regulators and capacitor banks. In effect, the condition of a large segment of the distribution

153 *Supervisory control and data acquisition* is a control system architecture that uses computers, networked data communications, and graphical user interfaces for high-level process supervisory management. Typically used at the transmission level, it is being implemented for distribution systems.

system can be understood and signals sent in near–real time to optimize overall response to these conditions.

Another issue of growing importance is the need to understand and control reactive power. In recent years, the types of equipment in customer premises have shifted toward items that consume or generate reactive power.[154] Reactive power versus real power imbalances create power quality problems that were less important, and certainly less appreciated, historically. Tighter control over reactive power can expand distribution system capacity to provide real power to end users, thus allowing greater use of existing distribution system capacity and thereby reducing or delaying equipment upgrades. Generally, CVR nomenclature has been replaced by volt-VAR optimization or sometimes CVR/VVO to reflect this interest in reactive power control.[155]

Recent Utility Efforts

Several research/demonstration projects in California utility service areas were funded by DOE through the American Recovery and Reinvestment Act of 2009. Among them are CVR projects at Glendale Water and Power (GWP) and the Sacramento Municipal Utility District (SMUD) that were part of distribution system improvements. Palo Alto undertook a self-funded project specifically oriented to using CVR as an end-user energy savings project.

GWP undertook a pilot project in 2014-15 testing a software product patented by Dominion Voltage, Inc. The software uses AMI data to understand short-time-interval reductions in energy consumption by end users, along with distribution line equipment measurements to determine total energy consumption reductions when various control strategies are implemented.[156] GWP was sufficiently convinced of the merits of CVR/VVO to undertake a full-scale implementation of these technologies on its system. GWP expects to deploy these technologies on 12 kilovolt (kV) feeders serving about one-third of its end-use customers by the end of 2017. Whether CVR/VVO is cost-effective for lower voltage feeders is still being assessed.[157]

SMUD undertook a multifaceted distribution system research project as part of its DOE-funded Smart Sacramento® project. A volt/VAR optimization was part of this effort. In 2011, SMUD assessed how six feeders would respond to triggering of capacitor banks or one of several voltage settings. While SMUD obtained favorable results, there was some

154 Reactive power is a by-product of alternating current systems when voltage and current are not in phase. Reactive power is required to maintain the voltage to deliver active power (watts) through transmission lines.

155 VoltVAR optimization is a process of optimally managing voltage level and reactive power to achieve more efficient grid operation by reducing system losses, peak demand, or energy consumption, or a combination of the three. The efficiency gains are realized primarily from reduction in system voltage.

156 City of Glendale, City Council Agenda, Agreement with Dominion Voltage, Inc., January 28, 2014.

157 GWP representative, personal email, June 1, 2017.

diversity among the circuits. SMUD intended to pursue a larger demonstration to refine the control strategy of the initial demonstration.[158]

Palo Alto's CVR project was designed to examine the impacts of CVR on end-user energy consumption and to determine whether energy savings on the Palo Alto system matched those found on other utility distribution systems.[159] Given some differences of the Palo Alto system from those examined in previous studies, the expected impact of CVR was unclear. A simple engineering study manually assessed impacts on several feeders and confirmed that further reductions of distribution feeder voltage would induce end-user energy savings. According the consultant study, Palo Alto's implementation of CVR on its system may depend partly upon whether there are any energy efficiency mandates for which CVR savings could contribute. Now that SB 350 energy efficiency targets can use CVR as a compliance mechanism, Palo Alto may be interested in pursuing CVR implementation.

PG&E[160] and SCE[161] have pursued similar efforts under various smart grid initiatives that are heavily motivated by distributed energy resource (DER) issues. A principal issue for these IOUs has been development of improved abilities to predict where the existing distribution system can accept DER exports back into the distribution grid. Such exports create voltage and power quality issues affecting other end users on nearby segments of the distribution system, so direction from the CPUC to improve abilities to guide DER development has accelerated interest in modern CVR/VVO systems. Both SCE and PG&E pursued expansion of deployment efforts in recent general rate cases. A settlement agreement scaled back the expansion initially proposed by PG&E for at least the near term,[162] and SCE's general rate case is under review.

158 Energy Commission, *Sacramento Municipal Utility District SCADA Retrofit*, Publication Number: CEC-500-2014-078, September 2014, Appendix A.

159 Plaxico, *Final Report: Evaluation of Conservation Voltage Reduction (CVR) Potential on City of Palo Alto Distribution System – Early Experimental Results*, 2013.

160 PG&E, 2017 General Rate Case Prepared Testimony On Electric Distribution, Exhibit (PG&E-4), pages 13-2, and 13-35 through 13-42, September 2015. See http://pgera.azurewebsites.net/Regulation/ValidateDocAccess?docID=346362.

161 SCE, 2018 General Rate Case Testimony, Transmission & Distribution (T&D) Volume 11 – Grid Technology, Exhibit SCE-02, Vol. 11, September 2016, pages 43-49. See http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/EE6E8ADC1D78B5CF882580210068F916/$FILE/SCE02V11.pdf.

162 Personal communication via email, Simon Baker, February 09, 2017.

APPENDIX B:

APPENDIX B

SB 350

ENERGY SAVINGS POTENTIAL

DEVELOPMENT PLAN

Final Update

Prepared for:

California Energy Commission

Prepared by:

NORESCO

Supported by:

TRC Energy Services

Center for Sustainable Energy

Prepared on:

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Work Authorization 2

Appendix B: Non-utility program Technical assessment

Building standards – Title 24 from 2019[163] through 2029

Program Description:

Title 24 Part 6 (Title 24) is the California Building Energy Efficiency Standards, and covers regulated energy uses in buildings. Title 24 contains the regulations that govern the construction of buildings in California. The code is on a three year cycle, with the most recent implemented version being 2016, effective January 1, 2017. Future versions relevant to this analysis will be 2019, 2022, 2025, 2028, and possibly 2031 (as it relates to early adoption, for example).

Buildings Affected:

- Residential and nonresidential buildings, excluding certain building types and end uses (hospitals, industrial buildings, and non-covered processes, including refrigerated warehouse loads and data center uninterruptible power supply (UPS) power).
- Applies to all cases in which an application for a building permit or renewal of existing permit is filed (new construction, additions, or alterations). Requirements are different for new construction than for additions or alterations to existing buildings.

Methods

Relevant Measures:

- The code covers a wide range of building systems, including: envelope, space conditioning systems, water heating systems, lighting, and certain covered processes.
- Requirements are different for new construction than for additions, alteration or repairs to existing buildings; measure packages will be altered accordingly.

163 The starting year of the analysis depends on Navigant's 2018 Potential and Goals study. Currently, Navigant results are only available through Title 24 2016. However, Navigant is analyzing proposed Title 24 2019 for new construction as part of the 2018 Potential and Goals study.

- For their Potential and Goals Study analyses, Navigant has analyzed a number of measures associated with versions of Title 24 spanning 2005 to 2019 (new construction). Measures have been analyzed both individually and as bundles.
- In general, Title 24 measures can be categorized as follows:
    - Mandatory measures: always required by code for applicable permit scope (e.g., new construction, alteration, and addition).
    - Prescriptive measures: required when using a prescriptive compliance approach, but may be "traded off" for other specified efficiency features through alternative prescriptive pathways. The prescriptive package is the basis for the standard design, which establishes the reference baseline that a proposed building is compared against. Prescriptive measures are used to define performance for savings projections.
    - Compliance options: building components or technologies which can be used in a performance compliance model, but are not required. This list established the range of viable design options for projects utilizing the alternative compliance method (ACM). Because these measures are not required, they do not factor into savings projections.
    - Acceptance tests: may improve compliance rates, and their application may be considered an efficiency measure.

Data Sources:

- Projected IOU savings for 2016 Title 24 will be extracted from the Results Viewer[164] for Navigant's 2015 Potential and Goals Study.
- Projected IOU savings for 2019 Title 24 for new construction will be included in Navigant's 2018 Potential and Goals Study[165]. Navigant will not include estimates of 2022 Title 24 in the 2018 Potential and Goals Study, although preliminary estimates were considered.
- Updated POU targets for 2018-2023 and new POU targets for 2024-2027 will be extracted from the 2017 POU Energy Efficiency Report[166].
- Some recent technical feasibility studies could shed light on the long-term limit for C&S savings, including Arup's 'The Technical Feasibility of Zero Net Energy in

164 Navigant. "2015 Potential & Goals Study." California Public Utilities Commission. May 25, 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452620.

165 Navigant. "2018 Potential & Goals Study." California Public Utilities Commission. May 25, 2017. http://www.cpuc.ca.gov/General.aspx?id=6442452619.

166 "Energy Efficiency in California's Public Power Sector: 11th Edition." Northern California Power Agency. 2017.

California' from 2012[167], and ASHRAE's 'Final Report ASHRAE 1651-RP Development of Maximum Technically Achievable Energy Targets for Commercial Buildings Ultra-Low Energy Use Building Set' from 2015[168].

- The 2016 Impact Analysis Report[169] will be used as a reference point for comparison with Navigant's 2018 PG results (as they become available).
- The 2015 AAEE analysis[170] provides a reference for the scale of POU Building Standards savings compared to that for IOUs.

Methodology:

The NORESCO Team leveraged available data and methodology to the extent possible, most specifically from Navigant's Potential and Goals Studies. Navigant's most recent data included updated estimates for savings associated with 2016 Title 24, as well as new construction estimates for 2019 Title 24, was collected and incorporated. Accordingly, the NORESCO Team was responsible for estimating savings associated with additions and alterations for version 2019 and for new construction, additions, and alterations for version 2022 and beyond. From a methodology standpoint, the research team worked with Navigant to ensure the analysis approach is consistent with that which Navigant has applied and refined through numerous Potential and Goals efforts. Details of Navigant's analysis as they relate to this study include:

- For their Potential and Goals analysis, Navigant has used the Integrated Standards Savings Model (ISSM) developed by CADMUS and DNV GL to estimate net C&S savings attributable to the IOU C&S Program efforts[171].
- The 2015 Potential and Goals Study include savings estimates for 2016 Title 24; estimates were derived via bundled measures (single family new construction, multi-family new construction, non-residential new construction, and other).
- For the 2018 Potential and Goals Study, Navigant's codes and standards measure list indicates that discrete measures were analyzed for versions of Title 24 through 2016 (although only a handful of discrete non-residential addition and alteration measures were analyzed for 2016, whereas a much more comprehensive set of discrete measures was analyzed for 2013), but that 2019

167 Arup. "The Technical Feasibility of Zero Net Energy Buildings in California." PG&E, SCE, SDG&E, and SCGC. December 31, 2012.

168 Glazer, Jason. "Final Report ASHRAE 1651-RP Development of Maximum Technically Achievable Energy Targets for Commercial Buildings Ultra-Low Energy Use Building Set." 2015.

169 Nittler, Ken. "Impact Analysis: 2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings." NORESCO. 2015.

170 California Energy Commission. Additional Achievable Energy Efficiency. December 2015. Available online at http://www.energy.ca.gov/2015_energypolicy/documents/2015-12-17_additional_aee.php .

171 Cadmus, Energy Services Division and DNV GL. Integrated Standards Savings Model (ISSM).

Title 24 for new construction was analyzed exclusively using bundled measures based on program-level savings estimates.

For building additions and alterations, as opposed to new construction, any measure-based savings projections was based on existing condition estimates by building type and climate region. Savings estimates for additions and alterations considered which building type(s) are affected, what triggers to-code updates and what frequency of to-code updates is expected. This is consistent with Navigant's Potential and Goals analysis methodology as it relates to existing building additions and alterations.

It is anticipated that the overall program scope of Title 24 will change over time; to be successful, any approach to projecting savings potential of future program iterations will have to capture this expected progression. For example, expansions or anticipated expansions to Title 24 that have been incorporated or considered in recent years include:

- New covered processes have been added (commercial kitchens, laboratory exhausts, parking garage exhaust, data centers)
- Increased acceptance testing and fault detection and diagnostics have been employed as steps along a path to verify as-designed savings
- Hospitals have been considered for inclusion

Approach:

Phase 1 Approach:

- The research team extracted 2016 Title 24 electricity and natural gas savings projections for California new construction from the Results Viewer for Navigant's 2015 Potential and Goals Study. The Potential and Goals study only captures net attributable savings to IOU C&S Program efforts.
- According to the 2016 Impact Analysis Report, 2016 Title 24 is on the order of 10 percent more stringent than 2013 Title 24. Assuming that Navigant's new construction savings estimates correspond to roughly a 10 percent improvement in the Standard, the research team made the following assumptions to project new construction savings for future code iterations:
    - 2019 Title 24 for new construction will be 10 percent more stringent than 2016 Title 24, resulting in equivalent year-over-year savings starting in year 2020.

- Improvements to Title 24 will slow starting with 2022 Title 24, due to diminishing returns and reduction in available energy reductions associated with increasing the stringency of requirements for currently regulated loads. As Title 24 continues to improve, the gap between best-in-class performance and the minimum requirements of Title 24 is shrinking. The assumption is that Title 24 progression for new construction improved efficiency will slow to 5 percent for 2022 Title 24 and 2025 Title 24, resulting in year-over-year savings that are 50 percent less than what Navigant is projecting for 2016 Title 24.
- As savings opportunities shrink for currently regulated loads, the research team expects the scope of Title 24 to expand to include previously unregulated loads (for example, hospital loads and plug loads). With an expanded scope, the expectation is that Title 24 progression will increase back to 10 percent improvement for the 2028 iteration, increasing year-over-year savings projections back to what Navigant is projecting for 2016 Title 24.
- For each iteration of Title 24, the effective date is the calendar year following the adoption year (for example, 2019 (additions and alterations) Title 24 savings begin to be realized in 2020).

- The 2016 Impact Analysis Report indicates that the magnitude of savings expected due to additions and alterations is roughly equivalent to that which is expected for new construction. Accordingly, the research team made the following assumptions to project addition and alteration savings:
  - 2016 Title 24 year-over-year alteration savings are equivalent to what Navigant is projecting for new construction.
  - Whereas new construction savings are expected to decrease for future iterations due to diminishing returns associated with currently regulated loads, addition and alteration savings are expected to increase. The NORESCO team anticipates that future Title 24 will increase emphasis on realizing addition and alteration savings because the opportunity is so great due to the size of the current building stock compared to the small percentage of new construction that occurs each year. Accordingly, year-over-year savings due to additions and alterations are expected to remain steady through 2019 Title 24, increase by 50 percent through 2025 Title 24, and increase by an additional 50 percent for 2028 Title 24 (such that the year-over-year addition and alteration savings realized by 2028 Title 24 will be double those realized by 2016 Title 24).

- POU-claimed Title 24 savings were estimated by scaling estimates for IOU-claimed savings according to the ratio of POU to IOU Building Standards savings projected by the 2015 AAEE[172].

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: The NORESCO team analyzed residential and nonresidential savings for Title 24 by taking a measure-based energy modeling approach. The methodologies adopted for each building stock (residential and nonresidential) are described as follow in the corresponding sections.

Title 24 Modeling Methodology for Residential Buildings:

This section details the analysis approach for residential modeling (for purposes of this analysis, low-rise residential is considered residential and high-rise residential is considered nonresidential). Because of the State's 2020 Zero Net Energy (ZNE) goal for residential buildings, the NORESCO team assumed that residential new construction savings beyond what is already being projected for the bottom wedge (according to Navigant's 2018 PG analysis) would be negligible; accordingly, residential new construction was not modeled. The project team assumes that subsequent updates to Title 24 residential requirements will focus on enforcing heightened energy efficiency improvements during retrofits.

Generally, the project team applied a measure-based energy modeling approach to project savings attributed to Title 24 code updates, covering additions and alterations for the 2019, and new construction and additions and alterations for 2022, 2025, and 2028 iterations. The measure-based approach estimates what energy efficiency improvements are likely to be implemented in code through 2029 for retrofits, and to determine the corresponding energy savings, the portion of the existing building population that will trigger these code requirements through retrofits.

Application of Previous Urban Footprint[173] Research

To specify a set of energy efficiency measures that align with the long-term performance and jurisdiction of Title 24, the NORESCO team leveraged previous efforts from the Urban Footprint project. The Urban Footprint project estimated energy savings potential for a range of existing residential buildings by simulating four residential prototypes

172 Note that the 2015 AAEE contains savings projections only for SMUD and LADWP amongst the POUs. To scale up to total POU savings from SMUD and LADWP savings, the research team applied the assumption that SMUD and LADWP make up 74.2 percent of POU savings, which aligns with the assumption made by the Energy Commission as part of the Framework analysis.

173 Energy Commission Contract 400-12-003, Work Authorization #15, Urban Footprint Nonresidential Modeling; Energy Commission Contract 400-12-002, Work Authorization #13, Urban Footprint Residential Modeling.

and four vintage combinations, and applying various efficiency upgrade packages to each combination. However, the Urban Footprint energy efficiency packages included upgrades to HVAC and DHW system efficiencies, such as higher SEER and AFUE. These measures fall outside the purview of Title 24; therefore, associated savings were removed from Urban Footprint results so that they could apply to this analysis.

Residential Building Stock and Prototypes

Based on research efforts for the Urban Footprint work, the NORESCO team modeled the 2,100 square foot single family prototype and the eight-unit, two-story, 6,960 square foot low-rise multifamily prototype. The simulation output of these prototypes was then used to adjust the range of Urban Footprint results and characterize the existing building population. The majority of existing building characteristics were derived from the Residential Appliance Saturation Survey (RASS), Appendix B of the Residential Compliance Manual, and other research. The construction and appliance characteristics are categorized into the following vintages; additional details for the building characteristics for each vintage by climate zone are provided in the results workbook.

- Old: 1991 and earlier
- Average: 1992 to 2005
- Newer: 2006 to 2014
- New: 2015 (built to 2013 Title 24)

The "New" vintage is built to 2013 Title 24 because, at the time the Urban Footprint work was done, 2016 Title 24 had not yet gone into effect and no homes were currently on the market built to that standard.

The Urban Footprint work also identified the types of HVAC systems installed throughout California depending on climate zone, based on RASS data. Because each HVAC system has varying energy performance, the Urban Footprint study modeled six different heating and cooling systems for each combination of prototype, vintage, and climate zone. Simulation results were weighted by prevalence of the selected HVAC system to determine an average energy use for each prototype that represents a realistic distribution of system types in existing residential buildings. This is further discussed in the methodology section below.

Existing Buildings Modeling Approach

The Urban Footprint project established baseline building packages, as well as three energy efficiency upgrade packages, which are specific to each climate zone and vintage. For the purposes of the SB 350 project, the NORESCO team used the baseline packages and the maximum efficiency (Max Efficiency) packages to estimate Title 24 savings.

- The baseline package represents the building as it was initially constructed, according to vintage.
- The Max Efficiency package assumes that all building characteristics are upgraded to the highest level of technical and economic feasibility, given real-world constraints. The project team assumed that this package represents the requirements of the 2030 Title 24 residential retrofit code. As mentioned above, the NORESCO team revised the Max Efficiency packaged to exclude efficiency upgrades to HVAC and DHW systems because they are not currently regulated by Title 24. This package is referred to as MaxEff Minus Appliance Efficiency.

The NORESCO team modeled the 2,100 and 6,960 square foot prototypes in four representative climate zones, based on four vintages and one HVAC system type.

The NORESCO team selected climate zones 1, 4, 9, and 14 as the representative climate zones, and results from these climate zones were scaled to the remaining 12 climate zones based on similarities in annual energy use. Climate zones were grouped based on similar annual energy usage by end use, as shown in **Figure B-1** and **Figure B-2** below. Due to differences in annual electricity and natural gas usage between climate zones, the NORESCO team developed two sets groups: one for kWh and one for Therms usage, as shown in **Table B-1**. Then, four climate zones were selected based on the groupings and whether they were close to the average annual kWh or Therms usage for their group.

Figure B-1. Standard Design Annual Electric Usage by Climate Zone for the 2,100 Square Foot Prototype

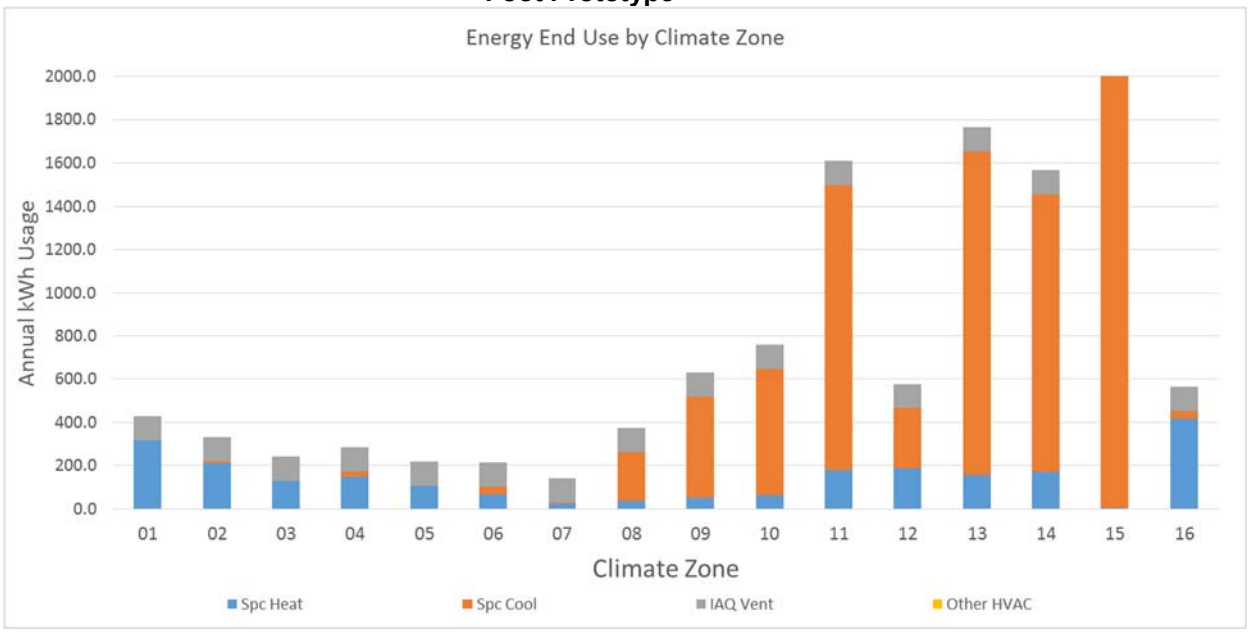

Figure B-2. Standard Design Annual Gas Usage by Climate Zone for the 2,100 Square Foot

Prototype

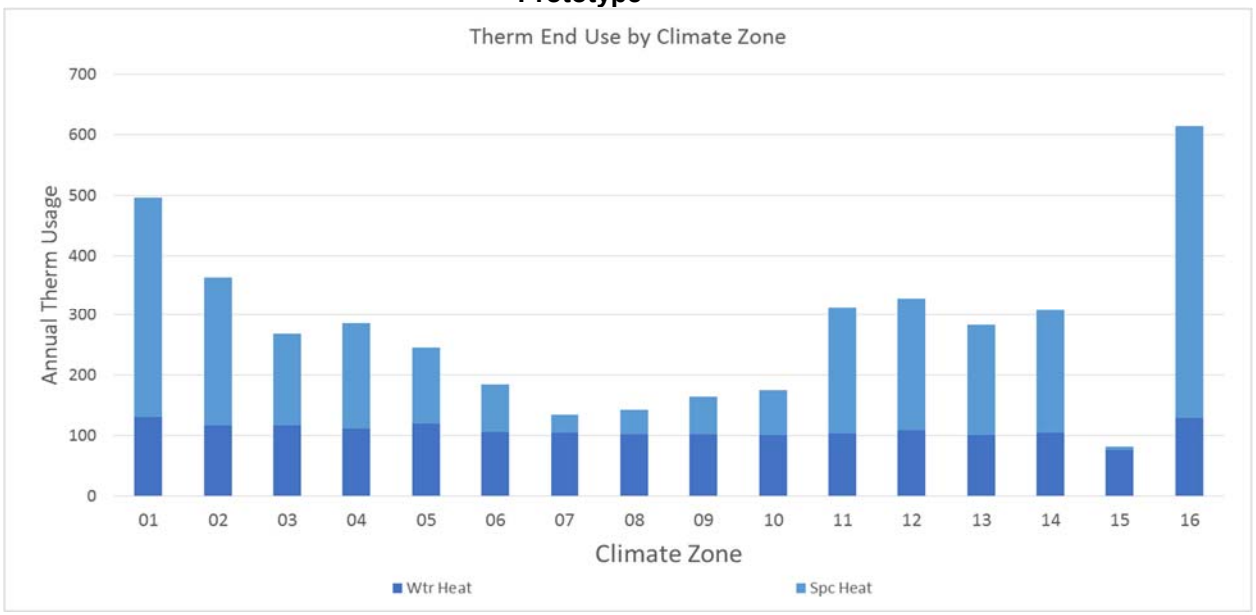
Therm End Use by Climate Zone
Annual Therm Usage
700
600
500
400
300
200
100
0
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
Climate Zone
Wtr Heat
Spc Heat

Table B-1: Climate zone grouping and representative climate zone identification

Group	CZ to model	kWh Group CZs	Therms Group CZs
Group 1	1	1, 2, 3, 5, 7	1, 16
Group 2	4	4, 6, 16	n/a
Group 3	9	8, 9, 10, 12	6, 7, 8, 9, 10, 15
Group 4	14	11, 13, 14, 15	2, 3, 5, 11, 12, 13, 14

For each combination of efficiency package, prototype, and climate zone, the NORESCO team modeled HVAC01 from the six HVAC combinations, as shown in **Table B-2**. The energy use for the remaining HVAC systems was adjusted based on the HVAC01 simulation, according to the type of system and efficiency upgrades in the Urban Footprint Max Efficiency package. For instance, HVAC03 has "No Cooling"; therefore there is no impact to the kWh load for cooling. Once all of the Urban Footprint Max Efficiency annual energy use results were correctly adjusted to remove energy savings from improved equipment efficiencies, the total annual energy consumption for each prototype, in each vintage, and each climate zone was calculated using the weighted average based on the prevalence of each HVAC system, as shown in

Table B-3. The proportion of each HVAC system in each climate zone was developed during the Urban Footprint study.

Table B-2: Residential HVAC system types

HVAC ID	Heating System	Cool System
HVAC01	Central Furnace	Central AC
HVAC02	Central Furnace	Central AC
HVAC03	Central Furnace	No Cooling
HVAC04	Gravity Wall Furnace	PTAC Cooling
HVAC05	Electric Heat	No Cooling
HVAC06	Hydronic Heat	No Cooling

Table B-3: HVAC system type distribution in existing buildings by climate zone

CZ	HVAC01	HVAC02	HVAC03	HVAC04	HVAC05	HVAC06
CZ01	5%	39%	43%	0%	13%	0%
CZ02	25%	47%	13%	2%	11%	2%
CZ03	5%	51%	25%	1%	15%	3%
CZ04	39%	38%	11%	3%	9%	0%
CZ05	7%	63%	12%	0%	17%	0%
CZ06	24%	47%	14%	2%	12%	1%
CZ07	17%	42%	19%	3%	17%	1%
CZ08	33%	32%	18%	7%	8%	1%
CZ09	57%	22%	8%	7%	5%	0%
CZ10	89%	8%	1%	1%	2%	0%
CZ11	89%	5%	1%	4%	1%	0%
CZ12	84%	11%	1%	1%	2%	0%
CZ13	88%	9%	1%	1%	1%	0%
CZ14	84%	10%	2%	3%	1%	0%
CZ15	95%	4%	0%	0%	1%	0%
CZ16	38%	40%	9%	2%	11%	0%

Scaling Simulation Results

To determine the energy use for the climate zones not modeled, the NORESCO team applied the same proportional changes in energy use observed from each simulated climate zones to the other climate zones in its group. In other words, the percent changes in energy use in the simulated climate zones from the Urban Footprint Max Efficiency package to the MaxEff Minus Appliance Efficiency packages were then applied to the other climate zones based on the grouping above.

In the same manner, results from the 2,100 square foot prototype were used to adjust the 2,700 square foot prototype annual energy use results from the Urban Footprint Max Efficiency package. The result is to achieve the annual energy use for three prototypes (2,100 single family, 2,700 single family, and 6,960 multifamily), four

vintages (old, average, newer, new), two packages (MaxEff and MaxEff Minus Appliance Efficiencies), and all sixteen climate zones.

Estimating Energy Savings through 2029

In practice, most residential buildings go through gradual updates as items need to be replaced or remodels or additions occur. It is not realistic to assume that every home built prior to 1991, the Old vintage, will be renovated to perform at the Max Efficiency level by 2022, or even by 2028 Title 24. In order to accurately represent the retrofit market, the analysis approach is to assume that homes are gradually renovated over time. For instance, a portion of Old vintage homes (built in 1991 or prior) may have retrofits that occur such as window upgrades and additional ceiling insulation, that cause the annual energy usage to be equivalent to Average vintage homes (built between 1992 and 2005), and a portion of Old vintage homes will have major renovations that will cause the annual energy usage to be equivalent to the Newer, New or even Max Efficiency home.

An example of the estimated portion of homes built to the Old vintage that are performing at each energy consumption tier (from highest to lowest consumption) through 2029 is shown in the **Table B-4**. The sub columns (Old, Average, Newer, New, and Max Eff) represent the energy consumption packages. In the figure below, 45% of Old vintage homes are assumed to have had no upgrade, while 30% of Old vintage homes have had some minor upgrades that cause them to consume energy equivalent to an Average vintage home. The full details of these assumptions for each vintage and scenarios are provided in Appendix C2.

Table B-4: Retrofit upgrade estimates of homes built to Old vintage construction through 2029

Measure Category	Old Buildings – 2029 Upgrade Profile				
	OLD	AVERAGE	NEWER	NEW	MAX EFF
Residential Existing Building Population in 2017	45%	30%	20%	5%	0%

The energy use for each package was then applied to the appropriate portion of the existing building population by vintage using the percentages above. The analysis developed varying scenarios of energy savings: conservative, reference, and aggressive. As the scenarios become more aggressive, portions of the retrofit market performing in the higher efficiency packages increases. This assumes that code will become more stringent when requirements are triggered and/or on enforcing compliance with retrofit codes; therefore, capturing more of the retrofit population.

Title 24 Modeling Methodology for Nonresidential Buildings:

This document details the planned modeling approach for the nonresidential side.

In general, the goal was to apply a measure-based, energy modeling approach to project savings that can be attributed to Title 24 code improvement, starting with 2019 additions and alterations and covering both new construction and additions and alterations for the 2022, 2025, and 2028 iterations.

Leveraging Urban Footprint[174] Nonresidential Energy Models

The following 15 prototypes are used for establishing energy use baselines. These prototypes were previously developed for the Urban Footprint analysis work for incorporation into the California Building Energy Explorer tool.

- Small School
- Large School
- Small Office
- Medium Office
- Large Office
- Medium Retail
- Large Retail
- Strip Mall
- Grocery Store
- Small Restaurant
- Small Hotel
- Warehouse
- High Rise Apartment
- Refrigerated Warehouse
- Hospital.

Refer to Appendix B1 for more detail on prototype model descriptions applicable to the nonresidential Title 24 analysis.

174 Energy Commission Contract 400-12-003, Work Authorization #15, Urban Footprint Nonresidential Modeling; Energy Commission Contract 400-12-002, Work Authorization #13, Urban Footprint Residential Modeling.

Weather files from the following 16 representative California climate zones were used for the analysis.

Table B-5: Representative Climate Zones

Climate Zone	Representative City
Climate Zone 01	ARCATA_725945
Climate Zone 02	SANTA-ROSA_724957
Climate Zone 03	OAKLAND_724930
Climate Zone 04	SAN-JOSE-REID_724946
Climate Zone 05	SANTA-MARIA_723940
Climate Zone 06	TORRANCE_722955
Climate Zone 07	SAN-DIEGO-LINDBERGH
Climate Zone 08	FULLERTON_722976
Climate Zone 09	BURBANK-GLENDALE_722880
Climate Zone 10	RIVERSIDE_722869
Climate Zone 11	RED-BLUFF_725910
Climate Zone 12	SACRAMENTO-EXECUTIVE_724830
Climate Zone 13	FRESNO_723890
Climate Zone 14	PALMDALE_723820
Climate Zone 15	PALM-SPRINGS-INTL
Climate Zone 16	BLUE-CANYON_725845

Prototype Variation by Vintage:

The prototype buildings described above were modeled in each of the 16 California climate zones. For each prototype and climate zone combination, four individual vintages were modeled (1980s, 1990s, 2000s, and 2016) to account for typical variations in building design and systems according to age.

- 2016 vintage: represents new construction complying with the 2016 Title 24 code.
- 2000 vintage: represents buildings built during the 2000- era (reference year 2006).
- 1990 vintage: represents buildings built during the 1990- era (reference year 1992).
- 1980 vintage: represents buildings built prior to 1990 (reference year 1982).

The exception is the Refrigerated Warehouse, which has only two vintages (2013 and pre-code) because refrigerated warehouses only entered the purview of Title 24 in 2008. Title 24 of the relevant year has been used as the basis for determining values for building parameters.

For each of the above vintages, building parameters were varied for envelope, lighting efficiencies, lighting control, HVAC system type, HVAC system efficiencies, HVAC system controls, service hot water efficiencies, and exterior light efficiencies. The models were simulated in Energy Plus v8.1.0.

Refer to Appendix B2 for more detail on prototype vintage data applicable to the nonresidential Title 24 analysis.

Baseline Model Calibration:

As part of the Urban Footprint analysis work, the baseline prototype site EUIs were compared against published commercial building EUI data for the existing building stock. Data from CEUS and Energy Star Portfolio Manager were used for this comparison. The **Table B-6** shows the building identifiers for this project and the corresponding buildings from CEUS and Energy Star Portfolio Manager.

Table B-6: UF Prototype Mapping with CEUS and Energy Star Building Types

Prototype Mapping		
UF-Prototype	CEUS Building Type	Energy Star Building Type
Small Office	Small Office	*Not Available*
Medium Office	Small Office	Office
Large Office	Large Office	Office
Medical Office	*Not Available*	Medical Office
Retail Medium	Retail	Retail Store
Retail- GF of Mixed use	*Not Available*	*Not Available*
Strip Mall	*Not Available*	Strip Mall
Large Retail	*Not Available*	Supermarket/Grocery Store
Grocery Store	Grocery	Supermarket/Grocery Store
Small School	School	K-12 School
Large School	School	K-12 School
Small Restaurant	Restaurant	Fast Food Restaurant

Large Restaurant	*Not Available*	Restaurant
Small Hotel	Lodging	Hotel
Warehouse	Warehouse	Non-Refrig. Warehouse
Refrigerated Warehouse	Refrig. Warehouse	Refrig. Warehouse
HR Apartment	*Not Available*	Multi-family Housing
Parking Garage	*Not Available*	Parking
Hospital	Health	Hospital
Gas Station Convenience Store	*Not Available*	Convenience Store w Gas Station

Initial Site EUI results from simulations were compared against CEUS and Energy Star Portfolio manager EUI's. Prototypes that require further calibration to fit the CEUS and Energy Star reported EUIs were identified. For these prototypes modeled inputs were compared against CEUS data to determine modeling updates required for the prototype buildings.

Summarizes the site EUI ranges of the calibrated models across all climate zones and existing building vintages. CEUS and Energy Star EUIs are also included for comparison.

Table B-7: Site EUI range for all California climates across all vintages

UF-Prototype	CEUS EUI (kBtu/sf)	Energy Star EUI (kBtu/sf)	Urban Footprint EUI (kBtu/sf)	
			Min	*Max*
Small Office	55	-	35	66
Medium Office	55	67	33	65
Large Office	82	67	39	66
Retail Medium	53	47	37	114
Strip Mall	-	94	51	138
Large Retail	-	186	97	258
Grocery Store	168	186	123	198
Small School	41	58	35	95
Large School	41	58	36	78
Small Restaurant	-	224	165	223
Small Hotel	84	73	37	88
Warehouse	18	29	14	48
HR Apartment	-	79	40	75
Refrigerated Warehouse	74	253	249	296
Hospital	142	197	90	148

Defining Long-Term Performance

To specify a set of energy efficiency measures that align with the long-term performance and jurisdiction of Title 24, the NORESCO team leveraged relevant technical feasibility studies, including:

- Arup's 'The Technical Feasibility of Zero Net Energy in California' from 2012[175],
- ASHRAE's 'Final Report ASHRAE 1651-RP Development of Maximum Technically Achievable Energy Targets for Commercial Buildings Ultra-Low Energy Use Building Set' from 2015[176].

175 Arup. "The Technical Feasibility of Zero Net Energy Buildings in California," 2012.

176 Glazer, Jason. "Final Report ASHRAE 1651-RP Development of Maximum Technically Achievable Energy Targets for Commercial Buildings Ultra-Low Energy U se Building Set," 2015.

Where key end-uses fall outside the limits of current jurisdiction, the NORESCO team explored more aggressive scenarios that assume expansion of jurisdiction would be implemented to achieve the ZNE goal; areas for potential expansion that were incorporated into the analysis include plug load controls and refrigeration loads.

Characterizing the California Nonresidential Building Stock

The scope of the analysis includes a set of prototype models that represent the IEPR building types. Within each building type, multiple vintages were utilized to appropriately capture the variation in building efficiency levels that exists within the California nonresidential building stock. For each building type, the following existing building vintages were analyzed: (1) 1980s vintage; (2) 1990s vintage; (3) 2000s vintage, and (4) 2016 new construction vintage. The distribution of square footage across the combinations of vintage and climate zone were determined for each building type using the IEPR building stock data set.

The starting points for the vintages for each building type was the set of models previously developed for the Urban Footprint modeling analysis and approved by the Energy Commission. Refer to Appendix B3 for more detail on how the NORESCO team mapped the 15 Urban Footprint prototypes to the IEPR building types.

Where multiple prototypes map to a single IEPR building type, floor area weighting factors have been applied as per the 2016 Impact Analysis Report[177]. As part of the Urban Footprint analysis, key modeling inputs (plug load equipment density, exterior lighting power, etc.) were adjusted from typical baseline values to better align with CBECS and CEUS data; the prototypes utilized for this analysis reflect those adjustments.

2029 Energy Efficiency Measures

For the nonresidential analysis, the NORESCO team applied a set of energy efficiency measures representing the anticipated level of building performance to be mandated by Title 24 by the end of 2029. Because the 2028 iteration of Title 24 will be the last iteration of the code prior to the end of the SB 350 analysis period, the applied measure package aligns with the NORESCO team's expectations for 2028 requirements. In general, the NORESCO team expects Title 24 2028 requirements to align with pre-established 2030 ZNE goals. Note however that potential ZNE measures must be filtered to include only those measures that are expected to align with Title 24 jurisdiction. The NORESCO team has selected 2029 energy efficiency measures according to the following criteria:

- Currently part of code that is likely to persist or become more stringent

177 NORESCO; Nittler, Ken. "Impact Analysis: 2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings," 2015.

- Not currently in code but likely to be added to code by 2028
- No or minimal overlap with Title 20 and Federal Appliances Standards
- Applicability to a particular building type and/or climate zone

While certain measures are much less likely to be implemented in a retrofit scenario than in a new construction scenario (for example, increasing exterior wall insulation), the same set of measures defines the technical potential for both existing buildings and new construction. The likelihood of adoption by scenario will be used to scale savings in post-processing. Refer to Appendix B2 for more detail on the 2029 measure package that the NORESCO team selected for analysis. Measures are grouped into packages according to how they were applied to the prototype models. Relevant input parameters and associated references are included.

New Construction Modeling Approach

To account for new construction savings for the 2022, 2025, and 2028 iterations of Title 24 for each of the IEPR building types, the NORESCO team compared the performance of minimally-compliant Title 24 2016 models (2016 new construction vintage) to the performance of those same models with the 2029 code-representative efficiency measures packages applied.

Scope:

- Climate zones: All 16 California Climate Zones (CZs)
- Prototypes: All 15 Urban Footprint prototypes
- Building Vintages: 2016 new construction

Baseline Models:

Minimally-compliant Title 24 2016 model for each combination of prototype and climate zone

Proposed Models:

2029 energy efficiency measure packages, applied both individually and as a group

For each combination of prototype and climate zone, the difference in performance between the baseline case and the case with all 2029 energy efficiency measure packages applied represents the overall projected progression of the Title 24 new construction requirements between the 2016 and 2028 iterations of Title 24. The NORESCO team then estimated what portion of that overall progression would likely be attributed to each of the intermittent iterations of the code. Combining the expected performance progression by iteration with IEPR projections for new construction by building type through 2029 enabled the NORESCO team to project annual electricity and gas savings from 2017 through 2029. To isolate the savings during this analysis period

that are attributable to the 2022, 2025, and 2028 iterations, the NORESCO team subtracted out incremental savings reported by Navigant for earlier code vintages. Subtracted savings include those that Navigant has attributed to the 2016 additions and alterations, and older vintages of new construction and additions and alterations; the source of these savings is the 2018 Potential and Goals Results Viewer[178].

Separately modeling each package is a forward-facing strategy that will enable savings estimates to be adjusted (without the need for additional modeling) according to new assumptions for 2029 performance thresholds at the measure package level. For example, if it is later determined that the NORESCO team's assumptions for 2029 interior lighting LPDs are too aggressive, lighting savings could be scaled back accordingly and then recombined with the savings attributed to other measure packages. The details regarding how this adjustment would be made will be explored in greater detail in the subsequent section on existing building modeling.

Existing Buildings Modeling Approach

The approach for existing building modeling combines: (1) the application of the simulation techniques detailed in the previous section to an expanded set of baseline models with (2) a post-processing step that enables savings estimates to be based on realistic predictions for the state of the California nonresidential building stock at the beginning (January 1, 2017, when Title 24 2016 requirements went into effect) and end (December 31, 2029) of the relevant analysis period.

Scope:

- Climate zones: All 16 California CZs
- Prototypes: All 15 Urban Footprint prototypes
- Building Vintages: 1980s, 1990s and 2000s, and 2016 new construction

Baseline model:

- The baseline models for the 1980s, 1990s, and 2000s vintages were extracted directly from the Urban Footprint analysis without additional modification. The 2016 new construction baseline was the same minimally-compliant Title 24 2016 model that served as the baseline for new construction modeling
- For each vintage, each combination of prototype and climate zone was modeled

Proposed model:

178 California Public Utilities Commission. "2018 Potential & Goals Study." June 2017. Available online at http://www.cpuc.ca.gov/General.aspx?id=6442452619.

- 2029 energy efficiency measure packages, applied both individually and as a group

For each combination of prototype, climate zone, and vintage, the difference in performance between the baseline case and the case with all 2029 energy efficiency measure packages applied represents the potential for cost-effective improvement through renovation between when the building was originally constructed and 2029.

Title 24 Data Post-processing for Residential and Nonresidential Buildings:

To account for the fact that existing buildings improve gradually over time through cyclical renovation, the NORESCO team developed a set of equipment turnover rates for each building vintage[179]. Turnover rates are specific to measure category and are based on the estimated useful life for equipment. Additional reduction factors were applied to turnover rates to account for: (1) the fact that equipment (especially envelope constructions) often remains in service well beyond its estimated life, and (2) the fact that newer buildings are less likely to upgrade equipment than older buildings (for example, a 45-year old HVAC system is much more likely to be replaced than a 5-year old HVAC system).

The final equipment turnover rates were applied to each vintage to predict reasonable starting (January 1, 2017) and ending points (December 31, 2029) for each building vintage. Appendix B4 contains the turnover rates for each combination of building vintage and efficiency measure category as well as the resulting inputs that define the starting and ending performance levels for each building vintage.

Savings for each combination of building type, vintage, and climate zone were calculated by tracking the area-weighted performance improvement defined by the starting and ending tables in Appendix B4. To determine the energy savings associated with progression from one performance level to the next, the NORESCO team subtracted the total potential savings (associated with improving to the 2029 measure package) for the newer vintage from that for the older vintage. For example, the savings associated with improving from 1980-level performance to 1990-level performance is the difference in potential between (1) improving from 1980-level performance to 2029-level performance, and (2) improving from 1990-level performance to 2029-level performance.

Savings were computed separately for each measure category and then summed to whole-building totals using interaction factors that were calculated by comparing

179 This approach applied to the nonresidential analysis. For the residential analysis, engineering judgment was applied to directly specify building portfolio performance levels at the starting and ending points of the analysis. The NORESCO team views both approaches as valid: while the turnover rate approach is more traceable, the manual approach allows for greater flexibility.

savings associated with application of the total set of measure packages to the sum of the savings for each individual measure package.

For each combination of building type, vintage, and climate zone, per square foot electricity and natural gas savings were calculated according to this approach and then multiplied by the appropriate square footage (obtained from the IEPR data set) to obtain total energy savings. All savings were then summed and distributed across individual years according to assumptions regarding the progression of code performance over time.

Once annual cumulative savings were calculated, they were adjusted in two ways:

- A Net-to-Gross factor was calculated according to the methodology established in the 2013-2015 Codes & Standards Integrated Standards Savings Model (ISSM)[180].
- Relevant savings from Navigant's 2018 PG study[178] were subtracted from the totals. For new construction, this includes Title 24 new construction savings prior to 2016 (because the analysis measured progression between the 2016 and 2028 code vintages). For existing buildings, this includes all previous and future vintages for each Navigant's study captures addition and alteration savings.

Refer to Appendix B5 and C3 for more detail on the post-processing approach for nonresidential and residential buildings, respectively.

Scenario-based Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

Reference Case: The reference case assumed typical equipment turnover rates for estimating addition and alteration savings. See Appendix B4 for details on turnover rates. Because the methodology for calculating new construction savings is well-established, scenarios only account for adjustments to addition and alteration savings.

Conservative Case: For the conservative case, the NORESCO team assumed a 10 percent reduction in equipment turnover rates compared to the reference case. Because the methodology for calculating new construction savings is well-established, scenarios only account for adjustments to addition and alteration savings.

Aggressive Case: For the aggressive case, the NORESCO team assumed a 30 percent increase in equipment turnover rates compared to the reference case. Because the methodology for calculating new construction savings is well-established, scenarios only account for adjustments to addition and alteration savings.

Results:

The Title 24 modeling analysis was designed for maximum flexibility. Because the actual modeling runs capture the maximum possible (code-claimable) savings for each combination of building type, vintage, climate zone, and measure category, any potential update (with the exception of exploring performance levels beyond what the NORESCO team deemed technically and economically feasible) can be made using the post-processing workbooks. Potential supported updates would include: (1) accounting for updated IEPR data; (2) revising equipment turnover rates; (3) revising program NTG

180 https://pda.energydataweb.com/#/documents/1322/view.

ratio; (4) incorporating new Potential and Goals data, or (5) manually adjusting portfolio assumptions for analysis starting and ending points (bypassing turnover rates).

Table B-8: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for Building Energy Efficiency Standards

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	-	-	157	398	651	1060	1597	2122	2697	3275	3861	4507	5153	5801	6638
NG (MM therms)	0.0	0.0	22	46	70	101	138	175	213	251	289	328	366	405	445

Source: California Energy Commission staff.

Appliance Regulations – Title 20 from 2018[181] through 2029

Program Description:

Title 20, known as the California Appliance Efficiency Regulations, contains the efficiency standards that establish the minimum performance for listed appliances to be sold or offered for sale in California. The code includes performance and design requirements for the energy and water use of appliances. The California Energy Commission, which develops and implements Title 20, is not required to update the code on any specific interval; individual standards are updated upon receiving sufficient data to support new or amended efficiency standards or test procedures for individual appliances. The scope of Title 20 is limited by federal appliance standards developed or implemented by the U.S. Department of Energy (DOE) under the Energy Policy and Conservation Act of 1975 and its amendments. The federal appliance statute states that no individual state can adopt appliance standards for products for which there is a national standard, with some specific exceptions for individual appliances or situations, or upon grant of a waiver of preemption on a specific appliance to an individual state. Therefore, Title 20 can generally only regulate appliances outside the scope of DOE appliance standards.

181 The starting year of the analysis depends on Navigant's 2018 Potential and Goals study. The starting year is 2015, but no savings is anticipated in the middle wedge until 2017 and increasing as the Navigant PG model tapers off to 2024.

Buildings Affected:

Title 20 appliance standards indirectly affect all building types if the regulated appliance or product is installed or used within a building; the standards extend beyond the building into personal electronics and other devices that are not hard wired into a structure. These standards are implemented at the manufacturing stage and impact any market sector where the products are installed or used. Building markets affected include any in which a regulated appliance or product will be installed or used and consume energy, this includes:

- Residential and nonresidential.
- New construction and additions, alterations, and repairs. New equipment in an addition, alteration or repair will be affected.
- Private and public buildings

Methods

Relevant Measures:

Title 20 standards apply to most appliances, equipment, luminaires, and miscellaneous load products, such as televisions, used in all types of buildings. The code covers a wide range of consumer and commercial products. This study will analyze and estimate impacts to California statewide energy consumption through 2029 due to future Title 20 standards based on available data, limitations imposed by federal preemption, and accounting for overlap with measures included in the 2015 and 2018 Potential and Goals Studies.

The analysis will investigate possible new standards for appliances and products which have not been previously regulated, as well as updates to existing standards where technological advancements, reduced costs, or improved test standards make it feasible to increase the stringency of a standard. Potential opportunities include establishing indoor luminaire standards for products that are not currently regulated under Title 20 or federal standards, and updates to computers and computer systems standards, which the Energy Commission recently adopted in 2016, due to technological advancements that may allow for an update from now through 2029.

Additionally, there are measures worth evaluating for standard development that are either emerging technologies or do not have a clear measure path at this time. The large scale adoption of Internet of Things (IoT) and computerized building systems and controls, such as Building Automation Systems (BAS) and monitoring panels for building systems, has a significant upside in being able to monitor building energy use and respond to energy market signals for improved grid harmonization. However, the introduction and potential widespread implementation of these tools introduce a constant load for buildings that has not historically been present. There are many

devices in the building that are providing status or monitoring information and enabling wired or wireless communication in the building systems that often have a continuous load on the electrical system, regardless of equipment operation status. Therefore, there is opportunity to regulate the amount of energy these tools can consume while they are helping manage total building energy use.

Data Sources:

This study will use projected savings from individual measures that Navigant has not currently included in the 2018 Potential and Goals calculations. For measures that are not currently in Title 20 planning (and in the future measures list) the impact of various measures may be difficult to collect. Data sources to identify potential measures and energy saving estimates include:

- The Appliance Standards Awareness Project (ASAP) report "Next Generation Standards: How the National Energy Efficiency Standards Program Can Continue to Drive Energy, Economic, and Environmental Benefits."[182]
- ENERGY STAR® and other voluntary standard and specification product databases.
- California Investor Owned Utility (IOU) and other utility-sponsored incentive programs for specific appliance installations.
- Additional information for measures not covered in the bottom wedge may be available from Navigant or through simplified market review of the possible measures.
- Discussions with IOU Codes and Standards program staff and their consultants working on Title 20 efforts.
- Shipment or installation data from manufacturing industry representatives, such as NEMA, or U.S. imports data.
- U.S. DOE Test Standards, which provide the opportunity to establish an appliance performance standard.

Methodology:

The NORESCO team used available research to provide reasonable energy savings estimates for future Title 20 measures. Research was based on the data sources listed above and any applicable data from 2018 Potential and Goals documents.

182 deLaski, Andrew, et. al., "Next Generation Standards: How the National Energy Efficiency Standards Program Can Continue to Drive Energy, Economic, and Environmental Benefits", ASAP, Washington DC, 2016. Available online at https://appliance-standards.org/sites/default/files/Next%20Gen%20Report%20Final_1.pdf.

Approach:

Phase 1 Approach: Phase 1 establishes a high-level, top-down savings estimate for future Title 20 updates. For this phase, the NORESCO team assumed that annual incremental savings decrease over time as appliance standards become increasingly more stringent, reducing available energy performance improvements, and opportunities for new standards decrease. The analysis used the following assumptions:

- Savings returns per unit of new appliance standards for currently regulated appliances decrease for each iteration as standards become more efficient, and incremental savings reduce (with the exception of some appliances where major technological innovations may greatly reduce energy consumption).
- Navigant 2018 PG Title 20 incremental savings end in 2024 (no new standards considered beyond 2024, although savings due to standards implemented through 2024 persist into later years). Accordingly, savings attributed to standards projected to be implemented after 2024 would fall into the middle wedge.
- Navigant's 2018 PG analysis considers interactive effects for electricity and natural gas due to adopted measures. In their analysis, natural gas savings are negative in some years due to an increase in heating load as certain electrical loads in a building decrease due to Title 20 standards effective in those years. A reduction in cooling is also included in the interactive effects for these measures, when applicable. There is a stabilization of natural gas savings moving forward due to a combination of electrical and natural gas savings opportunities in Title 20 appliances, and the general move toward electrification in the future.
- New Title 20 savings opportunities will occur at the same rate as historical trends[183].

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: The NORESCO team developed a list of potential Title 20 measures that are viable for development and inclusion into the Title 20 standards through 2029. This included any known measures that are identified by Navigant but not included in the 2018 Potential and Goals study, any known or expected long-term future measures that are in guiding documents from the Energy Commission or other sources, and additional measure opportunities identified from data collection and discussion with IOU Codes and Standards Staff. The NORESCO team made minor updates to the analysis approach as follows:

183 There is no required schedule or review of Title 20 standards; therefore, the NORESCO team used historical trends to estimate the rate of adopted standards.

- The NORESCO team used a bottom-up approach to determine the savings potential for viable Title 20 standards, based on currently available studies and discussion with members from ASAP and the California IOU Statewide Codes and Standards team, both of which are looking into future appliance standards at each level: federal and state.
- Due to time and resource constraints, the NORESCO team did not reach out to individual contacts within the market sectors for individual measures. Instead, the NORESCO team relied on current analyses and studies, as well as information that the Energy Commission provided regarding expected rulemakings.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

Reference Case: The reference case assumes that the Energy Commission will adopt updates to current Title 20 standards, where feasible, and will also adopt new standards for currently unregulated appliances and products, with consideration of federal preemption. The compliance factor, which represents the proportion of the market that will comply with the standard at the time it goes into effect, is set at 85 percent in alignment with Navigant's assumption. This equates to an average new standard adoption rate of approximately 1 new standard every two years.

Conservative Case: In the conservative case, the NORESCO team assumes that the Energy Commission will adopt updates to current Title 20 standards where feasible, and will adopt new standards for currently unregulated appliances and products for which they have indicated interest, as shown on the Energy Commission Pre-Rulemaking Title 20 docket. The compliance factor is set at 85 percent in alignment with Navigant's assumptions. This equates to an average new standard adoption rate of approximately 1 new standard every four years.

Aggressive Case: The aggressive case assumes that the Energy Commission will adopt updates to current Title 20 standards where feasible, and will also adopt new standards for currently unregulated appliances and products, with consideration to federal preemption. The compliance factor is set at 100 percent as requested by the Energy Commission.

Results:

The results show that Title 20 standards have significant savings potential through 2029 due to rapidly improving technology efficiencies and reduced costs for more efficient products. The savings estimates are based on the "max tech" at the time of the most recent rulemaking, which is the maximum feasible energy efficiency level for products at the time of the analysis or previous rulemaking. With rapid improvements in technology and efficiency, this analysis as well as ASAP's analysis assumes that the max

tech at the time of the last rulemaking for some products will be surpassed in the market by the time of the next rulemaking. The realization of these savings is dependable due to funding for research and standard development process from the California Statewide IOU Codes and Standards team.

The associated Program Data Analysis workbook provides detail on the analysis results and scenarios comparison for this program. As seen in the workbook, the analysis uses the following assumptions:

- Annual installation rates and naturally occurring market adoption (NOMAD) remain static over the life of the standard in this analysis, which aligns with ASAP's methodology (2016). The rationale being that actual installation rates and NOMAD would both likely increases over time, which counteracts each other in claimable savings. For the purposes of the analysis, the two factors are assumed to directly cancel out each other remain constant year over year.
- Consistent with ASAP's methodology (2016) NOMAD is 10 percent for products which do not have an ENERGY STAR® specification, and 25 percent for those that do.
- Savings begin to accrue for a standard based on the noted effective date; the annual installations are also based on the effective date.
- For products that neither the Energy Commission nor DOE currently regulate, but both have stated interest in developing a standard, this analysis assumes the product will fall under the purview of Title 20.
- For each year, the estimated savings reflect installations for all products effective that year, as well as savings from products installed the year(s) prior. Saving from prior installations are included because energy savings will occur in each year the product or appliance is in use, regardless if it is the same product or a replacement meeting the same energy performance criteria. An applicable decay rate is applied to the savings to reflect diminishing performance over time. National annual installations were scaled to California sales based on population; California represents 12 percent of the nation's population. Although scaling by population may introduce error in the market impact for certain products, it is the best estimate available for the purposes of this analysis. If a better estimate was available, such as through a Title 20 Codes and Standards Enhancement (CASE) report for an individual measure, it was used.

Table B-9: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for Appliance Efficiency Regulations

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029

Elec (GWh)	0.0	0.0	0.0	0.0	0.0	307	766	1,226	1,685	2,596	3,525	4,455	5,918	7,382	8,875
NG (MM therms)	-	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1

Source: California Energy Commission staff.

FEDERAL APPLIANCE STANDARDS FROM 2019[184] THROUGH 2029

Program Description:

Under U.S. legislation, starting with the Energy Policy and Conservation Act (EPCA) of 1975, the U.S. Department of Energy (DOE) is directed to develop and update energy efficiency standards and test procedures for certain appliances, equipment, lighting, and consumer products. The federal standards set the minimum energy efficiency requirement for products. The DOE is required by Congressional legislation to review each standard at least once every six years for potential revisions, and to set appliance efficiency standards at levels that achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified[185]. DOE establishes and updates the standards according to the deadlines established in the federal appliance statute, on a rolling basis. The national standards program currently covers the energy requirements of 60 categories of products.

Buildings Affected:

Federal appliance standards are not unique or specific to any particular building type. These standards are implemented at the manufacturing stage and impact any market sector where the products are installed or used. Building markets affected include:

Residential and nonresidential

New construction and additions, alterations, and repairs. New equipment in an addition, alteration or repair will be affected.

Private and public buildings

Methods

Relevant Measures:

184 The starting year of the analysis depends on Navigant's 2018 Potential and Goals study.

185 U.S. Department of Energy. "Federal Appliance Standards." Accessed in May 2017. Available online at: https://energy.gov/savings/federal-appliance-standards

Federal appliance standards apply to most appliances, equipment, and lighting products used in most building types, and some consumer products not designated to any particular building sector, such as external power supplies and battery chargers. Potential appliances and products for this analysis fall into the following two categories:

- Those that currently have a federal appliance standard in place. These appliance standards could be updated during DOE's mandatory review process if there are technology improvements, cost reductions, or other updates that allow a more stringent standard to be adopted.
- Those that are not currently regulated under DOE appliance standards either because they are outside the scope of current standards or are new technologies.

Current federal standards cover, but are not limited to, the following technology categories:

- Residential, nonresidential, and industrial heating and air conditioning systems
- Residential and nonresidential water heating
- Consumer Electronics, including:
    - Battery chargers
- Microwave ovens
- Residential and/or nonresidential appliances, including:
    - Clothes washer and dryer
    - Dishwasher
    - Ceiling fans
    - Refrigerators and freezers
- Lamps and ballasts used in residential and nonresidential installations (to a limited scope)

Additional measures that will be investigated for energy savings potential include:

Establishing or improving test standards that will allow for adoption or improvement of an appliance standard.

Lighting products and other appliances not currently covered in federal standards, such as set-top boxes and commercial dryers.[186]

186 When products or appliances are not currently regulated under either federal or Title 20 standards, both DOE and CEC may have interest in adopting a new standard. For the purpose of this analysis, the NORESCO

Emerging technologies.

Voluntary standards, specifications, and test procedures that can inform mandatory standards, such as ENERGY STAR and WaterSense, and industry standards such as ASHRAE, NEMA, AHRI, or IAPMO.

Connected products through the Internet of Things and building networks.

Improved compliance and enforcement of standards by DOE.

Federal appliance standards also cover water conservation measures, including those for faucets, showerheads, and water closets. However, due to DOE's failure to update these standards by the deadline set in statute, states are no longer preempted from setting more stringent standards for these products.[187] Therefore, savings potential from these products is being considered under Title 20.

For each expected new or updated standard, the baseline will be the energy performance of the previous appliance standard or, for new appliance standards, the market standard performance. The DOE is required to review appliance standards at least once every six years from the prior adoption date, but each standard is on its own unique schedule; that is, standards are not all updated simultaneously.

Data Sources:

This analysis relied on several data sources to identify future updates to current standards and potential new standards. A primary data source to identify known and adopted standards will be the 2018 Navigant Potential and Goals (PG) study.

Additionally, the following data sources were used to identify current standards, potential future updates to current standards, and potential new standards for appliances not yet regulated by DOE:

Data Source	Expected Use	Phase
U.S. DOE Building Technology Office (BTO) Multi-Year Program Plan: Fiscal Years 2016-2020	High level savings goals due to federal appliance standards. The BTO set a goal of 20 percent reduction in energy consumption by 2025 due to appliance standards.	Phase 1
2003 and 2012 Commercial Building Energy	To estimate nonresidential building energy use intensity (EUI) in kWh/ft^2 and	Phase 1

team assumes that CEC will adopt the standard into Title 20, therefore avoiding preemption concerns. For that reason, there may be some standards in which DOE has indicated interest which are not included in this analysis, but rather, are included in the Title 20 analysis.

187 10 C.F.R § 430 (2010)

Consumption Survey (CBECS) from U.S. Energy Information Administration[188]	therms/ft^2. This will be used to identify the trends in energy use from 2003 to 2012 to estimate 2010 EUIs. The actual EUIs from CBECS will not be used because California building energy use is likely different than the national average; the trend data will be used.	
2006 California Commercial End Use Survey (CEUS)[189]	To estimate California nonresidential building energy use intensity (EUI) in kWh/ft^2 and therms/ft^2. This will be used to estimate the 2010 EUIs in California, adjusted from 2006 using the trends in consumption determined from the national CBECS data.	Phase 1
2009 California Residential Appliance Saturation Survey (RASS)	To estimate residential building energy use intensity (EUI) in kWh/ft^2 and therms/ft^2. This will be used to estimate the savings associated with the goals set in the BTO Multi-Year Plan to reduce energy consumption per square foot by 20 percent.	Phase 1
California Energy Commission Demand Forecast office residential and nonresidential building stock and new construction forecast	Estimate the future square footage affected by appliance standards.	Phase 1
Appliance Standard Awareness Program (ASAP) U.S. DOE Appliance Standards Rulemakings Schedule 2016 – 2017	Identify standards expected to be adopted and likely included in 2018 PG study and AAEE.	Phase 3

188 U.S. Energy Information Administration. "Commercial Buildings Energy Consumption Survey (CBECS)." Accessed in May 2017. Available online at: https://www.eia.gov/consumption/commercial/

189 California Energy Commission. "California Commercial End-Use Survey (CEUS)." http://www.energy.ca.gov/ceus/

(including test procedures)[190]		
Expected U.S. DOE Standard Update table[191]	Identify potential future standards not included in the 2018 PG Study.	Phase 3
ENERGY STAR® and other voluntary standard and specification product databases	Identify potential future standards not included in the 2018 PG Study.	Phase 3
California Investor Owned Utility (IOU) and other utility-sponsored incentive programs for specific appliance installations, such as those for refrigerators, water heaters, and pool pumps	Identify potential future standards not included in 2018 PG study. These programs often increase market penetration of high efficiency products and appliances and can be adopted as mandatory standards.	Phase 3
U.S. DOE Standards and Test Procedures[192]	Identify current standards and those that may be reviewed and updated from 2019 through 2029.	Phase 3
Expected Title 20 appliance standards	Title 20 adopts some standards in advance of DOE standards. Overlap will be accounted for with Title 20	Phase 3
Next Generation of Standards: How the National Energy Efficiency Standards Program Can Continue to Drive Energy, Economic, and Environmental Benefits (ASAP 2016)[193]	Identify potential future standards not included in Navigant's 2018 Potential and Goals study or AAEE.	Phase 3

190 Appliance Standards Awareness Project. "U.S. DOE Appliance Standards Rulemakings Schedule 2016-2017." October 3, 2016. Available online at: https://appliance-standards.org/sites/default/files/doe_schedules/DOE_Schedule_by_Date_76.pdf

191 Appliance Standards Awareness Project. National Standards. https://appliance-standards.org/national

192 Office of Energy Efficiency & Renewable Energy. "Standards and Test Procedures." Accessed in May 2017. Available online at: https://energy.gov/eere/buildings/standards-and-test-procedures

193 deLaski, Andrew, et. al., "Next Generation Standards: How the National Energy Efficiency Standards Program Can Continue to Drive Energy, Economic, and Environmental Benefits." Available online at: https://appliance-standards.org/sites/default/files/Next%20Gen%20Report%20Final_1.pdf

Interview ASAP staff	Identify potential future standards and energy savings potential.	Phase 3
Review information from Statewide IOU Emerging Technologies Program (ETP) and Emerging Technologies Coordination Council (ETCC)	Identify potential future standards.	Phase 3
Energy Conservation Program: Energy Conservation Standards Final Rulemaking documents	Identify potential energy savings and shipment or installation data for future standards update current standards.	Phase 3
Product shipment or installation data from manufacturing industry representatives, such as NEMA, or U.S. government imports data.	Identify potential market penetration of appliances.	Phase 3

Additional data that supported Phase 3 of this analysis include:

- Unit energy savings estimates for future potential appliance standard
- Unit costs for future potential appliance standards
- Current and expected sales of appliances for future potential standards, specifically in California if available.

Methodology:

To estimate energy savings potential for future federal appliance standards, both new standards and updates to current standards, the NORESCO team made high level estimates for Phase 1 based on DOE Building Technology Office (BTO) goals, and then refined savings estimates based on measure-by-measure data or estimates based on available sources. The analysis used the following information, or made estimates based on professional judgment and available data:

DOE energy reduction goals

List of measures or groups of measures expected to be adopted

Building sector, as applicable, for each expected measure

Timeline of expected measure adoption/effective date and updates (six year cycle per standard)

Unit energy savings estimates

California sales estimates (or scaled by population)

Compliance rate for each standard

Normal market adoption (NOMAD) at time standard goes into effect

Approach:

Phase 1 Approach: The NORESCO team established a high-level savings estimate for future updates to current federal appliance standards and future new appliance standards. The NORESCO team based estimates on goals set by the Department of Energy's (DOE) Building Technology Office (BTO) to reduce building energy consumption by 30 percent compared to 2010 energy consumption through 2029[194]. To support this, the BTO set a goal to reduce energy use per square foot in buildings by 20 percent by 2025 through appliance and equipment standards. The NORESCO team estimated California-specific savings by establishing 2010 building energy use intensities and reducing energy consumption per building by 20 percent by 2025. The analysis applied the savings to new construction and expected alteration and retrofit square footage in California through 2029. The resulting savings impact both electricity and natural gas usage. The following approach established Phase 1 estimates:

Estimated 2010 California building energy use intensity (EUI) for nonresidential and residential buildings in California using CBECS, CEUS, and RASS data. 2010 EUIs are needed to align with the BTO reduction goals. The NORESCO team used the 2003 and 2012 national CBECS data to identify trends in nonresidential building consumption. The team then used the trending to adjust 2006 California CEUS data to estimate nonresidential building kWh and therms consumption per square foot in 2010. The CBECS and CEUS data do not include identical building types; therefore, the most relevant CBECS building type was applied to the CEUS data. For example, CBECS does not differentiate between small and large office buildings like CEUS does, so the office building trend data was used for both. 2009 RASS data was collected in 2009 through early 2010; therefore, the 2009 RASS data was used for residential kWh and therms use per square foot[195].

Estimated energy reduction from 2010 to 2025 based on the BTO goal of 20 percent reduction by 2025. 20 percent is achieved by estimating that appliance standards will reduce energy consumption by two to four percent every two years until 2024[196].

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194 U.S. DOE Building Technology Office Multi-Year Program Plan: Fiscal Years 2016-2020. https://energy.gov/eere/buildings/downloads/multi-year-program-plan

195 The the Energy Commission funded the study and began administering the survey in 2009; therefore it is called the 2009 RASS study.

196 Reductions only occur through 2024 because the BTO goal is to achieve 20 percent reduction by 2025.

Identified affected square footage using Energy Commission Demand Forecast Office new construction and building stock estimates. All new construction will be impacted by appliance standards. Existing buildings will be impacted if replacing equipment or performing a retrofit. The affected existing building square footage was estimated assuming an effective useful life (EUL) of 15 years; meaning a replacement or retrofit will occur every 15 years. The analysis team divided existing building square footage for each year by 15 to estimate impacted square footage.

Estimated energy savings by applying the reduced EUI per year to the affected new construction and existing building square footage per year. The analysis reduced the 2010 EUIs by two to four percent every two years and the savings are applied to the applicable square footage from 2015 through 2029. For the analysis, the team assumed that savings to meet the goal will begin to be realized at year 2011 and must commence by 2024 to achieve 20 percent by 2025; however, the NORESCO team only includes savings starting in 2015 under the assumption that prior savings are captured in previous PG and AAEE studies. This requires 1.5 percent savings per year, or 3 percent every two years. The analysis assumes annual savings will increase in 2016 due to activity from the Obama administration, then ramp up again in the years preceding the 2025 goal. The Phase 1 analysis does not estimate additional energy reduction from appliance standards beyond 2025; therefore, the energy savings per year estimated for 2024 are projected to continue each year through 2029.

There are considerations and limitations for the Phase 1 estimates, including:

The savings estimates are based on BTO goals without identifying appliances and equipment standards that will contribute to the savings.

The 2010 EUIs are best estimates based on available survey data from years before and after 2010.

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: The NORESCO team made minor updates to the analysis approach as follow:

Phase 3 did not further explore appliances and products, such as emerging technologies, which do not have a clearly defined path to adoption at this time. Phase 3 instead remained focused on products that are known to the market and for which DOE has stated interest in pursuing a new or updated standard.

For products that neither the Energy Commission nor DOE currently regulate, but both have stated interested in developing a standard, this analysis assumes the product will fall under the purview of Title 20.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

Reference Case: The reference case assumes that DOE will adopt updates to current Federal Appliance standards where feasible, and will also adopt standards for appliances and products that were out for public review, but not fully completed under the previous administration[197]. The compliance factor, which represents the proportion of the market that will comply with the standard at the time it goes into effect, is set at 85 percent in alignment with Navigant's assumption, unless documented in their report.

Conservative Case: In the conservative case, the NORESCO team assumes that DOE will not adopt updates to current Federal Appliance standards or adopt new standards, but will adopt standards for appliances and products that were out for public review, but not fully completed under the previous administration. The compliance factor is set at 85 percent in alignment with Navigant's assumptions.

Aggressive Case: The aggressive case assumes that DOE will adopt updates to current Federal Appliance standards, where feasible, and will also adopt new standards for currently unregulated appliances and products. The compliance factor is set at 100 percent as requested by the Energy Commission.

Results:

The results show that Federal Appliance standards have significant savings potential through 2029 due to rapidly improving technology efficiencies and reduced costs for more efficient products. The savings estimates are based on the "max tech" at the time of the most recent rulemaking, which is the maximum feasible energy efficiency level for products at the time of the analysis or previous rulemaking. With rapid improvements in technology and efficiency, this analysis as well as ASAP's analysis assumes that the max tech at the time of the last rulemaking for some products will be surpassed in the market by the time of the next rulemaking. The realization of these savings is dependable due to legislation that requires DOE review current standards once every six years, and funding for research and standard development process from the California Statewide IOU Codes and Standards team.

The associated Program Data Analysis workbook provides detail on the analysis results and scenarios comparison for this program. As seen in the workbook, the analysis uses the following assumptions:

- Annual installation rates and naturally occurring market adoption (NOMAD) remain static over the life of the standard in this analysis, which aligns with ASAP's methodology (2016). The rationale being that actual installation rates and NOMAD would both likely increase over time, which counteract each other in

197 At the end of 2016, rulemakings for some standards were out for review, but are currently still in the final rulemaking process during the change in presidential administrations. These are identified in ASAP's U.S. DOE Appliance Standards Rulemakings Schedule- 2017: https://appliance-standards.org/sites/default/files/DOE_Schedule_by_Date_2.pdf.

claimable savings. For the purposes of the analysis, the two factors are assumed to directly cancel out each other and remain constant year over year.

- Consistent with ASAP's methodology (2016), NOMAD is 10 percent for products which do not have an ENERGY STAR® specification, and 25 percent for those that do.
- Savings begin to accrue for a standard based on the noted effective date; the annual installations are also based on the effective date.
- For products which neither the Energy Commission nor DOE currently regulate, but both have stated interested in developing a standard, this analysis assumes the product will fall under the purview of Title 20.
- For each year, the estimated savings reflect installations for all products effective that year, as well as savings from products installed the year(s) prior, because regardless if the product is still in place or has been replaced by a new product meeting the same energy performance criteria, the savings would still be occurring year over year. An applicable decay rate is applied to the savings to reflect diminishing performance over time.
- National annual installations were scaled to California sales based on population size; California represents 12 percent of the nation's population. Although scaling by population may introduce error in the market impact for certain products, it is the best estimate available for the purposes of this analysis. If a better estimate was available, it was used.

Table B-10: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for Federal Appliance Standards

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	-	-	-	-	-	-	-	-	-	22.9	551.0	1,243.8	2,103.0	2,980.8	3,905.6
NG (MM therms)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	16.3	33.0	49.7	66.4	85.7

Source: California Energy Commission staff.

LOCAL GOVERNMENT ORDINANCES FROM 2016[198] THROUGH 2029

Program Description:

Jurisdictions within California develop and adopt local ordinances requiring that select or all new construction and/or additions, alterations, and repairs projects improve energy efficiency beyond Title 24, Part 6. Jurisdictions often adopt these ordinances when a new version of Title 24 Building Energy Efficiency Standards goes into effect. The main drivers for these ordinances are for cities or counties to achieve goals set in their Climate Action Plans, such as greenhouse gas emissions targets, carbon neutrality, and reduced energy consumption.

Buildings Affected:

The following building types, construction, and market sectors may be included under a local ordinance. Each jurisdiction can determine which are appropriate and feasible to include for their goals. Local ordinances may include:

- Residential and nonresidential, excluding certain building types if exempt in the ordinance (e.g. hospitals, industrial, etc.).
- New construction and additions, alterations, and repairs. Requirements for new construction may differ from those for additions, alterations, or repairs to existing buildings.
- Private and public buildings

Methods

Relevant Measures:

Local government ordinances can either require specific measure installation, such as a cool roof, or whole building performance, such as a percent improvement over Title 24 baseline. The baseline for energy savings is the current Title 24 code at the time the ordinance goes into effect. As California has progressively moved towards zero net energy (ZNE) for all new construction, jurisdictions have adopted whole building performance requirements more often than individual measure requirements.

Jurisdictions can develop their own local ordinance, or can conduct an analysis to adopt Title 24, Part 11 California Green Building Standards Code (CALGreen), which includes voluntary green building standards that become mandatory where adopted[199]. Whether adopting a CALGreen tier or developing a specific local ordinance, jurisdictions must

198 Navigant's 2018 Potential and Goals study does not include this program.

199 California Building Standards Commission. "California Green Building Standards Code (Part 11 of Title 24, California Code of Regulations)." Access in May 2017. Available online at: http://www.bsc.ca.gov/Home/CALGreen.aspx

submit an analysis to the Energy Commission showing the ordinance is cost effective and will not result in more energy use than the Title 24, Part 6 baseline. Within 2016 CALGreen, there are residential and nonresidential energy efficiency in Appendices A4 and A5 that list the tiers of whole building performance for residential and nonresidential new construction. The whole building tiers include:

- Residential:
    - Prerequisite: Quality Insulation Installation (QII)
    - Tier 1: 15 percent compliance margin or Energy Budget that is no more than 85 percent of the Standard Design Energy Budget.
    - Tier 2: 30 percent compliance margin or Energy Budget that is no more than 70 percent of Standard Design Energy Budget.
    - Zero Net Energy design: Tier 1 (CZ 6 and 7 for single family, CZ 3, 5, 6, and 7 low-rise multifamily) or Tier 2 (CZ 1-5, 9-16 for single family, CZ 1, 2, 4, and 8-16 low-rise multifamily) + on-site renewable energy generation to achieve an Energy Design Rating (EDR) zero as calculated by compliance software.
- Nonresidential:
    - Prerequisite:
        - Outdoor lighting 90 percent or less of allowed outdoor lighting power,
        - Restaurants 8,000 square feet or greater must install solar thermal with a solar savings fraction of 0.15
    - Tier 1: 5 percent (projects with either lighting or mechanical) or 10 percent (projects with lighting and mechanical) reduction in Energy Budget compared to Standard Design Energy Budget.
    - Tier 2: 10 percent (projects with either lighting or mechanical) or 15 percent (projects with lighting and mechanical) reduction in Energy Budget compared to Standard Design Energy Budget.
    - On-site Renewable Energy:
        - Includes solar, wind, geothermal, low-impact hydro, biomass, and bio-gas
        - 1 percent of electric power or 1 kW, in addition to the electrical demand required to meet 1 percent of natural gas and propane, OR
        - Green power that provides a minimum of 50 percent electric from renewable sources

To conduct the cost effectiveness study, jurisdictions follow the California Energy Commission time dependent valuation (TDV)-based Life Cycle Cost Analysis methodology and only include measures that are regulated under Title 24 to achieve whole building performance (i.e. excluding equipment regulated by federal or Title 20 appliance standards). However, under the whole building performance approach, projects are not limited to installing measures that are regulated under Title 24 to meet the ordinance. It is expected that many projects will meet the requirements through the following improvements:

- Quality Insulation Installation
- Efficient heating, ventilation, and air-conditioning equipment and distribution system
- Efficient domestic hot water systems
- Home Energy Rating System (HERS) verifications
- Daylighting, high efficacy lighting, and controls in nonresidential buildings

Data Sources:

The following data sources are known and were used in this analysis:

Data Source	Expected Use	Phase
Energy Commission website list of adopted and pending local energy ordinances by jurisdiction[200]	Identify jurisdictions that will or intend to adopt ordinances, and identify the required efficiency level	Phases 1 and 3
Energy Commission forecasted new construction square footage	Determine portion of total new construction that will be impacted by local ordinances	Phases 1and 3
Energy Commission existing building stock data	Determine portion of existing building stock that will be impacted by local ordinances	Phases 1 and 3
Permits issued in local jurisdictions that have	Determine portion of total new construction, additions, and alterations that will be impacted by local ordinances	Phases 1 and 3

200 California Energy Commission. "Local Ordinances Exceeding the 2016 Building Energy Efficiency Standards." Accessed in May 2017. Available online at: http://www.energy.ca.gov/title24/2016standards/ordinances/

adopted or intend to adopt a local ordinance		
CALGreen Cost Effectiveness Study (DEG 2016)	Determine potential local ordinances and energy savings for 2017 through 2020 based on 2016 Title 24.	Phase 3
2016 Santa Monica Reach Code Cost Effectiveness Analysis	Determine potential energy savings for 2017 through 2020 for Santa Monica's Local Government Ordinance.	Phase 3
2016 Palo Alto Reach Code Cost Effectiveness Analysis	Determine potential energy savings for 2017 through 2020 for Palo Alto's Local Government Ordinance.	Phase 3
2016 San Mateo Reach Code Cost Effectiveness Analysis	Determine potential energy savings for 2017 through 2020 for San Mateo's Local Government Ordinance.	Phase 3
Energy savings results from simulations	Simulations for building types and climate zones where local ordinances will go into effect will be used to estimate energy savings potential	Phase 3
Technical feasibility studies for ZNE, such as ARUP (2012)[201].	Inform energy savings potential for ZNE for residential and nonresidential building local ordinances	Phase 3
IOU and POU above-code incentive program participation data	Identify participation rates in jurisdictions that adopt local energy efficiency ordinances to determine and remove construction square footage that will likely participate in an IOU/POU incentive program.	Phase 3

Methodology:

To estimate potential electricity and natural gas savings for local government ordinances, the analysis team estimated the portion of California new construction that were impacted by a Local Government Ordinance and the estimated energy savings for a Local Government Ordinance in each jurisdiction. For the analysis, the team assumed that each Local Government Ordinance will adopt performance requirements in line with the expected improvement for the next version of Title 24. That is, a local ordinance

201 ARUP. "The Technical Feasibility of Zero Net Energy Buildings in California." December 2012. http://www.energydataweb.com/cpucfiles/pdadocs/904/california_zne_technical_feasibility_report_final.pdf

adopted for 2019 Title 24 will be in line with the expected efficiency improvements for 2022 Title 24. The savings from the Local Government Ordinance are achieved until the next version of Title 24 goes into effect. At that point, it is assumed that each jurisdiction would adopt a new reach code in line with the next version of Title 24; therefore, no overlap occurs between Local Government Ordinances and Title 24.

The NORESCO team used the same projected Title 24 efficiency improvements as those used for the Title 24 program analysis for each future cycle of Title 24 from 2019 through 2029. The team gathered data on the jurisdictions that will likely adopt a Local Government Ordinance requiring energy efficiency improvement over Title 24 baselines; this was based on historical data from the Energy Commission[202]. For local ordinances requiring efficiency above 2016 Title 24, data is currently available on the Energy Commission website and was used to determine unit energy savings, that is, savings per square foot. Square footage impacted was determined based on publicly available permit data from jurisdictions that have adopted, intend to adopt, or are expected to adopt a local ordinance.

Local government ordinances have not previously been included in PG studies and was not be captured in the 2018 PG study.

Approach:

Phase 1 Approach: For Phase 1 potential energy savings, the analysis team assumed that jurisdictions that adopted a Local Government Ordinance above 2016 Title 24 will continue to adopt Local Government Ordinances for future versions of Title 24. Phase 1 estimated the square footage that will likely be impacted by future Local Government Ordinances in each of these jurisdictions and applied the expected statewide efficiency level and energy savings for the next Title 24 code update through 2029. The following steps were used to estimate potential energy savings:

- Established baseline: in coordination with the Title 24 program energy savings estimates, the team used expected energy efficiency improvements for 2019, 2022, 2025, and 2028 Title 24 as the baseline for future Local Government Ordinances.
- Determined the portion of affected California construction: based on Energy Commission data of previously adopted local ordinances, the analysis team assumes the same jurisdictions will continue to Local Government Ordinances. The estimated square footage is based on available issued permit data in these jurisdictions and Energy Commission forecast construction data. The eligible square footage in each jurisdiction will be reduced to the affected square footage

202 California Energy Commission. "Local Ordinances Exceeding the 2016 Building Energy Efficiency Standards." Accessed in May 2017. Available online at: http://www.energy.ca.gov/title24/2016standards/ordinances/

based on historical participation rates for IOU/POU above-code incentive programs, such as Savings by Design, to account for overlap. IOU program participation rates will be applied to the granularity available; the rates may not be available by city or county, but instead, by IOU territory. POU program participation will be more specific to the cities and counties where a Local Government Ordinance is adopted.

- Estimated energy savings: For Phase 1, the analysis team assumed that jurisdictions will adopt local ordinances that require whole building performance in line with the expected efficiency improvement for the next version of Title 24. For example, local ordinances adopted for 2016 Title 24 will require performance equivalent to the expected efficiency improvements for 2019 Title 24. Although Local Government Ordinances are localized requirements, TRC applied the statewide energy savings estimates from the Title 24 program analysis, which the NORESCO team is also conducting.
- Determined total potential energy savings: using the affected square footage and the expected future Title 24 energy efficiency levels, the analysis team estimated the total potential energy savings for Local Government Ordinances through 2029.

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: The NORESCO team updated the analysis approach as follows:

- Information regarding the specifics of expected local government ordinances by jurisdiction is not available beyond the level used in the Phase 1 approach. Therefore, the analysis methodology is consistent with the above-stated approach:
    - Jurisdictions which have historically or most recently adopted local government ordinances to go beyond current Title 24 requirements are expected to continue proposing and adopting ordinances in the future.
    - Jurisdictions adopt ordinances at the same level of energy efficiency expected in the future Title 24 code cycle. Therefore, the analysis uses the energy savings estimates for the future Title 24 analysis, but due to earlier adoption of local ordinances in these jurisdictions, the savings are realized earlier for the new construction in those jurisdictions than they would be under the Title 24 code update schedule.
- Note that while the evaluation approach has not changed since Phase 1, savings estimates still needed to be updated for Phase 3 according to subsequent updates to the Title 24 savings projections.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

Reference Case: The reference case assumes that jurisdictions which have historically adopted or most recently adopted local government ordinances for 2016 Title 24 will continue to propose and adopt ordinances for future cycles of Title 24. According to floor area weighting, this is expected to generate savings equivalent to 0.7 percent of what is expected for the next iteration of Title 24 (updating according to typical code cycles).

Conservative Case: The conservative case assumes that some jurisdictions which have previously adopted local government ordinances will not continue to pursue ordinances for future Title 24. This may be because it will be deemed to be not cost effective in their climate zone(s) at that time. According to floor area weighting, this is expected to generate savings equivalent to 0.3 percent of what is expected for the next iteration of Title 24 (updating according to typical code cycles).

Aggressive Case: The aggressive case assumes that more jurisdictions than those that have historically adopted local government ordinances will pursue adoption of ordinances. This may be supported by on-going Energy Commission and California Statewide IOU Codes and Standards program work to develop tools for local governments to streamline ordinance adoption. According to floor area weighting, this is expected to generate savings equivalent to 2.0 percent of what is expected for the next iteration of Title 24 (updating according to typical code cycles).

Results:

The energy savings potential for local government ordinances is relatively small compared to other program opportunities. This is because the effected statewide square footage is small based on the jurisdictions that have historically adopted local government ordinances. Additionally, if above code incentive programs are offered in those jurisdictions, the savings potential has already been mostly accounted for through those programs. As Title 24 becomes more stringent, jurisdictions may find it increasingly difficult to find cost effective solutions that are regulated under Title 24 to make a feasible case for adopting a local government ordinance.

To account for this in the analysis, the NORESCO team assumes the opportunity of LGO savings goes to zero once code requirements reach net zero energy-ready (NZE-ready) levels of performance. Based on known Title 24 goals, the NORESCO team anticipates code-required NZE-ready performance requirements as of the 2019 code cycle (effective January 1, 2020) for residential buildings, and as of the 2028 code cycle (effective January 1, 2029) for nonresidential buildings. Accordingly, the last year of incremental LGO savings is assumed to be 2019 for residential buildings and 2028 for nonresidential savings.

Table B-11: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for Local Government Ordinances (CALGreen)

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	0.8	1.4	2.8	4.4	6.0	7.2	8.3	9.4	10.9	12.3	13.8	15.9	17.5	19.3	19.3
NG (MM therms)	0.1	0.1	0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6

Source: California Energy Commission staff.

AIR QUALITY MANAGEMENT DISTRICTS POLLUTANT MITIGATION

Program Description:

The California Environmental Quality Act (CEQA) requires state and local agencies within California to follow a protocol of analysis and public disclosure of environmental impacts of proposed projects and adopt all feasible measures to mitigate those impacts. In California, there are 35 different air quality districts tasked with enforcing the requirements of CEQA: 23 Air Pollution Control Districts (APCDs) and 12 Air Quality Management Districts (AQMDs). Where any project under CEQA's jurisdiction is identified as having potentially significant environmental impacts, the relevant APCD or AQMD is tasked with identifying mitigation measures and alternatives by preparing an Environmental Impact Report. Environmental impact is assessed according to a variety of different environmental resource factors: (1) agricultural resources, (2) air quality, (3) biological resources, (4) cultural resources, (5) geology and soils, (6) greenhouse gases (GHGs), (7) hazards and hazardous materials, (8) hydrology and water quality, (9) land use and planning, (10) mineral resources, (11) noise, (12) population and housing, (13) public services, (14) recreation, (15) transportation and traffic, and (16) utilities and service systems.

Guidelines published by individual air quality districts identify energy efficiency measures that can be applied to reduce GHGs and other Criteria Air Pollutants (CAP) to below the threshold values established by CEQA, or the discretion of the District.

Buildings Affected:

CEQA applies to nearly all projects in California. All public agencies are required to mitigate or avoid significant effects on the environment of projects that they carry out or approve whenever it is feasible to do so. Additionally, CEQA applies to all private projects for which a government permit or other entitlement for use is required. While specific guidance regarding ensuring CEQA compliance varies from district to district, all districts are tasked with enforcing the same set of CEQA requirements.

Methods

Relevant Measures:

Specific efficiency-based environmental impact mitigation measures include:

- Envelope/Site
- Shade trees
- Cool roof membranes
- Green roof construction
- Increase roof insulation
- HVAC
- Smart meters and programmable thermostats
- Duct sealing
- Domestic hot water heaters
- Solar water heaters
- Tank-less water heaters
- Low water use appliances and fixtures
- Lighting
- Daylighting
- Whole building measures
- New construction compliance with CA GBC standards
- Existing buildings retrofit to meet CA GBC standards

Data Sources:

- 2016 California Environmental Quality Act (CEQA) Statute and Guidelines[203]. This document contains all of the specific requirements that each air quality district is tasked with enforcing. It includes detailed descriptions of the environmental resource factors and thresholds of significance as they relate to pollutants and other impact metrics.
- Bay Area Air Quality Management District CEQA Air Quality Guidelines[204]. This document captures the guidelines that the Bay Area Air Quality Management

203 Association of Environmental Professionals. CEQA Statute and Guidelines. 2016. Available online: http://resources.ca.gov/ceqa/docs/2016_CEQA_Statutes_and_Guidelines.pdf

204 Bay Area Air Quality Management District. CEQA Air Quality Guidelines. May 2017. Available online: http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/CEQA/BAAQMD%20CEQA%20Guidelines%20May%202011.ashx?la=en

District (BAAQMD) has implemented to enforce CEQA requirements. It establishes a clear process for how to identify the need for impact mitigation and how to execute the resulting mitigation process. With respect to energy efficiency, the document recommends a set of energy efficiency measures that result in GHG and other CAP reductions.

- California Air Pollution Control Officer's Association. Association website[205] provides information on relevant energy efficiency efforts.
- Air Pollution Control District San Luis Obispo County. Website[206] provides information on relevant energy efficiency efforts.

Data has not been found to indicate the specific impact of CEQA on commercial and residential building efficiency via the enforcement of the air quality districts. Presumably, complying with applicable codes and standards (i.e. Title 24, Title 20, and Federal Appliance Standards) would go a long way towards bettering environmental impact thresholds.

Methodology:

With respect to estimating program impact, Air Quality Management District Criteria Pollutant Mitigation aligns more closely with Codes and Standards than with financing or rebate programs; CEQA establishes requirements and the air quality districts are tasked with enforcing those requirements. Accordingly, it is anticipated that the approach through which the savings potential of Air Quality Management District Criteria Pollutant Mitigation will be estimated will approximate that which will be developed for relevant codes and standards (i.e. Title 24, Title 20, and Federal Appliance Standards). However, while the expectation is that much of the data for codes and standards analysis was provided by Navigant, there is no current expectation that Navigant has considered the savings potential associated with regional air quality districts.

While it is expected that compliance with applicable Building and Appliance Standards will contribute significantly to meeting CEQA requirements, the NORESCO Team's literature review clearly indicates that meeting code minimum requirements for a new construction or alteration project is not expected in general to fully satisfy CEQA requirements. In particular, a memo published by the law firm Shute, Mihaly & Weinberger, LLP[207] clearly indicates that Title 24 "does not extend beyond the buildings themselves" and therefore "does not address many of the considerations required under

205 California Air Pollution Control Officers Association. May 2017. Available online: http://www.capcoa.org/

206 Air Pollution Control District San Luis Obispo County. May 2017. Available online: http://www.slocleanair.org/

207 Shute, Mihaly & Weinberger, LLP. "Don't Forget the Energy Implications of New Projects – CEQA Guidelines Appendix F". http://www.smwlaw.com/files/CEQA_Guidelines_Appendix_F.pdf

Appendix F of the CEQA Guideline." Indeed, CEQA Appendix F highlights a number of potentially significant energy implications of a project that extend beyond the scope of Title 24, including: (1) energy consuming equipment and processes which will be used during construction, operation, and/or removal of the project; (2) total estimated daily vehicle trips to be generated by the project and the additional energy consumed per trip by mode; and (3) the effects of the project on peak and base demand periods for electricity and other forms of energy.

Where a project is anticipated to exceed environmental impact thresholds established by CEQA, mitigation is required. While a wide range of action can contribute to mitigation, energy efficiency interventions factor prominently into recommended strategies. In particular, BAAQMD Air Quality Guidelines specifically identify exceeding the energy efficiency requirements of Title 24 as a potential approach to mitigation.

Approach:

Phase 1 Approach: AQMD requirements are currently assumed to result in an additional 5 percent of electricity and gas savings currently projected for iterations of Title 24 starting in 2016 and continuing through 2028.

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: In discussions following Phase 1, the Energy Commission recommended that the NORESCO team evaluate AQMD from a Financing Program perspective rather than from a Codes & Standards Program perspective. Initially, the NORESCO team assumed that individual projects would have to implement measures on site to meet mitigation requirements. The Energy Commission suggested that a more effective approach could be to require projects to pay a fee to address mitigation requirements. This approach would have multiple benefits, including: (1) reducing the schedule and resource burden imposed on individual projects by pollution mitigation requirements; and (2) enabling money to be pooled into a larger fund that could be used to address large-scale pollution concerns across a district.

That being said, the NORESCO team continued to apply the Phase 1 calculation approach. Whether mitigation is applied at the project-level or a fee commensurate with the mitigation requirements would be applied to reduce pollution at another location, the net effect should be approximately the same with respect to pollution/energy consumption averted per mitigation dollar spent. While it could be argued that program yield would be higher if funds are applied to targeted sources of pollution as opposed to whatever particular mitigation can be implemented within the constraints of a particular project, given the overall uncertainty around expected program impact, it seems appropriately conservative to keep savings projections at Phase 1 levels.

Note that while the evaluation approach has not changed since Phase 1, savings estimates still needed to be updated for Phase 3 according to subsequent updates to the Title 24 savings projections.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

Reference Case: The reference case assumes that mitigation requirements will result in annual energy savings equivalent to 5 percent of what is projected to be achieved by Title 24 in the reference case.

Conservative Case: The reference case assumes that mitigation requirements will result in annual energy savings equivalent to 1 percent of what is projected to be achieved by Title 24 in the reference case.

Aggressive Case: The reference case assumes that mitigation requirements will result in annual energy savings equivalent to 10 percent of what is projected to be achieved by Title 24 in the reference case.

Results:

As requested by the Energy Commission after Phase 1, the NORESCO team attempted to reach out to representatives of the most prominent and active AQMDs (Bay Area and South Coast) to get a better sense of the typical level of mitigation required and how that translates to electricity and natural gas savings. However, due to the compressed timeline for this effort, no meaningful data were able to be collected prior to project completion. As such data become available, savings projections could be updated accordingly.

Table B-12: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for Air Quality Management District Programs

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	-	-	10.7	26.1	41.9	64.1	88.6	112.3	138.4	164.6	191.1	220.4	249.8	279.2	317.9
NG (MM therms)	0.0	0.0	1.2	2.5	3.8	5.5	7.5	9.5	11.5	13.5	15.6	17.6	19.7	21.8	23.9

Source: California Energy Commission staff

LOCAL GOVERNMENT CHALLENGE (LGC)

Program Description:

This program consists of four awarded energy innovation grants to local governments, and a number of small government grants, primarily directed towards climate action plans, in response to Energy Commission solicitation GFO-16-404. The individual projects were recently awarded under funding stemming from the American Recovery and Reinvestment Act (ARRA).

The energy innovation grants were (Awardee-Project):

1) Marin Clean Energy – Building Efficiency Optimization Project
2) City of San Diego – Smart City Open Urban Platform (SCOUP)
3) City of San Leandro – Innovative Energy Efficiency and Renewable Energy Deployment Project
4) Stop Waste Energy Council – Accelerating Multifamily Building Upgrades

The small government leadership challenge awards were:

1) City of Del Mar - Civic Center Energy Efficiency Enhancements
2) Gateway Cities Council of Governments - Climate Action Planning (CAP) Framework
3) San Bernardino Council of Governments - Sub-Regional Greenhouse Gas Reduction Plan Update
4) County of San Luis Obispo - EnergyWise Plan Energy Section Update including Zero Net Energy Neighborhood Feasibility, Design, and Implementation Study
5) City of Santa Cruz - Deep Energy Efficiency at Municipal Facilities through Advanced Building Controls
6) Ventura County Regional Alliance - Central Coast Energy Plan
7) Marin General Services Authority - Marin Climate and Energy Partnership/Resilient Neighborhoods Grassroots Climate Action
8) City of Galt - City of Galt Climate Action Plan, Corridor Plan, and Master Plan
9) City of Santa Barbara - City of Santa Barbara, ZNE Roadmap and Implementation Plan

Due to the funding source, the energy savings estimate will be limited to the projects listed above.

Buildings Affected:

Residential and non-residential. The affected building type varies by project. The approach taken is to evaluate the energy innovation grants in detail, and evaluate a small subset of the climate action plans.

Methods

Relevant Measures:

The savings measures for this program vary by project, from multifamily building upgrades, to a detailed energy upgrade to a wastewater treatment plant, to outdoor lighting and street lighting energy savings. Where measures may not fall into a standard building end use category, they may need to be evaluated separately.

Data Sources:

A list of data sources is provided below.

- Energy Commission Award Notice[208]
- Brief Summary of awarded projects scope and project narratives[209]
- Program request for proposal guidelines[210]
- Interviews with project proposal authors (city governments and other organizations)
- Published literature on similar climate action plans
- Methodology for converting GHG emissions to energy savings
- Interviews with subject matter experts (Energy and Environmental Economics, and others)
- Information on Climate Action Plan(s) from other, similar cities and jurisdictions in California

208 California Energy Commission. Notice of Proposed Award. Local Government Challenge. Grant Solicitation, GFO-16-404. April 11, 2017.

209 Confidential. Local Government Challenge one-pagers of awarded projects from the Energy Commission.

210 California Energy Commission. Request for Proposals - Local Government Challenge. GFO-16-404. February 2017.

- Proposal submittals for the awarded projects[211]

Methodology:

Phase 1 Approach: Generate top-down estimates of the savings potential for the program. For this phase, the NORESCO team performed the following calculations and employed a set of assumptions to project the energy savings potential from 2015 through 2029.

- Some projects only included greenhouse reduction goals (GHG) reduction goals as the metric of performance, with no energy savings data available.
- First, the analysis categorized the Energy Innovation Grant projects and Local Government Challenge programs into projects (1) with specific energy efficiency measures or targets, and (2) with general GHG reduction goals. For programs with specific performance targets, the NORESCO team extracted electricity and gas savings from relevant project narratives or conversion of GHG reduction goals. The programs with specific targets as a direct result of photovoltaics systems or other renewable or storage technologies will not be considered in the Phase 1 savings estimate.
- For climate action plans at the city or county level, the Phase 1 savings approach is the following:
    - Developed estimates of greenhouse gas (GHG) reduction per capita, either from program data or from a representative city. NORESCO determined that the City of Pleasanton Climate Action Plan[212] was an exemplary model[213], with detailed projections of energy savings and greenhouse gas reductions by sector. Estimates of existing energy consumption or GHG production for the awarded cities were not available for the Phase 1 analysis.
    - Used a conversion from GHG reduction targets to energy savings targets from the City of Pleasanton Plan, and also used the City of Pleasanton's breakdown of energy consumption among the buildings, transportation, waste treatment and industrial sectors. While this will vary among local jurisdictions, NORESCO considers this a fair starting point for an estimate. The fraction of planned GHG savings that are due to building energy efficiency is approximately 50 percent of the total GHG planned reductions.

211 Confidential. Local Government Challenge proposal submittal packages from the Energy Commission.

212 City Of Pleasanton 2011. City of Pleasanton Climate Action Plan, December 2011. Available online at: http://www.cityofpleasantonca.gov/civicax/filebank/blobdload.aspx?BlobID=24757

213 Note that the City of Pleasanton was not awarded LGC funding.

    - Applied conversions between electricity and gas use and avoided CO_2 emissions from the Statewide IOU Codes and Standards Program.
    - Applied an estimate (assumed for Phase 1 at 25 percent) of the fraction of the energy savings target that can be attributed to the Climate Action Plan itself.
- For GHG to energy savings conversion, the split between electricity and gas was assumed to be 80 percent electricity and 20 percent gas for small municipalities. Although this was an assumption, data on non-residential buildings shows a similar split for non-residential and residential buildings.

Phase 2 Approach: Update the analysis approach as follows:

- Identify Baseline energy consumption for the affected area. This was collected from either the Proposal and project narrative, information from local government officials, or where neither of those methods was feasible, through city census estimates and comparison of energy use with similar local governments.
- Projects for Del Mar and Marin Clean Energy were deemed as not relevant to this savings estimate, since they deal with PV generation and supply side distributed energy resource (DER) management.
- For San Luis Obispo Country, since neither baseline energy usage nor energy savings targets were available, NORESCO first estimated the residential population that live in low-income areas as 20 percent of the county. An approximate EUI estimate and home size was applied to determine a baseline energy use. It was also assumed that 25 percent of single-family homes in this category could potentially receive efficiency upgrades through 2029.
- Each of the projects was evaluated through an attribution matrix that considered the following mitigating factors:
    - PV: where programs included PV among broad goals, the contribution of PV towards savings was set to 25 percent. Where PV was the only identified measure, it was set to 100 percent. Where targeted measures were identified with specific savings targets without any use of PV, the contribution was set to 0 percent.
    - IOU/POU Overlap: to align with other program methodologies, the overlap from any IOU and POU programs was fixed at 10 percent. For these programs, aggressive goals with building-level energy target reductions exceed many focused IOU and POU programs, so the anticipated overlap is limited.

- Non-Building Fraction: many climate action plans addressing GHG reduction identify measures well outside of building energy efficiency programs (streetlights, transportation, city planning, etc.). NORESCO estimated the fraction of planned savings attributed to measures outside of buildings based on the project narratives and review of program data.
- Attribution Factor: the percentage of the potential targeted building stock that would likely be directly affected by the program. For programs that are targeting specific buildings, the attribution factor is 100 percent. For others, it is assumed to be 25 percent.

A combination of each of these factors yields a "Potential Rate", which is the fraction of potential target savings that can be directly attributed to the program.

Table B-13: Summary of Program Potential against Targeted Savings

	PV Fraction	Non-Building Fraction	IOU/POU Overlap	Attribution	Potential Rate
StopWaste	25%	0	10%	100%	65%
Santa Barbara	25%	0%	10%	25%	16%
Galt	25%	40%	10%	25%	6%
Gateway Cities	25%	10%	10%	25%	14%
San Bernardino COG	25%	25%	10%	25%	10%
Del Mar	100%	0%	10%	25%	0%
Marin Clean Energy	100%	0%	10%	25%	0%
San Leandro	75%	0%	10%	100%	15%
San Luis Obispo	25%	0%	10%	25%	16%
Santa Cruz	0%	0%	10%	25%	23%
Ventura County	25%	0%	10%	25%	16%

Programs with specific building targets provided specific savings targets, so those targets were assumed for the savings estimate. From the potential rate of savings, a savings multiplier of 33 percent across all programs without a specific target was applied.

Finally, savings calculations were divided into annual incremental savings. For broader projects that affect a large number of buildings, it is assumed that the projects will ramp up in scope and savings steadily from 10 percent of targeted savings in 2021 to 100 percent through 2029.

The following considerations were also factored into the analysis:

- Accounting for Codes & Standards Overlap. Because this program targets public buildings, the NORESCO teams assumes little-to-no natural construction turnover in the absence of additional financing. As such, zero percent of program savings were assumed to overlap with Navigant's 2018 Potential and Goals[214] (2018 PG) codes and standards estimates.
- Accounting for Measure Savings Decay. The NORESCO team applied the approach described in the Phase 2 deliverable memo to account for measure savings decay. Weighting factors by measure category, which were based on detailed measure data collected through the program, were assigned as follows: 21.5 percent HVAC equipment, 3.2 percent HVAC control equipment, 8.6 percent HVAC operation, 53.9 percent lighting equipment, 4.8 percent lighting control equipment, and 8 percent other.
- Correcting for Market Saturation. The 2015 Existing Buildings Energy Efficiency Action Plan[215] indicates that: (1) the DGS reports about 125 million square feet of state-leased or –owned floor space; (2) nationwide, approximately 64 percent of government-owned buildings or municipality-owned, while 22 percent are state-owned. Additionally, the DGS reports[216] about 20 million square feet of state-leased floor space. Combining that information with project data that indicates an approximate 90/10 split between local government buildings and public schools, and an assumption of average per project electricity savings of 15 percent, the NORESCO team estimates the total market for this program at around 320 million square feet. Accordingly, the analysis team predicts that the calculated savings projection through 2029 would result in less than 10 percent

214 California Public Utilities Commission. "2018 Potential & Goals Study." June 2017. Available online at: http://www.cpuc.ca.gov/General.aspx?id=6442452619

215 CEC. California's Existing Buildings Energy Efficiency Action Plan. September 2015.

216 Department of General Services. "Real Estate Leasing and Planning Section - Private Sector Leases." April 2017. Available online at: http://www.dgs.ca.gov/resd/Programs/LeasingandPlanning.aspx

of all applicable buildings being improved through 2029. As this seems reasonable, no correction was made to account for market saturation.

Phase 3 Approach: The NORESCO team updated the analysis approach as follow:

- Updating Ratepayer Program Overlap Assumption. As the Local Government Challenge projects are newly awarded, there is no utility incentive information available for this program. Conservatively, this analysis assumed that the ratepayer savings overlap will be 4 percent based on the project data from Proposition 39. The savings estimates for this program therefore subtracted 4 percent from the raw projections prior to further adjustments. As more overlap data becomes available for this program, the results shall be updated accordingly.
- Updating Market Saturation Adjustments. The NORESCO team did not make adjustments to account for market saturation, as the savings potential of the building sectors relevant to this program likely will not saturate through 2029.
- Analyzing Additional Scenarios. The NORESCO team developed a more conservative and a more aggressive scenario, to quantify the potential impact associated with certain assumptions (program funding trends, project savings rates, fraction of project savings due to renewables or non-building areas such as transportation and street lighting).
- Incorporating Newest Available Data. NORESCO incorporated data on a small number of qualifying projects that were not awarded funding, to gain a better sense of the program's potential in future years.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario. All values have been rounded.

Reference Case: It was assumed that the savings level for projects where no specific building targets were identified were 33 percent, and that the attribution of savings to the LGC project is 25 percent. Also, the reference case used the assumption that between 10 percent and 40 percent of anticipated project savings was due to non-building measures, such as transportation or street lighting, or due to renewables, and was therefore excluded from the savings.

Conservative Case: For the conservative case, the NORESCO team reduced project savings level from 33 percent to 25 percent for most programs, and also assumed that a

higher percentage of project savings would come from non-energy efficiency savings (PV, transportation, street lighting, etc.).

Aggressive Case: For the aggressive case, the NORESCO team assumed that two additional rounds of funding would take place every 3-4 years, resulting in an aggregate program iteration savings level similar to the current round of awarded projects.

Results:

The NORESCO team estimates LGC program savings of approximately 3.94 GWh and 0.15 MM therm annually. This estimate excludes all renewable savings and non-building measure savings planned from awarded projects. The more conservative estimate reduces the predicted annual savings by nearly 50 percent, due to adjusted assumptions on the fraction of PV in projects, and reducing the estimated overall savings level from 33 percent to 25 percent for most projects.

Table B-14: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for the Local Government Challenge

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	-	-	-	-	-	-	4.4	8.9	13.3	17.6	21.8	26.1	30.2	34.4	38.3
NG (MM therms)	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.3

Source: California Energy Commission staff.

PROPOSITION 39 (CALIFORNIA CLEAN ENERGY JOBS ACT)

Program Description:

Proposition 39 (Prop 39), the California Clean Energy Jobs Act, provides funding for planning and installing energy efficiency upgrades and clean energy generation at schools. The initiative changed California's corporate income tax code and allocates projected revenue to the General Fund and the Clean Energy Job Creation Fund for five fiscal years, annually from 2013-2014 until the 2017-2018 fiscal year. As a result, funding for each fiscal year varies based on the State budget. The State of California requires that a large portion of Prop 39 funds be allocated to eligible Local Educational

Agencies [217](LEA) and California Community Colleges (CCC) for energy efficiency and self-generation projects. A small percentage of the Prop 39 funds is appropriated for other components of the program, including financing, technical assistance, workforce development, and energy planning services. All five years of funding (2013-2018) have been committed to eligible LEAs and CCCs. In the K-12 system, funds are allocated to specific LEAs according to average daily attendance (85 percent weighting) and number of students eligible for free and reduced-price meals (FRPM) (15 percent weighting) applicable to a funding year. In the CCC system, funds are allocated according to number of Full Time Equivalent Students (FTES).

As of July 2017, Governor Brown has signed Senate Bill 110 (SB 110)[218] to extend the Prop 39 program, allowing the program to continue indefinitely. The future funding level of Prop 39 will be subject to the annual State Budget process. In general, Prop 39 funds can be applied to energy efficiency retrofits and clean energy installations. Additionally, funds can be appropriated to hire energy managers and provide relevant energy related staff training. The use of funds must comply with two factors: loading order and cost effectiveness. Projects applying for Prop 39 funding shall be sequenced in accordance to California's "loading order" of energy resources. Energy efficiency and demand response projects are first priorities, followed by renewable energy generation, distributed generation, combined heat and power applications, and clean and efficient fossil-fired generation, in the order stated. Projects are also evaluated by the cost effectiveness criteria, calculated in terms of Savings to Investment Ratio (SIR), based on the total energy savings and net project costs over the project life-cycle.

Additionally, Prop 39 funds can be combined with other project financing and funding mechanisms such as utility incentives (mandatory), utility On-Bill Financing (OBF) programs, and the Energy Conservation Assistance Act (ECAA) loan programs. The Energy Commission published a Progress Report [219] in January 2017 that indicates the appropriation of Prop 39 funds from 2013 to 2017.

Buildings Affected:

Non-residential only

- Existing K-12 school facilities

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217 LEAs include K-12 school districts, county offices of education, charter schools, and state special schools.

218 California Legislative Information. "SB-110 Clean Energy Job Creation Program and citizen oversight board." July 11, 2017. Available online at: http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB110

219 California Energy Commission. The California Clean Energy Jobs Act: Proposition 39. Sacramento, California. January, 2017.

- Existing County offices of education facilities
- Existing Charter school facilities
- Existing State special school facilities
- Existing Community College facilities

Note: New construction is excluded from Prop 39.

Methods

Relevant Measures:

Data collected for Prop 39-funded projects indicates a clear list of commonly implemented measures, while there may be additional measures not yet reported and captured. Final reporting for project completion is due June 30, 2021, after which more data will be made available. For all cases, savings are measured against the existing building conditions. The currently available list of measures[220] that relate to energy efficiency is as follows:

- Building Envelope
    - Cool Roofs
    - Insulation
    - Shading Devices/Window Film
    - Windows/Skylights
- Domestic Hot Water (DHW)
    - DHW Heater
    - Waste Heat Recovery
    - Water Tank/Pipe Insulation
- Electrical
    - High Efficiency Transformer
- HVAC
    - Chiller/Boiler Replacement

[220] List of measures are based on various data sources, including the Energy Commission's K-12 Postsecondary Education Participants System (PEPS) Data Workbook and the Chancellor's Office Prop 39 Data Workbook.

    - Condensing Furnace
    - Door Switch/Occupancy Sensors
    - Energy Management System
    - Programmable/Smart Thermostats
    - Cooling Towers
    - Demand Controlled Ventilation
    - Duct Sealing
    - Evaporative Coolers
    - HVAC and Air Handler Repairs
    - New Economizer
    - Packaged/Split System AC/Heat Pump/VRF
    - Room/Window AC
    - VAV System
    - Retro-commissioning (Continuous)
- Irrigation
    - High Efficiency Sprinkler
    - Irrigation Pump Control
- Kitchen
    - High-Efficiency Appliances
    - Strip Curtain/Auto Closer
- Lighting
    - CFL Lamp Retrofit
    - Lighting Controls
    - Exterior Fixture Retrofit
    - Interior Fixture Retrofit
    - LED Exit Signs
    - Retrofit Interior Lamps to LED
- Plug Loads
    - Power Management

    - Vending Machine Misers
- Pool
    - Swimming Pool Cover
- Pumps, Motors, and Drives
    - Energy Efficient Pumps
    - Premium Efficiency Motors
    - Variable Frequency Drives

Note the following about the above list: (i) energy storage was removed from the list for not being an efficiency measure (while energy storage reduces peak demand, it is not a net energy saver); (ii) solar water heating is classified as renewable generation; and (iii) while irrigation measures primarily reduce water usage, they are included due to potential for at least some corresponding electrical savings.

Data Sources:

The process of data collection and analysis relies on available reports and workbooks published by the Energy Commission[221] and the Chancellor's Office[222]. An overview of relevant data sources used for this analysis is summarized below.

- K-12 Postsecondary Education Participants System (PEPS) Data Workbook. This workbook provides detailed information for each individual K-12 Prop 39 project. It is updated on a regular basis by the Energy Commission as more applications are approved; the latest version covers information through 2016-2017 fiscal year. The NORESCO team extracted information from the following available data parameters to support SB 350 analysis:
    - Detail of Prop 39 funding appropriations
        - Total annual grant amount requested by LEA's (2013-2017)
        - Total annual grant amount requested for Energy Manager
        - Total annual grant amount requested for Training per year
        - Total annual grant amount requested for Energy Efficiency Measures

221 California Energy Commission. Proposition 39 K-12 Program. 2017. http://www.energy.ca.gov/efficiency/proposition39/

222 California Community Colleges Chancellor's Office. Proposition 39. 2017. http://extranet.cccco.edu/Divisions/FinanceFacilities/Proposition39.aspx

    - Detail of energy efficiency measures funded by Prop 39
        - Energy efficiency measure title
        - Fiscal year in which the measure is funded
        - Estimated completion date
        - Average time gap between funding year to completion year
        - Estimated square footage affected by measure
        - Estimated annual electric savings
        - Estimated annual gas savings
        - Estimated measure cost
        - Estimated utility rebate
    - Detail of self-generation projects funded by Prop 39
        - Estimated measure cost
        - Estimated project rebate
    - Cost effectiveness
        - Savings-to-investment ratio at the measure level
        - Savings-to-investment ratio at the Energy Expenditure Plan level

- K-12 Proposition 39 Program: Energy Expenditure Plan Handbook. This handbook provides detail regarding project and measure eligibility, as well as the process through which an LEA can submit, execute, and track a Proposition 39 project. For projects that wish to bypass the need for a professional energy audit, 28 separate energy saving calculators are available to estimate the performance of specific measures (12 lighting measures, 9 HVAC measures, 2 plug load measures, 3 envelope measures, the electrical transformer measure, and a PV measure). Excluding the solar photovoltaic (PV) measure calculator, the details embedded in these calculators will be useful to specifying energy modeling inputs for relevant measures.
- K-12 Proposition 39 Progress Report to the Citizens Oversight Board. This report is published annually to summarize program outcomes to date for all active projects implemented by the LEAs. The latest version of the Progress Report covers information through the end of the 2015-2016 fiscal year (June 30, 2016). Summaries provided in the Progress Report will inform overall program performance, cost effectiveness, and limitations.
- CCC Chancellor's Office Project Data Workbook. This workbook provides detailed information for each individual CCC Prop 39 project. It is updated on a

regular basis as more applications are approved; the latest version captures information through 2016. The NORESCO team extracted information from the following available data parameters to support SB 350 analysis:

- Detail of Prop 39 funding appropriations
  - Total annual grant amount requested by CCC (2013-2016)
- Detail of energy efficiency measures funded by Prop 39
  - Energy efficiency measure title
  - Fiscal year in which the measure is funded
  - Estimated annual electric savings
  - Estimated annual gas savings
  - Estimated measure cost
  - Estimated utility rebate
- Detail of self-generation projects funded by Prop 39
  - Estimated measure cost
  - Estimated project rebate
- Cost effectiveness
  - Savings-to-investment ratio at the measure level

- CCC Prop 39 Implementation Guidelines and Addenda. This program guideline provides detail regarding project and measure eligibility, as well as the process through which a CCC can submit, execute, and track a Prop 39 project. Qualification criteria and cost effectiveness thresholds are provided along with calculation methodology and code compliance requirements.
- CCC Prop 39 Progress Report to the Citizens Oversight Board. This report is published annually to summarize program outcomes to date for all active projects implemented by community colleges. The latest version of the Progress Report covers information through the end of the 2014-2015 fiscal year (October 2015). Summaries provided in the Progress Report will inform overall program performance, cost effectiveness, and limitations.

Methodology:

While Prop 39 funding is expected to end in the 2017-2018 fiscal year with project close-out expected by June 2021, the SB 350 analysis will assume that Prop 39 (or a

similar program able to generate comparable savings) will be extended through 2029 for purposes of developing incremental savings projections that can be applied to SB 350. The analysis of this program will be conducted through a phased approach as follows:

Approach:

Phase 1 Approach: Generate top-down estimates of the savings potential for the program. For this phase, the NORESCO team performed the following calculations and employed a set of assumptions to project the energy savings potential from 2015 through 2029.

- For K-12, the first-year data for 2013-2014 demonstrates a relatively slow ramp-up in projects and funding requests, with later years showing increase in projects and funding requests that align more closely with allocated funding.
- For CCC, the data covers only up to 2016 with partial project data available for 2015-2016. There is no information for 2016-2017 published in the workbook.
- Since the Prop 39 data sets include both energy efficiency and self-generation projects, this analysis extracted the energy efficiency-only data to serve as basis of the savings projections.
- For the purpose of savings projections, the annual energy savings data were normalized by the associated funding amount. This method produced two normalized energy savings estimates for kWh savings and therm savings per dollar of funding.
- Using the normalized energy savings estimates along with the known funding amounts for 2013-2017 and the estimated funding amount for 2017-2018, the analysis extrapolated the available project data to generate annual funding and energy savings data for all five years of the current program cycle (2013-2018).
- The estimated five-year data were plotted to evaluate trends. However, the results did not reveal any clear patterns of energy savings or funding levels. Data seems to primarily vary by the approved funding amount which is dependent on the State budget approval. It appears that energy savings potential may fluctuate based on budget variance for each year.
- For the purpose of Phase 1, the analysis calculated an average annual funding level based on the five-year estimates and assumed that the funding level will remain constant from 2015 through 2029. The projected funding level was then applied to extrapolate average annual electric and gas savings projected through 2029.
- Funding level to remain constant through 2029 for the purpose of Phase 1 estimates.

- Publicly available data is limited to the information from K-12 and CCC workbooks.
- More project savings will be reported through 2021 as more projects are verified.
- The actual funding and energy savings data will better correspond to the approved budget as more data becomes reported.
- Average of funding and energy savings data by normalization can serve as a preliminary method of savings projections in Phase 1, despite many variables yet to be considered.

Phase 2 Approach: The NORESCO team updated the analysis approach as follow:

- Correcting for Renewable Generation. Solar PV savings had already been removed during Phase 1. During Phase 2, the NORESCO team also removed solar thermal savings (only 0.2 percent of total savings).
- Accounting for Codes & Standards Overlap. Because this program targets public buildings, the NORESCO teams assumes little-to-no natural construction turnover in the absence of additional financing. As such, zero percent of program savings were assumed to overlap with Navigant's 2018 Potential and Goals[223] (2018 PG) codes and standards estimates.
- Accounting for Measure Savings Decay. The NORESCO team applied the approach described in the Phase 2 deliverable memo to account for measure savings decay. Weighting factors by measure category, which were based on detailed measure data collected through the program, were assigned as follows: 21.5 percent HVAC equipment, 3.2 percent HVAC control equipment, 8.6 percent HVAC operation, 53.9 percent lighting equipment, 4.8 percent lighting control equipment, and 8 percent other.
- Correcting for Market Saturation. Assuming that 90 percent of K-12 schools in California are public[224], 44 percent of college buildings are at community colleges[225], and that each project achieves 15 percent electricity savings on average, the NORESCO team estimates that the calculated savings projection through 2029 would result in approximately 260 percent of public school and community college buildings being improved through 2029. While it is possible

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223 California Public Utilities Commission. "2018 Potential & Goals Study." April 2017. Available online at: http://www.cpuc.ca.gov/General.aspx?id=6442452619

224 Niche. "Private School vs. Public School Breakdown." May 2017. Available online at: https://articles.niche.com/private-school-vs-public-school-breakdown/

225 Public Policy Institute of California. Higher Education Center. "Higher Education in California." April 2016. Available online at: http://www.ppic.org/content/pubs/report/R_0416HEBKR.pdf

that some schools would execute multiple projects through the program through 2029, this seems like a clear indication of market saturation. To correct for market saturation, the NORESCO assumed program funding (and subsequent savings) would start to decrease by 30 percent each year starting in 2019. This correction lowers the market saturation rate to approximately 100 percent, which assumes that the number of repeat customers would be roughly equivalent to the number of schools that don't participate.

Phase 3 Approach: The NORESCO team updated the analysis approach as follow:

- Reincorporating Solar Thermal Projects as Energy Efficiency. Upon further evaluation, the Energy Commission directed that solar thermal projects for domestic hot water[226] qualify as energy efficiency. Previously, the savings estimates for Prop 39 subtracted 0.2 percent due to solar thermal projects. In Phase 3, the NORESCO team reincorporated energy savings from solar thermal projects into the savings projections for Prop 39.
- Ratepayer Program Overlap Assumption. Previously, a 10 percent ratepayer program overlap was applied as an approximate average between what the team identified for the community college projects and the K-12 projects. Upon detailed analysis, the assumption was further refined to apply a weighted average based on the average proportion of K-12 funding versus the community college funding. The adjusted utility overlap assumption decreased from 10 percent to 4 percent to more accurately reflect the Prop 39 data. The savings estimates for this program therefore subtracted 4 percent from the projections attributable to SB 350.
- Market Saturation Adjustment. No update has been made to the market saturation adjustment that the NORESCO team applied in Phase 2.
- Analyzing Additional Scenarios. In addition to the reference case, the NORESCO team considered both a more conservative and a more aggressive scenario, to quantify the potential impact associated with project funding and market saturation assumptions. See Scenario-based Approach section for details.
- Incorporating Newest Available Data. No new data have become available since Phase 2.

Scenario Approach:

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226 Department of Community Services and Development. "Low Income Weatherization Program (LIWP) – Funded from the State of California's Greenhouse Gas Reduction Fund." Available online at: http://www.csd.ca.gov/Portals/0/Documents/LIWP%20Public%20Hearing%20Presentation%20Final.pdf

Based on this information, the NORESCO team made the following assumptions for reference, conservative, and aggressive savings scenarios.

Reference Case: The NORESCO team estimated savings for the reference case according to the analysis approach described above, assuming that Prop 39 program funding will continue indefinitely beyond 2018, as enabled by SB 110, , but the energy savings projections are scaled back by 10 percent each year beginning 2019 to account for potential funding decrease through 2029.

Conservative Case: To calculate a more conservative scenario, the NORESCO team assumed that Prop 39 program funding will continue indefinitely beyond 2018, as enabled by SB 110, but the energy savings projections are scaled back by 10 percent each year beginning 2019 to account for potential funding decrease and additionally by 30 percent to account market saturation.

Aggressive Case: To calculate a more aggressive program savings estimate, the NORESCO team removed potential market saturation adjustment from the reference case and assumed that the current savings rate will persist through 2029 unimpeded.

Results:

The results of this analysis reveal that the Prop 39 program demonstrates significant potential in achieving energy efficiency savings through 2029, however, the realization of the estimated savings largely depend on the future prospect of the program. The anticipated availability in funding through SB 110 provides an encouraging outlook for Prop 39, however, the main question remains as whether the program will continue at its current pace without saturating the public school market? While initial estimates indicate that the market will become saturated (saturation is defined by each school executing a single Prop 39 project), there really is no reason why the program couldn't accommodate repeat schools.

Table B-15: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for Proposition 39

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	149	299	448	591	719	834	933	1022	1096	1160	1210	1255	1293	1327	1357
NG (MM therms)	1.3	2.6	3.9	5.1	6.2	7.2	8.1	8.9	9.5	10.1	10.5	10.9	11.2	11.5	11.8

Source: California Energy Commission staff.

GREENHOUSE GAS REDUCTION FUND – LOW INCOME WEATHERIZATION PROGRAM

Program Description:

Low Income Weatherization (LIW) is a statewide program funded by the Greenhouse Gas Reduction Fund (GGRF) through California Cap-and-Trade auction proceeds. The program aims to implement energy efficient measures in low-income single family and multi-family complexes in disadvantaged communities, including PV installations, solar hot water heaters, and other energy reducing projects.

The overarching goals of the LIW program are as follows:

- Reduce Greenhouse Gas emissions in disadvantaged communities.
- Create jobs and provide training for members of disadvantaged communities.
- Reduce the energy bills of the low-income households served.

The LIW program received $75 million in funding through the 2014-15 budget approved by the State legislation in order to implement these goals. It is estimated that 17,700 households will benefit from this program.

Buildings Affected:

Residential only – This program specifically targets 100 percent of the households located in disadvantaged communities as identified by CalEnviroScreen 2.0. The building stock of these households includes:

- Single-family buildings
- Small multi-family buildings
- Large multi-family buildings

Methods

Relevant Measures:

- Health and safety assessments and measures
- Weatherization and renewable energy measures
    - Energy efficient light bulbs

- Ceiling fans and appliances
- Insulation (ceiling, wall, floor)
- Microwaves, solar water heating and solar photovoltaics

Data Sources:

- Low Income Weatherization Program Fact Sheet[227]: This resource supplies general program information:
  - Details on program overview, as well as building types affected.
  - Funding information
  - Low Income Weatherization Program Overview:
  - Details on how funding was allocated for 2015

- Data_LIWP_SF_SMF_EE_Only_04_03_2017 data workbook[228]: This resource provides measure data, limited to the 2015 program year for energy efficiency projects:
  - Counties and agencies
  - Total project costs
  - GGRF funding amount granted
  - Project life/equipment life
  - GHG reductions in MT CO_2-equivalent
  - Estimated cost savings
  - Estimated energy savings (kWh and therms)
  - **MISSING**: Project/measure name

Methodology:

The analysis of this program will be conducted through a phased approach as follows:

Phase 1 Approach: Generate top-down estimates of the savings potential for the program. For this phase, the NORESCO team performed the following calculations and

227 California Department of Community Services & Development. Low Income Weatherization Program Fact Sheet. March 22, 2016.

228 Data_LIWP_SF_SMF_EE_Only_04_03_2017 data workbook provided by Community Services and Development (CSD).

employed a set of assumptions to project the energy savings potential from 2015 through 2029.

- The historical data set provides one full year of savings data for 2015. The lack of data for additional years prohibited the application of data trends or average values.
- The historical data set provides funding data for 2015.
- The Energy Commission provided feedback to indicate that additional data may be available to derive savings claims for past LIW program participants.
- 2015 project savings data were leveraged to determine total electricity and natural gas savings for the entire program year. The total savings from 2015 was then applied as the savings projections for 2015-2029.
- Annual growth of savings and funding level remain the same as the 2015 values.
- 10 percent of program savings are claimed by IOU/POU programs for rebates and incentives provided

Phase 2 Approach: The NORESCO team updated the analysis approach as follow:

- Accounting for Codes & Standards Overlap. Because this program targets low-income housing in disadvantaged communities, the NORESCO teams assumes little-to-no natural construction turnover in the absence of additional financing. As such, zero percent of program savings were assumed to overlap with Navigant's 2018 Potential and Goals[229] (2018 PG) codes and standards estimates.
- Accounting for Measure Savings Decay. The NORESCO team applied the approach described in the Phase 2 deliverable memo to account for measure savings decay. Weighting factors by measure category, which were based on detailed measure data collected through the Proposition 39 program, were assigned as follows: 21.5 percent HVAC equipment, 3.2 percent HVAC control equipment, 8.6 percent HVAC operation, 53.9 percent lighting equipment, 4.8 percent lighting control equipment, and 8 percent other.
- Correcting for Market Saturation. Assuming 2.2 million[230] of 12.3 million[231] households qualify as "low-income," at that each project achieves 15 percent electricity savings on average, the NORESCO team estimates that the calculated savings projection through 2029 would result in approximately one third of low-

229 California Public Utilities Commission. "2018 Potential & Goals Study." June 2017. Available online at: http://www.cpuc.ca.gov/General.aspx?id=6442452619

230 http://www.csd.ca.gov/Portals/0/Documents/LIWP%20Public%20Hearing%20Presentation%20Final.pdf

231 California Energy Commission. Integrated Energy Policy Report (IEPR) Building Stock Data. 2016

income households being improved through 2029. As this seems reasonable, no correction was made to account for market saturation.

Phase 3 Approach: The NORESCO team updated the analysis approach as follow:

- Reincorporating solar thermal projects as energy efficiency. Upon further evaluation, the Energy Commission directed that solar thermal projects for domestic hot water[232] qualify as energy efficiency. Previously, the savings estimates for LIWP subtracted 36 percent from total program savings due to solar PV projects, and another 15 percent due to solar thermal projects. In Phase 3, the NORESCO team reincorporated energy savings from solar thermal projects into the SB 350 projections for LIWP. As a result, the total program savings were reduced only by 36 percent to isolate renewable project savings from energy efficiency improvements.
- Updating Ratepayer Program Overlap Assumption. According to the CPUC, the utilities currently do not claim savings from this program. However, the projects funded by this program likely receive utility incentive and may be claimed by IOU/POU as ratepayer savings. Due to the lack of utility incentive information in the data sources, this analysis assumed that the ratepayer savings overlap will be 4 percent based on the project data from Proposition 39. The savings estimates for this program therefore subtracted 4 percent from the raw projections prior to further adjustments. As more overlap data become available for this program, the results shall be updated accordingly.
- Updating Market Saturation Adjustments. No adjustment was made to account for market saturation, as the savings potential of the building sectors relevant to this program likely will not saturate through 2029.
- Analyzing Additional Scenarios. The results of this analysis represented the "reference" case where savings estimates were projected assuming a consistent trend of funding or policy requirements. The "reference" case then served as the basis for a more "conservative" and a more "aggressive" case, assuming variations in funding or policy requirements.
- Incorporating Newest Available Data. The analysis did not incorporate any new data, as none was made available to the NORESCO team.

Scenario Approach:

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232 Department of Community Services and Development. "Low Income Weatherization Program (LIWP) – Funded from the State of California's Greenhouse Gas Reduction Fund." Available online at: http://www.csd.ca.gov/Portals/0/Documents/LIWP%20Public%20Hearing%20Presentation%20Final.pdf

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

All Scenarios: Data indicates approximately 36 percent savings come from solar PV projects; exclusive of solar thermal. For this analysis, solar thermal is considered energy efficiency.

Reference Case: This scenario assumes that program funding will persist at the same level, resulting in a steady increase in cumulative savings.

Conservative Case: Due to the lack of policy or funding projects after the funding year of 2016, this scenario assumes that program funding will decrease by 50 percent after 2017, resulting in a smaller increase in cumulative savings from 2018 through 2029.

Aggressive Case: Due to the lack of policy or funding projects after the funding year of 2016, this scenario assumes that program funding will increase by 50 percent after 2017, resulting in a larger increase in cumulative savings from 2018 through 2029.

Results:

The results of this analysis reveal that the DWR Low Income Weatherization program, funded by GGRF, demonstrates a significant potential in achieving energy efficiency savings for residential buildings through 2029, however, the realization of the estimated savings largely depend on the future level of funding for the program. Compared to other financing programs, the funding trend of LIWP may be uncertain as it is dependent on the future prospect of the GGRF allocation of funds. If the current funding persists after 2017, even at 50 percent more or less than the current level, the scenario results show that this financing program may still contribute a substantial amount of residential energy savings attributable to SB 350.

Table B-16: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for the Low Income Weatherization Program

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	202
Elec (GWh)	44.3	88.6	133.0	175.4	217.8	260.2	301.7	343.1	382.8	422.0	459.5	496.9	534.
NG (MM therms)	2.5	5.0	7.5	9.9	12.3	14.7	17.0	19.3	21.6	23.8	25.9	28.0	30.1

Source: California Energy Commission staff.

GREENHOUSE GAS REDUCTION FUND – DEPARTMENT OF WATER RESOURCES WATER-ENERGY GRANT PROGRAM

Program Description:

The Water-Energy Grant Program (WEG), funded by the Greenhouse Gas Reduction Fund (GGRF) and operated by the Department of Water Resources (DWR) is a statewide program to promote reduction of greenhouse gas emissions primarily in the residential and non-residential sectors and particularly in disadvantaged communities. Proceeds from the California Cap-and-Trade Program are allocated each year to the WEG program to fund projects that reduce greenhouse gas emissions in California, while also delivering economic, environmental, and public health benefits for Californians, particularly including benefits to disadvantaged communities. Another key objective of the WEG program is to establish an incentive structure for making climate investments through clean technologies and innovative solutions. Water reduction or conservation is the main criterion for program eligibility, but energy use and greenhouse gas reduction are also prioritized.

Buildings Affected:

The following building types, construction, and market sectors may be included under a local ordinance. Each jurisdiction can determine which are appropriate for their goals. Local ordinances may include:

- Residential and nonresidential, excluding certain building types if exempt in the ordinance (e.g. hospitals, industrial, etc).
- New construction and additions, alterations, and repairs. Requirements for new construction may differ from those for additions, alterations, or repairs to existing buildings.
- Private and public buildings

Methods

Relevant Measures:

- Replace high-water-use and high-energy-use fixtures with WaterSense labeled efficient.
- Implementation of an Automated Metering Infrastructure (AMI) system
- Retrofit residential turf and expand water-energy programs by installing water-saving devices

- Augment local gas company programs with water saving devices and development of marketing materials
- Design and installation of smart irrigation control systems
- Installation of low-flow irrigation units and timers.
- Increase large landscape irrigation efficiency at commercial, industrial and institutional sites (CII)
- Direct installation of clothes washers and dryers in disadvantaged communities.
- Replace turf grass with Central Valley-appropriate drought tolerant landscapes.
- Retrofit faucet aerators and low-flow showerheads
- Install water meters and upgrading 10,100 existing water meter transponders to the advanced metering infrastructure/automatic meter reading (AMI/AMR) system transponders.
- Increase the total number of rebates distributed by including rebates for water and energy-efficient dishwashers.

Data Sources:

- Cap and Trade Annual Report[233]. This report is published annually to summarize program outcomes to date for all active projects. The latest version of the Progress Report covers information through the end of the 2016. Summaries provided in the Progress Report will inform overall program performance, cost effectiveness, and limitations.

- Fixed_DWR_WUE Excel workbook[234]: This workbook provides detailed information for each individual WUE project including:
    - Detailed list of measures to be applied
    - Estimated total cost for each measure

Methodology:

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233 California Air Resources Board. Cap and Trade Annual Report. March 2017. https://arb.ca.gov/cc/capandtrade/auctionproceeds/cci_annual_report_2017.pdf

234 Department of Water Resources. "Fixed_DWR_WUE Excel workbook." April 12, 2017. Sourced by the Energy Commission.

The analysis of this program will be conducted through a phased approach as follows:

Phase 1 Approach: Generate top-down estimates of the savings potential for the program. For this phase, the NORESCO team performed the following calculations and employed a set of assumptions to project the energy savings potential from 2015 through 2029.

- The historical data set provides a full-year of savings data for 2014 and a partial-year savings data for 2016.
- The historical data set provides only one year of funding data for 2014. The funding amount for 2016 and 2017 were based on research of publicly available data.
- An estimate of the projected savings for this program was made by taking the average of electricity and gas savings from 2014 and 2016 historical savings data. The average savings from 2014 and 2016 was then applied as the savings projections for 2015-2029 due to a lack of more granular historical data.
- Annual growth of savings and funding level remain the same as the average of 2014 and 2016 values.
- 10 percent of program savings are claimed by IOU/POU programs for rebates and incentives provided

Phase 2 Approach: The NORESCO team updated the analysis approach as follow:

- Correcting for Renewable Generation. There is no indication from the program data set that solar thermal projects are included. As such, the NORESCO team made no correction to correct for savings due to renewable generation.
- Accounting for Codes & Standards Overlap. Because this program targets disadvantaged communities, the NORESCO teams assumes little-to-no natural construction turnover in the absence of additional financing. As such, zero percent of program savings were assumed to overlap with Navigant's 2018 Potential and Goals[235] (2018 PG) codes and standards estimates.
- Accounting for Measure Savings Decay. The NORESCO team applied the approach described in the Phase 2 deliverable memo to account for measure savings decay. Weighting factors by measure category, which were based on detailed measure data collected through the Proposition 39 program, were assigned as follows: 21.5 percent HVAC equipment, 3.2 percent HVAC control

[235] California Public Utilities Commission. "2018 Potential & Goals Study." June 2017. Available online at: http://www.cpuc.ca.gov/General.aspx?id=6442452619

equipment, 8.6 percent HVAC operation, 53.9 percent lighting equipment, 4.8 percent lighting control equipment, and 8 percent other.

- Correcting for Market Saturation. For the GGRF Low Income Weatherization Program (LIWP), the NORESCO team estimated that 2.2 million of 12.3 million households, approximately 18 percent, qualify as "low-income." By extending this ratio to disadvantaged communities as a whole, biasing towards building types that consume the most water (restaurants, schools, hospitals, and dwellings), and assuming that each project achieves 10 percent[236] electricity savings on average, the NORESCO team estimates that the calculated savings projection through 2029 would result in approximately 40 percent of low-income households being improved through 2029. As this seems reasonable, no correction was made to account for market saturation.

Phase 3 Approach: The NORESCO team updated the analysis approach as follow:

- Updating Ratepayer Program Overlap Assumption. According to the CPUC, the utilities currently do not claim savings from this program. However, the projects funded by this program likely receive utility incentive and may be claimed by IOU/POU as ratepayer savings. Due to the lack of utility incentive information within the DWR Water Energy data sources, this analysis assumed that the ratepayer savings overlap will be 4 percent based on the project data from Proposition 39. The savings estimates for this program therefore subtracted 4 percent from the raw projections prior to further adjustments. As more overlap data becomes available for this program, the results shall be updated accordingly.
- Updating Market Saturation Adjustments. The NORESCO team did not make adjustments to account for market saturation, as the savings potential of the building sectors relevant to this program likely will not saturate through 2029.
- Analyzing Additional Scenarios. The results of this analysis represented the "reference" case where savings estimates were projected assuming a consistent trend of funding or policy requirements. The "reference" case then served as the basis for a more "conservative" and a more "aggressive" case, assuming variations in funding or policy requirements.
- Incorporating Newest Available Data. The analysis did not incorporate any new data, as none was made available to the NORESCO team.

[236] Note that this is less than the 15 percent estimate applied to other retrofit programs because only domestic hot water generation is impacted.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

Reference Case: This scenario assumes that program funding will persist at the same level, resulting in a steady increase in cumulative savings.

Conservative Case: Due to the lack of policy or funding projects after the funding year of 2016, this scenario assumes that program funding will decrease by 50 percent after 2016, resulting in a smaller increase in cumulative savings from 2017 through 2029.

Aggressive Case: Due to the lack of policy or funding projects after the funding year of 2016, this scenario assumes that program funding will increase by 50 percent after 2016, resulting in a larger increase in cumulative savings from 2017 through 2029.

Results:

Overall, the results of this analysis reveal that the DWR Water Energy Grant program, funded by GGRF, demonstrates a relatively moderate potential in achieving energy efficiency savings through 2029, however, the realization of the estimated savings largely depend on the future level of funding for the program. WEG is a relatively new program, with funding approved in 2014 and 2016. Compared to other financing programs, the funding trend of WEG may be uncertain as it is dependent on the future prospect of the GGRF allocation of funds. If the current funding persists after 2016, even at 50 percent more or less than the current level, the scenario results show that this program may still contribute a moderate amount of energy savings attributable to SB 350.

Table B-17: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for the Water-Energy Grant

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	27.2	54.5	81.7	107.8	133.8	159.9	185.4	210.9	235.2	259.3	282.4	305.4	328.2	351.1	373.9
NG (MM therms)	9.4	18.9	28.3	37.3	46.4	55.4	64.2	73.1	81.5	89.9	97.8	105.8	113.7	121.6	129.6

Source: California Energy Commission staff.

DEPARTMENT OF GENERAL SERVICES STATEWIDE ENERGY RETROFIT PROGRAM

Program Description:

This program, administered by the Department of General Services (DGS), provides funding to State agencies to fund energy efficiency (EE) retrofits in their buildings through the Energy Efficient Property Revolving Fund. The funds for this program were supplied by the American Recovery and Reinvestment Act of 2009 (ARRA). The funding is expected to be paid back from the energy savings that result from the energy retrofit projects, at which point, the funds will be replenished and become available for subsequent projects.

There are several EE projects remaining in the current funding cycle, but most have completed. A new funding cycle has been approved for 2017-18. DGS improved the process by streamlining program implementation.

Buildings Affected:

Public buildings owned or operated by State agencies.

Methods

Relevant Measures:

The list of current and past projects provided by DGS presents a set of applicable measures that could be employed in this program. The following are the most prevalent energy efficiency measures funded by this program:

- Lighting retrofit
- Lighting controls
- Energy management system upgrade
- HVAC equipment replacement
- HVAC retro-commissioning and optimization
- Variable Air Volume (VAV) conversion
- Variable speed drive installation

Data Sources:

- DGS 2015-2017 project list: In June 2017, DGS provided a list of projects that had received DGS financing in the 2015-2017 program year, including the amount of financing provided by each source (utility incentives, DGS financing, and customer funds), and annual energy savings (electricity and natural gas) for each project.
- DGS ESCO_EE_data_current workbook[237]. This data, which were provided by DGS, provide information on the amount of funding that has been paid back to the fund, the simple payback of the measures, and the annual savings in kWh, therms, and project implementation costs. The projects in the "DGS 2015-2017 project list" were a subset of the "DGS ESCO EE Data current workbook". However, several of the projects in the "DGS ESCO EE Data current workbook" had not moved forward with the program, so were not included in the list of projects that participated in the 2015-2017 program.

- DGS Annual Legislative Report (ALR)[238]. This report provides information regarding loans to state departments and agencies for energy projects on state owned buildings.

- Telephone interview with the DGS Program Manager. The DGS program manager provided information regarding current and future funding and participation levels. As described below, the DGS program manager emphasized that future funding and participation levels are uncertain, so projects should be viewed as high level estimates.

Methodology:

There are a number of variables that may impact how this program will continue into the future. Assuming the current funding will remain available and the program will continue to replenish the funds from energy savings, it is possible to calculate the

237 Department of General Services. "DGS ESCO_EE_data_current workbook." Sourced by the Energy Commission. April 12, 2017.

238 Department of General Services. "Energy Efficient State Property Revolving Fund Annual Legislative Report." 2016.

weighted average simple payback for the projects to determine the rate at which funds are recycled into new projects. Combining this with a calculation of the annual kWh or therm savings for the projects that have occurred will provide a reasonable estimate for future efficiency savings through this program.

Additionally, it will be necessary to apply adjustment factors to the energy savings projections in order to account for opportunities that may be front-loaded in the priority list and newer technologies and techniques that will be adopted in the future. An evaluation of this program will be conducted to chart the savings opportunities available in the future.

Approach:

Phase 1 Approach: ALR and other DGS-supplied information will be used to estimate the savings and annual growth of savings assuming the program parameters and funding levels remain the same. At this time, the future energy savings for this program will be based on DGS estimates for future annual savings from the program rather than based on historical trends. Assumptions employed as part of the analysis include:

- Approximately 50 percent of the savings in this program are claimed initially through other utility incentive programs for equipment replacement. Utility incentive claims will decrease in the future as the oldest buildings are retrofitted and less attractive projects are available for future retrofits, but may increase (as a percentage) as the building approach ZNE and incentives to push buildings over emerge.
- The feedback from Energy Commission Staff indicates that there is an anticipated reduction in the investment levels as the revolving fund is paid back and becomes available for new projects. This is reflected in the savings rates. Based on input from the Energy Commission, the NORESCO team assumed 2 GWh annual savings beginning in 2018.
- Beyond the initial reduction guidance, the funding rate will be maintained as the fund is assumed to be managed sustainably into the future.
- The savings of natural gas will track comparably with electricity, and there is no adjustments made for electrification.
- For cumulative savings, the NORESCO team assumed all projects have an effective useful life (EUL) equal to 15 years so assumed no decay of savings. This is because the most recent program reporting document239 shows the program

[239] Department of General Services. "DGS ESCO_EE_data_current workbook." Sourced by the Energy Commission. April 12, 2017.

measures as interior and exterior lighting upgrades, HVAC upgrades, and envelope measures – all of which have an EUL of at least 15 years. This analysis also assumed no savings from renewable energy, since no renewable energy measures (e.g., solar PV) were shown in the program reporting document.

Phase 2 Approach: In general, the NORESCO team was not able to find publicly available information beyond the sources used for Phase I. The one change made for Phase 2 was to adjust the assumption of savings claimed by utility incentive programs – i.e., adjust the assumption listed in the first bullet under the Phase 1 approach.

- In Phase 1, the NORESCO team assumed that this varied by year but average approximately 50 percent.
- In Phase 2, NORESCO team assumed that utility incentive programs claimed 10 percent of savings each year. This is based on the NORESCO team's default assumption for state financing programs; the default assumption stems from the average fraction of project costs covered by utility programs for Proposition 39 projects.
- As part of Phase 3, the NORESCO team will seek to identify a value specific to the DGS program, as described in the Phase 3 Approach.

As part of Phase 2, the NORESCO team conducted an initial outreach to the DGS EE revolving loan fund program manager to request additional program information including future funding, projected savings, expected overlap with utility incentive programs, and other factors that would affect program savings. As described in the Phase 3 Approach, the NORESCO team will update the savings estimate accordingly based on the DGS response.

Because this program targets public buildings, the NORESCO teams assumes little-to-no natural construction turnover in the absence of additional financing. As such, zero percent of program savings were assumed to overlap with Navigant's 2018 Potential and Goals[240] (2018 PG) codes and standards estimates.

[240] California Public Utilities Commission. "2018 Potential & Goals Study." April 2017. Available online at: http://www.cpuc.ca.gov/General.aspx?id=6442452619

The 2015 Existing Buildings Energy Efficiency Action Plan[241] indicates that the DGS reports about 125 million square feet of state-leased or –owned floor space. Additionally, the DGS reports[242] about 20 million square feet of state-leased floor space. Given the size of the potential market, by assuming that program projects achieved 15 percent electricity savings on average the NORESCO team estimates that the calculated savings projection through 2029 would result in less than 10 percent of state-owned buildings being improved through 2029. As this seems reasonable, no correction was made to account for market saturation.

Phase 3 Approach: To project savings from the DGS program, the NORESCO Team reviewed the list of projects that had received DGS financing in the 2015-2017 program years to understand past trends, and conducted an interview with the DGS program manager to understand how the DGS program funding and energy savings may change in the future.

For the seven projects that had participated in the 2015-2017 DGS program:

- Total savings were 12.9 GWh and 0.026 MMTh, or an average of 4.3 GWh and 0.009 MMTh annually
- Total costs were $38.8M, of which
    - Utilities provided $1M (3 percent)
    - DGS provided $30.5 (79 percent)
    - The customer provided $7.3M (19 percent)

Because the utilities only claim the portion of savings that they fund, the NORESCO Team assigned the portions contributed by DGS (79 percent) and the customer (19 percent), or 97 percent cumulatively (after rounding) to the middle wedge. Consequently, the NORESCO team calculated that DGS financing contributed 4.2 GWh and 0.008 MMTh annually.

The DGS program manager emphasized that all projections in funding and energy savings were rough estimates. Current funding levels should continue for the next 3 to 4

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241 California Energy Commission. “California’s Existing Buildings Energy Efficiency Action Plan.” September 2015.

242 Department of General Services. “Real Estate Leasing and Planning Section - Private Sector Leases.” April 2017. Available online at: http://www.dgs.ca.gov/resd/Programs/LeasingandPlanning.aspx

years (until approximately 2020). After 2020, funding-in-place dropped by approximately one-third, although the DGS program manager reported that more funding could become available. For example, in the past, Department of Energy programs had ended and provided their remaining funds to the DGS program. Consequently, funding could decrease, increase, or remain approximately the same in the future. The DGS program manager reported that even under steady funding levels, project flows may not be constant, and some customers that complete applications ultimately do not complete a project or put the project on hold. Thus, the NORESCO team notes that all projections should be viewed as high level estimates, particularly beyond 2020.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario. All values have been rounded.

- All Scenarios: The analysis assumed that DGS financing and customer contributions (i.e., the contributions not claimed by the utilities) would continue to finance 97 percent of project costs, so counted 97 percent of savings towards the middle wedge. The savings described subsequently in each scenario represent savings after removing the utility savings, or 97 percent of total savings.

- Reference Case: The NORESCO team assumed that current trends would continue – i.e., annual savings of 4.2 GWh and 0.008 MMtherms for 2016 through 2029. The DGS program manager reported this was the most likely outcome, although both increasing and decreasing funds are distinct possibilities.

- Conservative Case: Building off of the reference case, this scenario assumed that funding would decline by 33 percent beginning in 2020 decrease, and that energy savings (both GWh and therms) would decline similarly. The NORESCO team assumed this decline would occur over three years –i.e., 11 percent decline each year from 2020 to 2023. Consequently, the conservative case assumes:
    - 4.2 GWh and 0.008 MMtherms for 2016 to 2019
    - 3.7 GWh and 0.008 MMTherms[243] for 2020

[243] Before rounding, this analysis assumed 0.0084 and 0.0075 MMTherms for 2019 and 2020, respectively.

- 3.3 GWh and 0.007 MMTherms for 2021
- 2.8 GWH and 0.006 MMTherms for 2022 through 2029.

- Aggressive Case: This scenario assumed that funding would increase by 33 percent starting in 2020, and that energy savings (both GWh and therms) would increase accordingly. This scenario also assumes that project participation will increase, including from Department of Corrections and Rehabilitation (DCR) projects, since the DGS project manager identified DCR facilities as having significant energy efficiency savings opportunity.[244] The NORESCO team assumed this increase would occur over three years –i.e., 11 percent increase each year from 2020 to 2023. Consequently, the conservative case assumes:
  - 4.2 GWh and 0.008 MMtherms for 2016 to 2019
  - 4.6 GWh and 0.009 MMTherms for 2020
  - 5.1 GWh and 0.010 MMTherms for 2021
  - 5.6 GWH and 0.011 MMTherms for 2022 through 2029.

Results:

Overall, the NORESCO team estimates DGS program savings will continue at approximately the same level as current DGS program savings, which is a relatively small portion of savings compared to total statewide savings. However, The NORESCO team's review found that the majority of financing for projects in the 2015-2017 program cycle came from DGS, rather than utility incentives, indicating that the program provides crucial financing for energy efficiency projects in state agency buildings. In addition, because of the "cap" (maximum financing amount) for projects from the utilities' On-Bill Financing program, DGS is able to finance larger projects – e.g., more measures or deeper savings measures. Although the DGS program represents a small portion of total savings, continuation of this program (through continued funding) will help the State meet its SB 350 goals.

Table B-18: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015

244 The NORESCO team conducted a brief telephone interview with a DCR staff member that focuses on energy efficiency projects. The DCR staff member confirmed that the department often conducts energy efficiency projects, particularly because most of its 39 functioning correctional facilities operate lighting continuously (8,760 hours annually). DCR projects can also include mechanical upgrades and other non-lighting projects. While DCR projects often leverage the IOUs' On Bill Financing (OBF) program, because of the OBF cap ($1 to $2M, depending on utility), the DGS program often contributes the majority of financing for large projects. In addition, approximately half of DCR projects are outside of IOU territory. The list of projects for the 2015-2017 DGS program includes one DCR project for $3M, for which DGS provided 100 percent of financing. DCR staff reported they will soon submit another DGS application for a $4M project outside of IOU territory.

Through 2029 for the Energy Savings Program

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	4	8	13	17	21	25	29	33	38	42	46	50	54	59	63
NG (MM therms)	0.01	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.08	0.08	0.09	0.10	0.11	0.12	0.13

Source: California Energy Commission staff.

ENERGY CONSERVATION ASSISTANCE ACT (ECAA)

Program Description:

The Energy Conservation Assistance Act (ECAA), is a revolving loan program administered by the Energy Commission to support energy efficiency and energy generation projects pursued by public institutions. ECAA provides loans of up to $3 million per application on a first come, first served basis. The ECAA Financing Program is designed to facilitate the adoption of energy projects, through a simple process that does not involve credit underwriting, collateral or fees. In order to be eligible for a loan, projects must demonstrate energy savings over the loan repayment period. ECAA loans must be repaid in energy cost savings within 20 years, including principal and interest, which is equivalent to a maximum of 20 years of simple payback for 0 percent loans and a maximum of 17 years for 1 percent loans. Project guidelines require that energy projects must be cost-effective and technically feasible in order to qualify for ECAA financing.

Buildings Affected:

Public agencies are eligible to receive ECAA funds; the bulleted list below indicates which types of public agencies are eligible for 0 percent loans and which are eligible for 1 percent interest rate loans. Residential, commercial, and/or private non-profit institutions are **not** eligible for these funds.

- Eligible for 0 percent Interest Rate Loans:
    - School districts
    - Charter schools
    - County offices of education
    - State special schools
    - Community college districts
- Eligible for 1 percent Interest Rate Loans:
    - Cities
    - Counties
    - Special districts
    - Public Colleges or Universities (except community college districts)
    - Public Care Institutions/Public Hospitals
    - University of California and

- California State University

Methods

Relevant Measures:

The following measures are common examples of energy efficiency measures implemented in past projects:

- Electrical
- High efficiency transformers
- Generation
- Solar photovoltaic systems
- Combined heat and power (cogeneration)
- Heating, Ventilation, and Air Conditioning (HVAC) and HVAC controls
- Heating, ventilation and air conditioning equipment upgrades
- Chiller replacements
- Direct digital control systems
- Programmable thermostats
- Kitchen
- Kitchen equipment controls
- Lighting and lighting controls
- Interior fixture retrofits
- LED exit signs
- Exterior fixture retrofits
- Lighting controls
- Street lighting retrofits
- Pumps, Motors, Drives
- Premium efficiency motors
- Pools
- Pool controls

Although renewable generation measures qualify for ECAA funding, they have not been included in this analysis because they do not contribute to reducing electricity and natural gas consumption.

Data Sources:

- 2015-2016 Project Data Workbook[245]. The Energy Commission has provided both high-level and measure-level product data for the past two years. Key data captured include:
    - Detailed list of measures to be applied
    - Estimated electricity and gas savings for each measure
    - Estimated useful life
    - Estimated total cost by project
    - Cost effectiveness, in the form of simple payback, for each measure
    - Rollup summaries at the project level

- Energy Efficiency Financing Website[246]. This resource outlines eligibility criteria, application requirements, and the process to apply for financing.

- California's Local Government Energy Efficiency Portal[247]. This resource provides a high level overview of the ECAA program as well as application requirements.
- ECAA Program Loans Website[248]. This resource lists the loan projects approved by the Energy Commission since July 1, 2009 by county. It also provides a summary of loans by recipient type as well as energy savings information since March 1, 2000, which is when the Commission started tracking this information. This website is updated quarterly.

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245 ECAA Project Data Workbook was sourced by the Energy Commission.

246 California Energy Commission. Energy Efficiency Financing. State of California. 2017. http://www.energy.ca.gov/efficiency/financing/

247 California's Local Government Energy Efficiency Portal. http://eecoordinator.info/cec-offers-1-loans-for-efficiency-generation-projects/

248 California Energy Commission. ECAA Program Loans. State of California. 2017. http://www.energy.ca.gov/efficiency/financing/calmap/county/.

Methodology:

The analysis of this program will be conducted through a phased approach as follows:

Phase 1 Approach: Generate top-down estimates of the savings potential for the program. For this phase, the NORESCO team performed the following calculations and employed a set of assumptions to project the energy savings potential from 2015 through 2029.

- There is no annual budget limit; however, the loan limit per application is $3M.
- There is no data on utility rebates applied to the measures in the data set.
- Since the ECAA data sets include both energy efficiency and self-generation projects, this analysis extracted the energy efficiency-only data to serve as basis of the savings projections.
- Historical data was gathered and organized based on project year. Where available, electrical and gas savings data were then utilized to project trends for future savings assumptions. There was no clear trend in the data, so instead an average value was used to project out through 2029.
- For Phase 1, the NORESCO team assumed that no ECAA savings can be assigned to the middle wedge because the current savings projections have been captured by the Demand Forecast.

Phase 2 Approach: The NORESCO team updated the analysis approach as follow:

- Accounting for Codes & Standards Overlap. Because this program targets public buildings, the NORESCO teams assumes little-to-no natural construction turnover in the absence of additional financing. As such, zero percent of program savings were assumed to overlap with Navigant's 2018 Potential and Goals[249] (2018 PG) codes and standards estimates.
- Accounting for Measure Savings Decay. The NORESCO team applied the approach described in the Phase 2 deliverable memo to account for measure savings decay. Weighting factors by measure category, which were based on detailed measure data collected through the Proposition 39 program, were assigned as follows: 21.5 percent HVAC equipment, 3.2 percent HVAC control equipment, 8.6 percent HVAC operation, 53.9 percent lighting equipment, 4.8 percent lighting control equipment, and 8 percent other.

[249] California Public Utilities Commission. "2018 Potential & Goals Study." June 2017. Available online at: http://www.cpuc.ca.gov/General.aspx?id=6442452619

- Correcting for Market Saturation. The 2015 Existing Buildings Energy Efficiency Action Plan[250] indicates that: (1) the DGS reports about 125 million square feet of state-leased or –owned floor space; (2) nationwide, approximately 64 percent of government-owned buildings or municipality-owned, while 22 percent are state-owned. Additionally, the DGS reports[251] about 20 million square feet of state-leased floor space. Combining that information with project data that indicates an approximate 80/20 split between state or local government buildings and public schools, and an assumption of average per project electricity savings of 15 percent , the NORESCO team estimates the total market for this program at around 550 million square feet. Accordingly, the analysis team predicts that the calculated savings projection through 2029 would result in approximately 16 percent of all applicable buildings being improved through 2029. As this seems reasonable, no correction was made to account for market saturation.

Phase 3 Approach: The NORESCO team updated the analysis approach as follow:

- Updating Ratepayer Program Overlap Assumption. According to the CPUC, the utilities currently do not claim savings from this program. However, the projects funded by this program likely receive utility incentive and may be claimed by IOU/POU as ratepayer savings. Due to the lack of utility incentive information in the data sources, this analysis assumed that the ratepayer savings overlap will be 4 percent based on the project data from Proposition 39. The savings estimates for this program therefore subtracted 4 percent from the raw projections prior to further adjustments. As more overlap data become available for this program, the results shall be updated accordingly.
- Updating Market Saturation Adjustments. The NORESCO team did not make adjustments to account for market saturation, as the savings potential of the building sectors relevant to this program likely will not saturate through 2029.
- Analyzing Additional Scenarios. The results of this analysis represented the "reference" case where savings estimates were projected assuming a consistent trend of funding or policy requirements. The "reference" case then served as the basis for a more "conservative" and a more "aggressive" case, assuming variations in funding or policy requirements.
- Incorporating Newest Available Data. The Energy Commission noted that additional funding may be expected in 2018 through SB 110, as such, the NORESCO team evaluated the impact of such new funding on energy savings

250 California Energy Commission. "California's Existing Buildings Energy Efficiency Action Plan." September 2015.

251 http://www.dgs.ca.gov/resd/Programs/LeasingandPlanning.aspx

potential. The analysis took into account the new funding information in the various scenarios that determine savings estimates for this program. No other new data was made available to the NORESCO team.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

Reference Case: This scenario assumes that additional ECAA-Ed funding will be expected July 2018, per SB 110 where ECAA-Ed may receive up to $100 million in additional funding. However, the implementation cycle of this funding is unknown, therefore, the analysis was unable to estimate annual funding additions to the program. Conservatively, the reference case assumes that about 10 percent of the total program savings can be attributed to SB 350, beginning 2019 when the SB 110 funding contributes to the ECAA program. In this scenario, all energy savings from 2015 through 2018 remain captured in the Demand Forecast with no "incremental" savings for SB 350.

Conservative Case: This scenario assumes that the additional funding from SB 110 will not significantly increase savings level beyond the current funding level, and that all savings after 2018 will continue to be claimed by Demand Forecast.

Aggressive Case: The scenario assumes that with SB 110 providing additional funding, there may be a significant increase in ECAA loans that achieve energy savings attributable to SB 350. Beginning 2019 through 2029, the aggressive case estimates that approximately 30 percent of the program savings may go beyond the Demand Forecast and can be captured as SB 350 savings potential.

Results:

Based on the analysis, the ECAA program has the potential to contribute a relatively small amount of energy savings to SB 350, due to the nature of much of the savings assumed to have already been counted by the Demand Forecast. To avoid double-counting, the NORESCO team applied an overall conservative approach in estimating savings potential in all of the scenarios, even if the program may receive new funding from SB 110. In order to evaluate the full potential of ECAA in the framework of SB 350, this analysis will require more data to show the extent of which program savings have been claimed by the Demand Forecast through 2029, so that any savings counted towards SB 350 would meet the "incremental" requirement.

Table B-19: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for ECAA

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029

Elec (GWh)	-	-	-	-	1.0	2.1	3.1	4.1	5.1	6.1	7.1	8.0	9.0	9.9	10.7
NG (MM therms)	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1

Source: California Energy Commission staff.

PROPERTY ASSESSED CLEAN ENERGY (PACE)

Program Description:

Property assessed clean energy (PACE) is a financing program that provides property owners with alternative financing options to fund energy efficiency, renewable energy, and water conservation upgrades on existing and new residential and commercial buildings. In California, the first commercial and residential PACE programs were created in 2008[252]. This financing program is offered by private lenders; hereafter referred to as PACE providers, and does not rely on public funding. PACE is designed to provide viable financing options to increase adoption of energy efficiency, renewable energy, and water conservation measures throughout California. Property owners of residential and commercial buildings can finance up to 100 percent of the project costs for qualifying projects through PACE. The fundamental mechanism of PACE relies on the existing framework of building property taxes whereby the entire loan, including principal and interest, can be repaid through a special tax assessment made on the property where energy projects are implemented. Loan payments can be amortized for a period of up to 20 years, with an option to extend payback period as necessary. By leveraging property taxes, the property improvements funded through PACE will be associated with the physical properties rather than the borrowers. In addition, the loan can be transferred between property owners at the time of sale or ownership transfer. Furthermore, the interest may be tax deductible. According to several PACE providers, the following features are representative of the key benefits of PACE:

- Long-term, fixed-rate financing
- No down payment required
- Financing terms independent of credit history
- Non-recourse, no financial covenants
- Easy credit approval
- Fully transferable and assignable upon sale

252 Kaat, Joe, *et al.* Residential and Commercial PACE Financing in California Rooftop Solar Challenge Areas. October 2014.

- Repaid through property taxes
- Treated as an operating expense and available for pass-through to tenant
- Available in active PACE participating districts in California

PACE financing is only available in participating districts where the private lenders have established legal agreements with cities and counties to channel the loan repayment through property taxes. This may be one of the limitations in the statewide adoption rate of PACE, although the number of PACE providers is on the rise. There are currently 19 PACE providers in California available to both residential and commercial property owners[253]. The number of projects funded by PACE is higher for residential than for commercial, primarily due to the simplicity in ownership for residential buildings. The complexity of commercial buildings may arise from the variance in owners, investors, lease holders, lease terms, and other factors that inhibit the adoption of PACE financing for improvement projects.

Despite the potential wide reach of PACE financing, the PACE providers are not currently required by law to publish any loan and project data. To address the lack of statewide data pertaining to PACE, ongoing legislative actions have been in place to advocate for more data reporting requirements. Senate Bill 242 B 242 (Skinner, Chapter 484, Statutes of 2017) (SB 242)[254] is one of the more prominent bills that include data reporting clauses. SB 242 has undergone several iterations since it was introduced in February 2017. In its current form, SB 242 primarily serves as a consumer protection bill, which outlines several parameters for how the PACE provider needs to communicate to the consumer and what type of disclosures need to be provided. There are, however, several aspects of the bill that relate to data collection. This bill only applies to residential properties with four or fewer units and does not apply to public agencies that administer PACE programs without a public administrator to administer a PACE program.

This bill makes modeling efforts in future years much easier sincethe Energy Commission can collect the data reported to local jurisdictions.

Excerpt from SB 242, Chapter 29.1, Part 3, Division 7, Streets and Highways Code § 5954:

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253 Center for Sustainable Energy®. PACE Searchable Database. California. State of California. 2016.

http://energycenter.org/policy/property-assessed-clean-energy-pace

254 Senator Skinner. "SB-242 Property Assessed Clean Energy Program." California Legislative Information. February 6, 2017. Available online at https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB242

For each PACE program that it administers, a program administrator shall submit a report to the public agency no later than February 1st for the activity that occurred between July 1st through December 31st of the previous year, and another report no later than August 1st for the activity that occurred between January 1st through June 30th of that year. Those reports shall contain the following information, along with all methodologies and supporting assumptions or sources relied upon in preparing the report:

- The number of PACE assessments funded, by city, county, and ZIP Code
- The aggregate dollar amount of PACE assessments funded, by city, county and ZIP Code
- The average dollar amount of PACE assessments funded, by city, county, and ZIP Code
- The categories of installed efficiency improvements whether energy or water efficiency, renewable energy, or seismic improvements, and the percentage of PACE assessments represented by each category type, on a number and dollar basis, by city, county and ZIP Code
- The definition of default used by the program administrator
- For each delinquent assessment:
    - The total defaulted amount
    - The number and dates of missed payments.
    - ZIP Code, city, and county in which the underlying property is located
- For each defaulted assessment:
    - The total defaulted amount
    - The number and dates of missed payments
    - ZIP Code, city, and county in which the underlying property is located
    - The percentage the defaults represent and the total assessments within each ZIP Code
    - The total number of parcels defaulted and the number of years in default for each property
- The estimated total amount of energy saved, and the estimated total dollar amount of those savings by property owners by the efficiency improvements installed in the calendar year, by city, county, and ZIP Code. In addition, the report shall state the total number of energy savings improvements, and number of improvements installed that are qualified for the Energy Star program of the

United States Environmental Protection Agency, including the overall average efficiency rating of installed units for each product type.

- The estimated total amount of renewable energy produced by the efficiency improvements installed in the calendar year, by city, county, and ZIP Code. In addition, the report shall state the total number of renewable energy installations, including the average and median system size.
- The estimated total amount of water saved, and the estimated total dollar amount of such savings by property owners, by city, county, and ZIP Code. In addition, the report shall state the total number of energy savings by property owners, by city, county, and ZIP Code. In addition, the report shall state the total number of water savings improvements, the number of efficiency improvements that are qualified for the WaterSense program of the United States Environmental Protection Agency, including the overall average efficiency rating of installed units for each product type.
- The estimated amount of greenhouse gas emissions reductions.
- The estimated number of jobs created.
- The average and median amount of annual and total PACE assessments based on ZIP Code, by city, county, and ZIP Code.
- The number and percentage of homeowners over 60 years old by city, county, and ZIP Code.
    - All reports submitted pursuant to this section shall include only aggregate data, and shall not include any nonpublic personal information.
    - A public agency that receives a report pursuant to this section shall make the data publicly available on its Internet Web site
    - This section does not limit another governmental or regulatory entity from establishing reporting requirements.

Buildings Affected:

The PACE financing program is primarily available to residential and commercial property owners. It may also be available to public or municipal properties depending on local jurisdiction. As such, the following building types will be considered, as primary and secondary, for the purpose of this analysis:

- Residential (primary)
- Commercial (primary)

- Municipal (secondary)

However, currently not all buildings in California in the residential, commercial and public sectors are affected by PACE due to the limited number of participating cities and counties. It may be reasonable to assume that PACE will become available statewide in all regions, since the program has expanded rapidly in the past few years and is continuing to expand. Many districts are in the process of offering PACE in their areas. Amongst the building sectors affected by PACE, those with the following circumstances may be ideal candidates for this financing program:

- Routine building improvements
- Recent property acquisitions
- Large tenant improvement projects
- New construction and redevelopment

Methods

Relevant Measures:

Eligible measures that can be financed with PACE may vary by PACE providers. In many jurisdictions, energy audits are recommended though not required for residential applications, whereas ASHRAE-level energy audits are often required for commercial buildings. Since the basis of PACE is on property valuation, the qualification of energy measures prioritizes building improvements that are permanently affixed to a property and can reduce on-site electric, gas or water consumption. As measures are approved by local PACE providers and may vary across districts, there is not a comprehensive list of measures available that applies to all districts. Below is a list of common measures:

- Building Envelope
- Attic insulation
- Building insulation
- Air Sealing and Ventilation
- HVAC equipment and controls
- Building control systems
- Lighting equipment and controls

- Daylighting
- Water heating
- Refrigeration
- Compressed air
- EV charging stations
- Elevator modernization
- Cool Roofs
- Cogeneration

Note that renewable generation measures are not included because they do not contribute to reducing electricity and natural gas consumption. The list of relevant measures may also include water conservation measures that reduce pumping load which in turn achieves energy savings. Further analysis will be necessary to understand the scope of water conservation measures.

Data Sources:

The process of data collection and analysis relies on the program insight provided by the Energy Commission, Center for Sustainable Energy (CSE), and other publicly available information. The lack of statewide reporting mandates enforced on PACE has limited the availability of project data with energy savings reported by measure. Further outreach and data collection efforts will be necessary to expand the breadth and depth of the data sources used for this analysis. An overview of relevant data sources used for this study is summarized below.

- Residential PACE in California: Feasibility of Studying Impacts on Mortgage Performance and Energy Savings[255]: This feasibility study is published by Lawrence Berkeley National Laboratory (LBNL) to assess the overall performance of the residential PACE activity statewide. The study states a list of objectives including (1) categorize residential PACE activity in California, (2) establish research questions relevant to PACE, and (3) identify data sources required to address the research questions, (4) identify existing data available, and (50 make recommendations on future PACE studies. However, the study does not provide concrete project or savings data that can be leveraged for this analysis. The NORESCO Team may apply

[255] Fadrhonc, Emily Martin, *et al.* Lawrence Berkeley National Laboratory. Residential PACE in California: Feasibility of Studying Impacts on Mortgage Performance and Energy Savings. January 2016.

findings of this study to establish outreach efforts and scenarios development in Phase 2/3 of this analysis.

- California State Treasurer PACE Loss Reserve Program[256]: This is a residential program that reports on residential projects enrolled into the PACE Loss Reserve Program, administered by the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA). Under this program, the PACE providers are required to report on the size and status of their portfolios on a semi-annual basis for all participating residential projects. Although this data source only represents a subset of all residential projects within the PACE framework and does not include commercial, the data available present a reference point for annual enrollment, funding and energy savings for the residential sector. The NORESCO team extracted information from the following available data parameters to support SB 350 analysis:
    - Annual kWh savings by PACE provider (2014-2016)
    - Annual therm savings by PACE provider (2014-2016)
    - Annual MT CO_2 savings by PACE provider (2014-2016)
    - Annual self-generation in kWh by PACE provider (2014-2016)
    - Annual total enrollment applications (2014-2016)
    - Annual total PACE financing amount (2014-2016)

- PACENation Market Data[257]: This data source aggregates commercial and residential statistics for PACE programs implemented throughout the United States. Most data points are reported on a national level, while a few select parameters are reported at the state level. The NORESCO team extracted information from the following available data parameters to the refinement of savings estimates in Phase 2/3 of this analysis:
    - Commercial:
        - Total financing approved nationwide
        - Total financing approved in California

256 California State Treasurer John Chiang. PACE Loss Reserve Program. State of California. June 30, 2016. Available online at http://treasurer.ca.gov/caeatfa/pace/activity.asp

257 PACENation. "PACE Market Data." Accessed May 2017. Available online at http://pacenation.us/pace-market-data/

        - Number of projects financed through PACE
        - Percent by project type (energy efficiency, renewable energy, mix)
        - Percent by building type (office, retail, etc.)
        - Annual funding amount (2010-2016)
    - Residential:
        - Total financing approved nationwide
        - Total financing approved in California
        - Number of projects financed through PACE
        - Percent by project type (energy efficiency, renewable energy, mix)
        - Annual funding amount (2010-2016)

- Residential and Commercial PACE Financing in California[258]. This paper provides a high-level overview of the PACE program, enabling policies and case studies. From the case studies that analyzed five PACE districts, the following data may be extracted to a varying extent:
    - Total funded amount in a defined period
    - Total bill savings in a defined period
    - Total energy savings in a defined period
    - Types of measures, if specified
    - Percent of loans for energy efficiency vs. renewable energy, if specified

- PACE districts searchable database[253]. There is a public web database available that can search for PACE district by address and shows a comprehensive list of active PACE districts in California.

- California HERO Public Stats[259]. Through Center for Sustainable Energy, there may be public statistical data available for specific PACE providers. Data that can be extracted may include:

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[258] Kaat, Joe, *et al.* Residential and Commercial PACE Financing in California Rooftop Solar Challenge Areas. October 2014.

[259] CaliforniaHERO PACE Program. PACE Statistics on Improvements and Lifetime Impact. 04/19/2017. http://www.herogov.com/faq

- Total funded amount in a defined period
- Total bill savings in a defined period
- Total energy savings in a defined period
- Quantity of applications submitted and approved in a defined period
- Percentage of improvements associated with energy efficiency versus other categories

Methodology:

The analysis of PACE focused on the energy efficiency component that can be used to establish energy savings potential through 2029. There appears to be significant potential for PACE to continue to penetrate the residential market while increasing saturation in the commercial sector.

The data sources identified was leveraged to produce initial savings estimates and refined savings estimates as described below. The analysis of this program was conducted through a phased approach as follows:

Approach:

Phase 1 Approach: Generate top-down estimates of the savings potential for the program. For this phase, the NORESCO team performed the following calculations and employed a set of assumptions to project the energy savings potential from 2015 through 2029.

- The lack of statewide reporting mandates enforced on PACE limited the availability of project data with energy savings reported by measure. Further outreach and data collection efforts will be necessary to expand the breadth and depth of the data sources used for this analysis.
- The Energy Commission and the NORESCO team identified some high-level statistics published by various PACE programs that can be used to generate initial savings estimates. However, the high-level statistics only represent a subset of the current PACE market. More data will need to be collected and analyzed to consider the entire market potential.
- Since the PACE data sets include both energy efficiency and self-generation projects, this analysis extracted the energy efficiency-only data to serve as basis of the savings projections.

- Due to limited project data, the SB 350 savings projections for Phase 1 were assumed to continue at a constant level based on the annual energy savings data reported by the CAEATFA PACE Loss Reserve Program for residential projects. This method took a conservative approach in leveraging existing data that only represents a subset of the residential market and a subset of the PACE programs.
- There is no comprehensive PACE data set available to indicate energy savings by building sector at the project level.
- The CAEATFA data consists of a subset of residential projects and does not cover the entire residential portfolio of PACE projects in California.
- Phase 1 savings projections are conservative and will be refined in Phase 3 with more scenarios and funding trends.

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: The NORESCO team conducted further outreach and data collection efforts and refined the results of Phase 1 to the extent possible using the additional data found to support energy savings estimates for this program. Outreach efforts included the following:

- Contacted PACE providers with no success in collecting project data.
- Confirmed the challenge in collecting statewide data for PACE.
- Interviewed the PACE Loss Reserve Program point of contact from CAEATFA and confirmed the following information:
    - CAEATFA data are subject to public records
    - CAEATFA only collects aggregate data available as published on the web
    - CAEATFA has not collected any project-level data from PACE providers
    - CAEATFA has observed as a general trend that PACE data is very limited
    - CAEATFA conducts outreach to recruit residential PACE providers, currently with 17 out of approximately 20 residential PACE providers enrolled in PACE Loss Reserve Program
    - CAEATFA defines residential buildings as "3 units or less" units
    - Some PACE providers report lifetime savings to CAEATFA, while some report annual savings.
    - CAEATFA does not verify energy savings reported by PACE providers, but instead uses high-level estimates from Energy Protection Agency (EPA) to gauge the order of magnitude of the data.

    - CAEATFA refers to PACENation for general market data, since a group of PACE providers participate on the Board of PACENation and provide aggregate data for commercial and residential overview of PACE projects nationwide.
- Reached out to contacts at Lawrence Berkeley National Laboratory (LBNL) with no success in collecting project data, but they recommended CAEATFA and PACENation as data sources, which had already been used for the analysis

Given the lack of additional project savings data, the NORESCO team built upon previous analysis and refined top-down estimates of the savings potential from 2015 through 2029 by applying the following methodologies:

- Estimated total annual savings in electricity and gas from the aggregate savings data published by CAEATFA PACE Loss Reserve Program[260], which only covers residential programs enrolled in the program as of June 30, 2016.
- Extrapolated total annual savings in electricity and gas for the entire residential market by applying data statistics about residential PACE providers[261] provided by CSE.
- Extrapolated nonresidential savings by using the market data published by PACENation[262], coupled with the residential data derived from the CAEATFA reports.

The NORESCO team further adjusted the savings estimates as follow:

- Accounting for Measure Savings Decay. The NORESCO team applied the approach described in the Phase 2 deliverable memo to account for measure savings decay. Weighting factors by measure category, which were based on detailed measure data collected through the Proposition 39 program, were assigned as follows: 21.5% HVAC equipment, 3.2% HVAC control equipment, 8.6% HVAC operation, 53.9% lighting equipment, 4.8% lighting control equipment, and 8% other.
- Updating Ratepayer Program Overlap Assumption. According to the CPUC, the utilities currently do not claim savings from this program. However, the projects

260 California State Treasurer John Chiang. PACE Loss Reserve Program. State of California. June 30, 2016. Available online at http://treasurer.ca.gov/caeatfa/pace/activity.asp

261 Center for Sustainable Energy®. PACE Searchable Database. California. State of California. 2016.

http://energycenter.org/policy/property-assessed-clean-energy-pace

262 PACENation. "PACE Market Data." Accessed May 2017. Available online at http://pacenation.us/pace-market-data/

funded by this program likely receive utility incentive and may be claimed by IOU/POU as ratepayer savings. Due to the lack of utility incentive information in the data sources, this analysis assumed that the ratepayer savings overlap will be 4% based on the project data from Proposition 39. The savings estimates for this program therefore subtracted 4% from the raw projections prior to further adjustments. As more overlap data become available for this program, the results shall be updated accordingly.

- Updating Market Saturation Adjustments. The NORESCO team did not make adjustments to account for market saturation, as the savings potential of the building sectors relevant to this program likely will not saturate through 2029.
- Analyzing Additional Scenarios. The results of this analysis represented the "reference" case where savings estimates were projected assuming a consistent trend of funding or policy requirements. The "reference" case then served as the basis for a more "conservative" and a more "aggressive" case, assuming variations in funding or policy requirements.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

Reference Case: This scenario assumed that the combined residential and nonresidential savings, which were extrapolated from 2016 data, will continue at a constant trajectory to achieve the same level of annual savings through 2029.

Conservative Case: This scenario assumed that the combined residential and nonresidential savings, which resulted from data extrapolation as described above, will result in 50% less savings if the project data were available for a formal verification process. This assumption factored the uncertainly in data reported by PACE providers, when they are not bounded to supply detailed project data.

Aggressive Case: This scenario assumed that the combined residential and nonresidential savings, which were extrapolated from 2016 data, will experience an exponential growth to reflect the corresponding growth in PACE financing data as reported by PACENation. As a result of this assumption, the annual savings increased exponentially beginning 2018 through 2029, assuming that 2017 followed the same funding level as 2016.

Results:

The results of this analysis reveals that the PACE financing program demonstrates a large potential in achieving energy savings attributable to SB 350. This finding illustrates the wide impact that PACE could have on promoting energy efficiency projects across the residential and commercial building stocks. The capitals enabled by PACE financing may serve as a market driver to implement energy efficiency projects that customers would not be able fund otherwise. However, as described above, there are inherent political concerns involving consumer protection and data reporting that remain in place, calling to question the extent of growth that PACE will experience through 2029 if the political issues were not addressed appropriately.

Table B-20: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for PACE

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	531	1,062	1,594	2,103	2,611	3,120	3,617	4,114	4,590	5,060	5,509	5,958	6,404	6,850	7,296
NG (MM therms)	0.8	1.6	2.4	3.2	4.0	4.8	5.5	6.3	7.0	7.7	8.4	9.1	9.8	10.5	11.2

Source: California Energy Commission staff.

WHOLE-BUILDING DATA ACCESS, BENCHMARKING, AND PUBLIC DISCLOSURE (AB 802)

Program Description:

AB 802[263] contains provisions requiring utilities to provide whole-building energy use data access to building owners on request and directing the Energy Commission to develop regulations for benchmarking and public disclosure of energy performance data for certain buildings; these regulations are currently under development. Giving decision makers access to actionable building performance data (along with a clear metric for energy performance, such as the ENERGY STAR score in the U.S. Environmental Protection Agency's ENERGY STAR Portfolio Manager[264]) is expected to result in cost-effective energy efficiency improvements via behavioral and operational improvements as well as building improvements. Mandatory state-wide benchmarking first appeared in California in 2007 with the passage of Assembly Bill 1103 (Saldana, Chapter 533, Statutes of 2007). AB 1103 required the owner or operator of a nonresidential building to disclose benchmarking information for the building to a prospective buyer, lessee, or lender. AB 802 repealed this requirement. Other provisions in AB 802 shift the way utilities provide rebates and claim energy efficiency savings by allowing programs to incentivize (1) all energy savings, including those resulting from a building being brought up to code[265], and (2) energy efficiency achieved through behavioral and operational efficiency interventions (BROs). AB 802 also allows the Energy Commission to receive account-level energy use data from utilities.

Proposed Regulations:

The Energy Commission has proposed regulations that would implement the benchmarking and public disclosure provisions of AB 802. Specifically, the regulations would require the owners of most commercial and residential buildings larger than 50,000 square feet to report building-level energy performance information to the Energy Commission annually, with commercial buildings beginning in 2018, and residential buildings beginning in 2019. The Energy Commission would publish this

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263 Williams, Chapter 590, Statutes of 2015

264 Energy Star. PortfolioManager. April 2017. Available online at: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager

265 Prior to AB 802, utility rebate programs could only claim savings for above-code improvement in repair-eligible equipment

information on a public website. The increased availability of energy performance information would help:

- Potential buyers and lessees better understand buildings they are considering purchasing or leasing.
- Policy makers and planners make better-informed decisions.
- Energy service companies target their services.

Under the proposed regulations, local jurisdictions with benchmarking and public disclosure ordinances would be allowed to apply to the Energy Commission for a determination that, if granted, would exempt building owners who report to a local jurisdiction from also reporting to the Energy Commission.

Assessment and Opportunities for Improvement:

Once the program has been implemented, the Energy Commission will analyze the results and consider program enhancements, which could include:

- Expanding the population of buildings included in the program, for example by decreasing the minimum building size (currently 50,000 square feet).
- Requiring action beyond benchmarking and reporting, for example by requiring building owners to complete energy audits. San Francisco, Berkeley, and Los Angeles all require energy audits in addition to benchmarking.)

Support for Local Programs:

At this time, San Francisco, Berkeley, and Los Angeles have ordinances requiring benchmarking, reporting, and audits. Energy savings from these early adopters are not estimated in this report, but will be considered in future updates. Increased access to building-level energy use information will make it easier for jurisdictions to create their own ordinances. As local ordinances with requirements exceeding the state-wide requirements (for example, by including smaller buildings or by requiring audits or retro-commissioning) become more common, the role of the Energy Commission could shift from primarily that of the implementer of the state-wide program to that of an advisor to local governments on matters including:

- Designing and implementing a benchmarking and disclosure program.
- Aligning data transfer protocols with state and national standards.
- Encouraging building owners to go beyond what is required for compliance (benchmarking or completing an audit) to performing retro-commissioning or implementing cost-effective improvements to buildings and equipment.

Buildings Affected:

The owners of commercial buildings larger than 50,000 square feet, and residential and mixed-use building larger than 50,000 square feet with more than 16 utility accounts, will be required to report building and energy use information to the Energy Commission annually.

Methods

Relevant Measures:

This program has the potential to improve building energy efficiency through a wide array of measures spanning the full range of building systems. Any measure category for which an existing baseline condition exists that fails to meet current code-minimum requirements creates an additional opportunity for below-code energy savings. The types of programs that would result in behavioral and operational efficiency interventions include, but are not limited to (1) building operator certification, (2) HVAC control retrofit, (3) lighting control retrofit, (4) building information and energy management systems, and (5) tenant engagement.

Data Sources:

- CEC Benchmarking Calculation. Energy Commission staff collaborated with NORESCO to generate a calculation method that estimates energy savings through 2021 based on policy outlooks, and projects savings from 2022 through 2029 based on other factors. The calculation was reviewed and adopted for this analysis.
- AB 802 Technical Analysis. Navigant produced a comprehensive report (and associated results viewer) that details the additional savings opportunities that

AB 802 makes available to utility rebate programs, including BROs savings and additional below-code savings[266].

- 2018 Potential and Goals Study. This analysis references the CPUC potential and goals analyses for 2018[267]. The impacts of AB 802 from an IOU standpoint with respect to BROs savings and additional below-code savings will be captured as part of that effort. A parallel effort for POUs is underway as well.
- Resources for the Future: Energy Benchmarking and Disclosure. This paper[268] summarizes the outcomes of a December 2014 workshop that included representatives from electric utilities, the real estate sector, ESCOs, energy data analytics companies, academia, and government and non-government organizations. The focus of the workshop was to characterize existing benchmarking and data disclosure programs and assess the ability of such programs to generate energy savings and reduce greenhouse gas emissions.
- Department of Energy: Benchmarking & Transparency Policy and Program Impact Evaluation Handbook. This handbook[269] is designed as a 'how-to guide' for assessing the impact of benchmarking and transparency (i.e., data disclosure) policy. Analysis methods are presented along with clear steps and data requirements. The presented methodologies provide means for estimating energy savings over time and identifying the component of savings directly attributable to the benchmarking and transparency policy.
- Institute for Market Transformation: Energy Benchmarking and Transparency Benefits. This fact sheet[270] provides a high-level overview of energy benchmarking and transparency, including savings estimates.
- Institute for Market Transformation: The Benefits of Benchmarking Building Performance. This report[271] provides a more in-depth assessment of the wide-ranging benefits of building benchmarking policies, including energy savings,

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266 California Public Utilities Commission. "2018 Potential & Goals Study." April 2017. Available online at: http://www.cpuc.ca.gov/General.aspx?id=6442452619

267 California Public Utilities Commission. "2018 Potential & Goals Study." April 2017. Available online at: http://www.cpuc.ca.gov/General.aspx?id=6442452619

268 O'Keeffe, Palmer, Walls, Hayes. 'Energy Benchmarking and Disclosure: Summary of a Workshop on City Experiences, Market Impacts, and Program Evaluation,' March 2015.

269 Navigant, Steven Winter Associates. 'Benchmarking & Transparency Policy and Program Impact Evaluation Handbook,' May 2015.

270 Institute for Market Transformation. "Energy Benchmarking and Transparency Benefits." June 2015. Available online at: http://www.imt.org/uploads/resources/files/IMTBenefitsofBenchmarking_Online_June2015.pdf

271 Institute for Market Transformation. "The Benefits of Benchmarking Building Performance." December 2015. Available online at: http://www.imt.org/uploads/resources/files/PCC_Benefits_of_Benchmarking.pdf

market competition, government efficiency, job creation, and other indirect economic, environmental, and health benefits.

- U.S. EPA: ENERGY STAR Benchmarking and Energy Savings. This fact sheet[272] details trends in building performance improvement (both in terms of energy use reduction and ENERGY STAR score increase) associated with the use of the ENERGY STAR Portfolio Manager to track and manage energy use.
- Benchmarking Tools that NORESCO Prepared for the City of Boulder. To facilitate the data-reporting requirements of the City of Boulder Energy Ordinance, NORESCO developed guidance for entering information into Portfolio Manager and reporting results to the city using a unique Building ID. Additional how-to guides were developed with respect to energy assessments, retro-commissioning, and an Energy Use Estimator.[273]
- LBNL: Evaluation of U.S. Building Energy Benchmarking and Transparency Programs: Attributes, Impact, and Best Practices. This report[274] provides a summary of benchmarking and transparency programs across the country, including report results and impacts, focusing on the efforts of 24 states and local jurisdictions.

Methodology:

This benchmarking analysis will focus on savings specifically associated with benchmarking and public disclosure. Because no program-specific data is available, the research-based data sources listed above will be leveraged to make reasonable estimates for energy savings that can be attributed to the AB 802 benchmarking and public disclosure requirements. There is a general expectation that the majority of savings that can be attributed to benchmarking and data disclosure will ultimately be realized through financing or incentive programs. The analysis of this program will be conducted through a phased approach as follows:

Approach:

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272 Energy Star. PortfolioManager. "Benchmarking and Energy Savings." October 2012. https://www.energystar.gov/sites/default/files/buildings/tools/DataTrends_Savings_20121002.pdf

273 City of Boulder, Colorado. "Boulder Building Performance – How to Apply." April 2017. https://bouldercolorado.gov/sustainability/boulder-building-performance-how-to-comply

274 Berkeley Lab, Electricity Markets Policy Group. "LBNL Benchmarking." May 2017. https://emp.lbl.gov/sites/default/files/lbnl_benchmarking_final_050417.pdf

Phase 1 Approach:

- Floor area data by building type were extracted from IEPR building stock data. For multifamily buildings, IEPR data capture number of households. To convert number of multifamily households, the research team followed the same assumptions leveraged by the 2016 Impact Analysis Report[275]: 26 percent of multifamily households are high-rise units with a floor area of 1,248 ft^2; the remaining households are contained within 6,960 ft^2, two-story, 8-dwelling buildings (870 ft^2 per unit).
- Distribution of nonresidential floor area by building type and size was collected from 2012 CBECS[276]. Data were collected to determine what fraction of floor area by building type is expected to be contained within buildings larger than 50,000 ft^2.
- The research team assumed that 30 percent of multifamily households are contained within buildings larger than 50,000 ft^2 (the 26 percent that are included in high-rise buildings plus a small additional percentage).
- Nonresidential building energy use intensities (for electricity and gas, separately) were extracted from the California Commercial End-Use Survey (CEUS)[277]. To account for the age of CEUS data, values were updated according to the ratio of energy use data captured by 2012 CBECS and 2003 CBECS[278] (ratios were calculated for each combination of fuel and building type).
- Multifamily building energy use intensities (for electricity and gas, separately) were extracted from the California Statewide Residential Appliance Saturation Study (RASS) for 2009[279].
- Annual benchmarking savings are derived from data collected from 2008 to 2011 for buildings in ENERGY STAR Portfolio Manager. While ENERGY STAR reports 2.4 percent annual savings, the data seem to indicate diminishing year-

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275 NORESCO; Nittler, Ken. "Impact Analysis: 2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings," 2015.

276 US Energy Information Administration. "2012 CBECS Survey Data." Available online at: https://www.eia.gov/consumption/commercial/data/2012

277 Itron. California Commercial End-use Survey. May 2017. Available online at: http://capabilities.itron.com/CeusWeb/Default.aspx

278 US Energy Information Administration. Available online at: "2003 CBECS Survey Data." Available online at: https://www.eia.gov/consumption/commercial/data/2003/

279 DNV-GL. "California Statewide Residential Appliance Saturation Study." 2010. Available online at: https://webtools.dnvgl.com/rass2009/

after-year returns[280]; accordingly, the NORESCO team's savings estimates are based on a logarithmic data fit that assumes savings decrease in out years once the low-hanging fruit have been harvested. Based on a 60/40 distribution between electricity and gas across the nonresidential and multifamily building stock, the NORESCO team assumes that the majority of savings due to benchmarking would be electricity savings. Based on a 60/40 distribution between electricity and gas across the nonresidential and multifamily building stock, assuming first-year benchmarking savings of 3.9 percent for electricity and 1.3 percent for gas results in an 80/20 split between electricity and natural gas savings and total savings that align with the logarithmic fit to the ENERGY STAR data.

- The NORESCO team assumes that current financing and incentive programs could accommodate energy improvements resulting from benchmarking and public disclosure for 5 percent of eligible buildings each year[281].
- The research team assumes that 90 percent of benchmarking savings would ultimately be realized through a financing or incentive program (the other 10 percent are assumed to occur naturally according to the initiative of the building owner or operator). For this phase, to make a clear distinction between savings expected to be claimed by utilities and those expected to be attributed to programs run by the state, the NORESCO team assigned a portion of the 90 percent of benchmarking and public disclosure savings expected to be realized through financing and incentive programs to expected enhanced IOU and POU programs according to the ratio of projected cumulative IOU and POU savings (both known and expected) to the total projected cumulative savings across all programs. The remainder of benchmarking and public disclosure savings is currently attributed to this program itself; however, it may be appropriate in later phases to assign a portion of that savings to other state-run programs.

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: It is not straightforward to estimate the savings attributable to the benchmarking program, as the proposed regulations do not require building owners to take any action to reduce energy use; the regulations would only require building

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280 The most significant opportunities for savings will be addressed first, leaving lesser opportunities for additional savings in future years.

281 In 2018, 5 percent of the existing building stock are assumed to start along the logarithmic savings curve (based on ENERGY STAR data); in 2019, that same 5 percent of the building stock continue to see savings (albeit somewhat reduced) while an additional 5 percent of the building stock start along the same savings curve.

owners to report energy performance information to the Energy Commission. However, the increased visibility of building energy performance the program provides may drive building owners and tenants to reduce energy use, either through making behavioral and operational changes, or through making building improvements.

- Energy Commission staff used investor-owned utility electricity sales as a portion of state-wide electricity sales[282] to estimate the portion of state-wide energy consumption in commercial and residential buildings[283] that is in investor-owned utility territories, then divided energy savings from investor-owned utility efficiency programs[284] by consumption to estimate percent savings from current participation in efficiency programs.
- Energy Commission staff assumed that participation in the benchmarking program would cause a doubling of the savings expected from participation in investor-owned utility energy efficiency programs in those buildings subject to the state-wide benchmarking and public disclosure program that are not already subject to a local mandatory benchmarking and public disclosure ordinance (which have more stringent requirements than the proposed state-wide program).
- Energy Commission staff's estimates of affected floor area are based on the proposed regulations, which only include commercial buildings larger than 50,000 square feet and residential buildings larger than 50,000 square feet with more than 16 utility accounts.
- To calculate consumption expected to be avoided due to the state-wide program, Energy Commission staff then multiplied the estimated savings rate by the estimated consumption in buildings subject to the program but not to local programs.
- NORESCO aligned near-term program savings with Energy Commission guidance. Farther out, an increased whole-building savings rate of 2 percent is assumed for the reference case. This savings rate is an aggregate rate of savings that can be expected to be attributed to the benchmarking program. This savings rate is

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282 *California Electric Utility Service Areas*, http://www.energy.ca.gov/maps/serviceareas/electric_service_areas.html, July 18, 2017

283 https://www.eia.gov/state/?sid=CA#tabs-2, July 18, 2017

284 http://eestats.cpuc.ca.gov/Views/EEDataPortal.aspx, July 18, 2017

somewhat lower than other recent studies[285, 286], due to expected overlap between programs and difficulties with attributing savings to benchmarking as distinguished from other programs.

Once savings for included buildings were determined, the NORESCO team applied a decay function to adjust the program savings levels. Compared to some programs, benchmarking is expected to have slightly below-average persistence, because it is typically easier to improve a building's performance rating over time by applying no-cost or low-cost measures, such as controls or operational changes. Measures such as major HVAC renovations are deemed less likely under this program. The decay causes the cumulative savings to decrease from 1,587 GWh to 1,348 GWh for electricity and 22.7 MM therm to 19.3 MM therm, a decrease of 15 percent to account for cumulative savings decay. Due to the projected increase in program participation and savings in 2022, there is a slight decline in annual savings in the subsequent year. However, the more important metric in estimating the effects of decay is the impact on cumulative energy savings.

The program estimates of decay are based on estimated savings shown in the table below. Measures that affect either controls or operations are expected to be disproportionately high, relative to other programs, given the potential for these measures to impact building ratings.

Decay inputs		
Measure Category	**Weighting**	**EUL (years)**
HVAC Equipment	5.00%	15
HVAC Control Equipment	15.00%	8
HVAC Control Operations	20.00%	3
Lighting Equipment	50.00%	15
Lighting Control	10.00%	8
Other	0.00%	10

285 Meng, Ting, D. Hsu and A. Han 2016. "Measuring Energy Savings from Benchmarking Policies in New York City," 2016 ACEEE Summer Study Proceedings, American Council for an Energy Efficiency Economy, Washington, D.C.

286 Mims, Natalie, et. al. 2017. "Evaluation of U.S. Building Energy Benchmarking and Transparenc7y Programs: Attributes, Impacts and Best Practices," Lawrence Berkeley National Laboratory, April 28 2017.

Total	100%	

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions:

For All Scenarios: The NORESCO team aligned estimates through 2021 with the Energy Commission's analysis.

Reference Case: The NORESCO team estimated savings for the reference case according to the analysis approach described above, by first aligning savings with Energy Commission projections through 2021. Beyond 2021, an aggregate whole-building savings level of 2 percent is assumed. This is somewhat conservative compared to other studies in other cities and jurisdictions, which show confirmed savings levels of 6 percent or higher.

Conservative Case: To calculate a more conservative program savings estimate, the NORESCO team assumed a whole-building average savings rate of 1 percent beginning in 2022.

Aggressive Case: To calculate a more aggressive program savings estimate, the NORESCO team assumed that year-over-year savings improvements could increase after certain durations of participation in the program; whole-building savings are increased to 2 percent beginning in 2022, and to 4 percent beginning in 2025. This increase is based on a scenario in which, given more time to assess the opportunities suggested by benchmarking data, building owners and operators would be better equipped to make more aggressive, more impactful decisions that could lead to increased energy savings.

Results:

Overlap with the baseline demand forecast is unlikely but overlap with ratepayer programs is possible. Because the Energy Commission's draft regulations have not yet been adopted, energy savings from them are not incorporated into the baseline forecast. Three cities in the state currently have local benchmarking programs; however, savings from those programs have been excluded by only projecting savings for buildings not subject to local benchmarking requirements. Ratepayer program savings may overlap with benchmarking energy savings because benchmarking is included in the measure list developed by Navigant as part of its IOU potential and goals study.[287] The NORESCO

[287] Navigant. *Energy Efficiency Potential and Goals Study for 2018 and Beyond.* June 2017.

team's current assumption is that the Energy Commission's analysis does not include any savings that would overlap with ratepayer or other programs.

Table B-21: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for Benchmarking and Disclosure

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	0.0	0.0	0.0	64.7	109.8	111.6	113.7	1394	1413	1438	1464	1351	1369	1394	1420
NG (MM therms)	0.0	0.0	0.0	0.7	1.2	1.3	1.3	19.9	20.2	20.6	20.9	19.3	19.6	20.0	20.3

Source: California Energy Commission staff.

BEHAVIORAL, RETROCOMMISSIONING AND OPERATIONAL SAVINGS (BROS) FROM 2016[288] THROUGH 2029

Program Description:

This program consists of energy efficiency measures that achieve energy savings through behavioral, retrocommissioning, and operational savings (BROS) with at least two- or three-year expected useful life into the 2018 Potential and Goals study (2018 PG)[289]. BROS programs target behavioral changes that result in energy savings (e.g., changes in thermostat set points, improvements that result in accomplishing the same work (e.g. space cooling) more efficiently, or reducing/eliminating energy use without relying on installation of new energy efficient technologies.

Buildings Affected:

BROS affect all market sectors, depending on the specific program target. Existing buildings are targeted more than new construction, where operational changes can result in energy savings without requiring expensive retrofits or equipment upgrades. The following building markets are impacted:

- Residential, primarily through behavioral programs, with small savings through competitions
- Non-residential, primarily through operational and retro-commissioning programs, with small savings through behavioral programs

288 Start year of analysis depends on Navigant's analysis period.

289 California Public Utilities Commission. "2018 Potential & Goals Study." June 2017. Available online at: http://www.cpuc.ca.gov/General.aspx?id=6442452619

- Public and private buildings

Methods

Relevant Measures:

To identify relevant measures, this study reviewed programs that Navigant has identified for the 2018 PG as well as additional program offerings from IOUs and POUs. Overall, this study found significant overlap with the 2018 PG programs, although the NORESCO team identified a small amount of additional savings potential from other possible BROS programs.

This study evaluated savings from the following programs.

*Indicates measures that Navigant is including in the 2018 PG.

Potential residential measures:

- Home Energy Reports*
- Challenge/Competitions*
- Residential Pay for Performance (P4P) – a PG&E pilot program that provides incentives for meter-based savings from behavioral changes and energy efficiency measures
- Manage Act Save – a SDG&E behavioral program that offers prizes for reaching energy efficiency goals
- A potential smart thermostat program

Potential commercial measures:

- Building Operator Certification (BOC)*
- Strategic Energy Management (SEM)*
- Building Energy Management and Information Systems (BEIMS)*
- Business Energy Reports (BERs)*
- Retrocommissioning (operations and controls solutions)*
- Challenge/Competitions*

This analysis excluded the following measures because they were included in other SB350 analysis

- Real-Time Feedback*: Online Portal and in-home Display: Included in the Smart Meter analysis
- Benchmarking*: Included in the Benchmarking analysis

In addition, this analysis investigated the following measures, but ultimately excluded them from the BROS analysis, because the NORESCO team found that the measures would not result in significant, reliable savings, or because savings would potentially overlap with other programs:

- Audits: Overlap with measure-based programs
- Green leases: Significant, reliable savings not identified
- Tenant-Operator Engagement (COMFY): Significant, reliable savings not identified
- Use of social media: Significant, reliable savings not identified, and potential overlap with behavioral programs and competitions
- Prepay (for example, mPower): Potential overlap with residential behavior programs

Data Sources:

This analysis used the following data sources:

- Navigant 2018 Potential and Goals (2018 PG) analysis, including supporting BROS documentation and studies, for current and projected savings from the Investor Owned Utilities (IOU)
- The Energy Commission report, Energy Efficiency in the Public Power Sector, 2017 ("EE in Public Power")[290], which describe savings from the Publicly Owned Utilities (POUs) for 2015 programs, and includes Appendix B which provides results of the POU potential study conducted by Navigant
- Interviews and communications with utility staff at PG&E, LADWP, and SMUD to discuss current and future BROS offerings
- Impact evaluation reports for the HER and MAS programs[291]

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290 Energy Efficiency in California's Public Power Sector 11th Edition — 2017

291 http://www.calmac.org/publications/DNVGL_PGE_HERs_2015_final_to_calmac.pdf, and http://www.calmac.org/publications/DNVGL_SDGE_HERs_2015_final_to_calmac.pdf

- Res P4P data program filing and data from EE Stats[292]
- A study describing results from a smart thermostat program in Oregon[293]
- Additional studies and evaluation reports, including:
- CIEE: Behavioral assumptions underlying energy efficiency programs for businesses[294]
- CIEE: Behavioral assumptions underlying California residential sector energy efficiency programs[295]
- See Change Institute: From Categorizing to Characterizing: A Landscape Analysis of Behavior-Based Energy Programs[296]

Methodology:

The analysis method for estimating BROS potential energy savings was to identify potential measures that can be offered in California, estimate savings potential, then determine feasibility and applicability to California participants. For Phase 1, the NORESCO team used representative measures with the best available data. During Phase 3, the NORESCO team refined those estimates, as well as included additional measures not assessed in Phase 1.

Approach:

Phase 1 Approach: To identify relevant programs for Phase I, the NORESCO team considered programs that Navigant identified for the 2018 PG as well as additional program offerings from IOUs, POUs, and third-parties.

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292 http://eestats.cpuc.ca.gov/Views/EEDataPortal.aspx, for the 2015-2017 program cycle

293 Lieb, Noah, "Thriller in Asilomar: Battle of the Smart Thermostats". ACEEE Summer Study 2016.

294 Sullivan, Michael, *et al.* "Behavioral Assumptions Underlying Energy Efficiency Programs for Businesses." CIEE. January 2009. http://www.calmac.org/publications/Behavioral_Assumptions_in_EE_Programs_for_Businesses_White_Paper.pdf

295 Lutzenhiser, Loren, et al. "Behavioral Assumptions Underlying California Residential Sector Energy Efficiency Programs." April 2009. https://energy.gov/sites/prod/files/2013/12/f6/ba_ee_res_wp.pdf

296 SeeChange Institute. "New Report: From Categorizing to Characterizing - A Landscape Analysis of Behavior-Based Energy Programs." April 3, 2017. https://www.seechangeinstitute.com/news/new-report-from-categorizing-to-characterizing-a-landscape-analysis-of-behavior-based-energy-programs

For Phase I, the NORESCO team included ten BROS programs from the 2018 PG study. These programs were not included in the Navigant 2015 AAEE workbook[297], so the team considered them to be incremental to savings included in the baseline wedge.

Table B-22 provides a list of the BROS programs included in this study's Phase I BROS analysis. The NORESCO team used the 2018 PG to develop assumptions for electricity and natural gas savings, and participation in these programs.

Table B-22: 2018 PGT BROS Programs included in the Phase I Analysis

Bldg Type (Res or Nonres)	Program Name (Abbreviation)	Program Summary
Res	Home Energy Report (HER)	Provides periodic mailings with feedback on home's energy use, normative comparisons to neighbors, and tips for improving energy efficiency
Res	Real-time Feedback: In home display (RT In home)	Uses advanced metering data to provide real-time electricity usage via an in-home display (IHD
Res	Real-time feedback: online portal (RT online)	Uses advanced metering data to provide real-time electricity usage via an online portal, such as a website or a smart phone application
Res	Small competitions (<10,000 people) (Small Comp.)	A small number of participants compete in energy- related challenges, events, or contests to reduce energy consumption either directly or through education;
Res	Large competitions (>10,000 people) (Large Comp.)	A large number of participants compete in energy-related challenges, events, or contests to reduce energy consumption either directly or through education
Res	Strategic Energy Management (SEM)	A continuous improvement approach that focuses on changing business practices to enable commercial and industrial companies to save money by reducing energy consumption and waste.

[297] The "AAEE CS Prog by Measure CED2015" workbook, sourced by California Energy Commission.

Nonres	Building Operator Certification (BOC)	Offers energy efficiency training and certification courses to commercial building operators
Nonres	Building Energy Management and Information Systems (BEMIS)	Provides IT-based monitoring and control systems that provide information on the performance of components of a building's infrastructure
Nonres	Business Energy Reports (BERs)	Provides small and medium businesses with mailings with feedback on energy use, normative comparisons to similar businesses, and energy saving tips (the commercial equivalent to HERs). 2018 PG assumes savings only for retail, lodging, restaurants, and "other".
Nonres	Retrocommissioning (RCx)	Commissioning to optimize performance of systems (primarily HVAC)

For Phase I, this study included three programs that were outside of the 2018 PG: (1) Smart Thermostat; (2) PG&E Pay for Performance (P4P), and (3) Advanced Metering Initiatives: Real-time Feedback.

Smart thermostat programs include initiatives that provide or incentivize smart thermostats – as in, devices that allow users to adjust the temperature remotely, use occupancy-based temperature management, automate settings, and provide other features to control and optimize thermostat settings. The NORESCO team used an ACEEE conference paper that described savings from an Energy Trust of Oregon program for smart thermostats to estimate savings (Lieb, 2016). Because the ACEEE paper only documented natural gas savings, the research team included only natural gas savings for Phase I. For Phase II, this research team will look for savings estimates for electricity savings, taking into account possible double-counting with other programs.

PG&E launched the P4P program as one of its High Opportunity Program and Projects (HOPPs). The P4P program works with Aggregators -- parties responsible for managing a portfolio consisting of numerous residential homes that receive energy efficiency interventions – to maximize energy savings from those sites. The Aggregators work directly with residential customers and contractors to achieve energy savings through retrofits in addition to operational and/or behavioral interventions. Aggregator payments are determined based on gross energy savings through a PG&E facilitated weather normalized pre/post analysis of each participating customer's metered energy consumption. PG&E pays each aggregator a set rate per therm and kWh. For Phase I, the NORESCO team took information on program savings and participation from the California Energy Data and Reporting System (CEDARS) (CPUC, 2017) and the HOPPs program filing (PG&E, 2016).

The NORESCO team used a meta-analysis conducted by the American Council for an Energy Efficient Economy (ACEEE) to estimate savings from advanced metering initiatives that provide real-time feedback, either through an on-line portal or in-home display (ACEEE, 2010). The savings documented in the ACEEE study from real-time feedback programs (4-6 percent) were higher than the savings estimated for the real-time programs in the 2018 PG (approximately 1-2 percent). As described in the Methodology section, the NORESCO team only counted incremental savings for the real-time feedback programs beyond the savings estimated in the 2018 PG for the real-time in-home display and real-time only programs.

The NORESCO team did not include savings from the following programs, because our initial data collection efforts did not identify documented savings from these programs. However, the NORESCO Team will conduct a more in-depth review for savings from these programs in Phase 3.

<u>Potential residential measures:</u>

- Audits
- Prepay (e.g. mPower)
- Community Based Social Marketing
- Social Media

<u>Potential commercial measures:</u>

- Commercial Challenge/Competitions
- Audits;
- CBSM - Community Based Social Marketing
- Green leases
- Tenant-Operator Engagement (COMFY)
- ISO 50001:2011 support for Energy Management Systems
- PG&E Step-up, Power-down
- PG&E Smart Choice

For the Phase I savings analysis, the NORESCO team used the assumptions shown in **Error! Reference source not found.** for savings, participation, and effective useful life (EUL) for BROS programs identified in the 2018 PG. The source for each assumption is indicated with a superscript letter (a, b, c, or d) described below the figure. As shown in **Table B-23**, this study primarily used the 2018 PG for savings and participation assumptions.

Table B-23: Savings Assumptions for BROS Programs Identified in the 2018 PGT

Program	% kWh Savings per participant (Range)	% Therm Savings per participant (Range)	Participation Assumption	EUL (years)
HER	1.5% (1-2.3%) [a]	0.6% (0.6-1.9%) [a]	1.6M in 2015[a]; participation increases according to population growth [b]	1 [b]
RT In-home	2.3%[b]	0.0% [b]	4%, with additional 8% growth annually [b]	1 [b]
RT Online	1.3%[b]	1.3%[b]	10%, with additional 8% growth annually [b]	1 [b]
Small Comp.	8.1%[b]	5.2%[b]	0.02%[b]	1 [b]
Large Comp.	4.1%[b]	5.2%[b]	115,000 in 2015[c]	1 [b]
SEM	3.0% [b]	3.5% [b]	1.0% [b]	5 [b]
BOC	63 per 1000 sf (18-151 per 1000 sf)[d]	6 per 1000 sf (0.8-14.2 per 1000 sf) [d]	1.18%, with additional 12.5% growth annually [b]	6.5 [b]
BEMIS	3% (0-4.2%) [d]	3.5% (0-7.4%) [d]	5.60% [b]	5 [b]
BERs	1.9% (1.6%-2.2%) [d]	0.9% restaurants [b]	1%, 1% increase each year [b]	2 [b]
RCx	4.7% (0-12.7%) [d]	4.7% (0-12.7%) [d]	1.28% [b]	5 [b]

- Savings vary for each IOU from 1-2.3 percent for kWh and 0.6-1.9 percent for therms. This study assumed the savings percentages for the PG&E HER program (1.5 percent kWh, 0.6 percent therms, based on the PG&E HER 2014 Impact Evaluation), because the PG&E HER program had significantly more participants than the SCE and SDG&E HER programs. For Phase 3, this study calculated savings specific to each IOU, and used the 2015 PG&E HER Impact Evaluation[298]. For the participation assumption, this study followed the 2018 PG and assumed that the number of

[298] Published on May 22, 2017, after development of this study's Phase I analysis.

participants in the 2015 HER programs would grow according to California population growth.

- Based on 2018 PG assumptions, as described in 2.PG Appendix - BROS Methodology_2017-04-13.
- Based on 2014 San Diego Gas & Electric Manage Act Save (MAS) participation numbers
- Based on 2018 PG assumptions. To identify an estimate with the range, this study averaged the values across all building types and Program Administrators (PAs). For Phase 3, this study calculated savings for each building type for each PA, and multiplied these by the estimated square footage of each building type in each PA territory.

For the Phase I savings analysis, the NORESCO team used the assumptions shown in **Error! Reference source not found.** for savings and participation for BROS programs identified outside of the 2018 PG. Because the research team did not identify estimates of savings persistence for these programs, this study used the conservative assumption of 1 year as the EUL for these programs.

- Smart Thermostat: The Energy Trust of Oregon study (Lieb, 2016) found 4.9-6 percent natural gas savings. Given that California has a milder climate than Oregon, the NORESCO team assumed half of the higher end savings: 6 percent / 2 = 3 percent. For participation, this study assumed 1 percent of households would participate based on industry judgment.
- AMI Real-time feedback: To estimate kWh savings per participant, the NORESCO team started with the ACEEE study findings, which found approximately 4 percent savings nationally. Because California is a mild climate compared with the rest of the U.S. (including a lower cooling load), the NORESCO team assumed 3 percent savings total from AMI real-time feedback. Because the 2018 PG assumed 1-2 percent savings from real-time feedback programs, the NORESCO team assumed an incremental savings of 1 percent for Phase I. For participation assumptions, the team used the 2018 PG assumption for in-home display programs of 4 percent, since this is more conservative than the assumption of 10 percent for on-line portals
- Res P4P: To estimate savings per participant, the NORESCO team used projections from the program HOPPs filing (PG&E, 2016). For the participation assumptions, the team assumed the number of participants from the HOPPs filing, and used our industry experience to assume that participation increases by 5 percent annually.

Table B-24: Savings Assumptions for BROS Programs Outside the 2018 PGT

Program	% kWh Savings per participant	% Therm Savings per participant	Participation Assumption	EUL (years)
Smart Thermostat	0%	3%	1%, with growth according to population growth	1
AMI Real-time Feedback	1%	0%	4%	1
Res P4P	6%	16%	2,000 households initially, with participation increasing by 5% annually	1

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: The NORESCO team analyzed energy savings that can be attributed to BROS measures through various POU and IOU programs. This analysis delineated energy savings that have been captured by the 2018 PG Study, which are assigned to the bottom wedge, from the energy savings that can be counted as "incremental" for SB 350.

This analysis assumed no gas savings from POU programs, since almost all POUs (including LADWP and SMUD) provide electricity only.[299] For POU electricity savings, the analysis consisted of the following:

- For 2015:
    - This analysis took BROS based on the Residential Behavioral programs from the EE in the Public Power Sector study. (Residential Behavior programs were the only BROS measures identified explicitly in the EE in the Public Power sector report, 2017.) The Residential Behavior savings were primarily comprised of SMUD HER savings, which currently serves 9 percent of SMUD households[300]. LADWP did not claim savings from residential behavioral programs in 2015 and is not currently operating HER, because their Instructional Technology department is addressing issues with its billing system. However, LADWP staff report that they intend to widely implement HER once the billing issue is resolved[301].

299 The City of Palo Alto Utilities (CPAU) provides gas, but this utility is relatively small. For example, CPAU's electricity savings comprised 1% of POU savings (Energy Efficiency in Public Power, 2017) so approximately 0.25% of statewide savings.

300 Personal communication from SMUD staff Richard Oberg, August 25, 2017

301 Interview with LADWP staff David Jacot, August 23, 2017.

- RCx: While the POUs have RCx measures, they are not delivered as a standalone RCx program, but rather as offerings in deemed and custom programs. Consequently, this analysis assumed the POUs' savings were the same as IOUs' RCx savings, adjusted by population – i.e., multiplied by 0.33, based on 25 percent of the population in POU territories / 75 percent in IOU territories[302].
- This analysis assumed no savings from other BRO programs, because most of the POUs (including the two largest - LADWP and SMUD) do not have other BROS programs, such as BIEMS, BOC, SEM, or commercial energy reports.
- For 2016-2018, this analysis assumed a 10 percent increase in HER savings annually, as POUs (except LADWP) increase penetration of the HER program. For RCx savings, this analysis assumed a similar incremental increase as the IOUs – 5 percent annually.
- For 2019, this analysis assumed a 25 percent increase in HER savings, based on the assumption that LADWP would launch its HER program and reach half of its eligible customers this year. This analysis also assumed POU savings from residential competitions that were the same as IOUs' RCx savings, adjusted by population – i.e., multiplied by 0.33. For RCx savings, this analysis assumed a similar incremental increase as the IOUs – 5 percent annually (as the NORESCO team did for 2016-18).

- For 2020, this analysis assumed another 25 percent increase in HER savings, based on LADWP reaching the other half of its eligible customers. For RCx savings, this analysis assumed a similar incremental increase as the IOUs – 5 percent annually (as the NORESCO team did for 2016-18). Because the Navigant POU Potential Study (Appendix B in EE in the Public Power Sector, 2017) assumed that commercial programs would expand in 2020 to 2021, the NORESCO team also assumed that the POUs would launch similar commercial BROS programs as the IOUs, so the NORESCO team assumed the same savings for BIEMs, BOC, BER, COM, and SEM as the IOUs, adjusted for population -- i.e., multiplied by 0.33.
- For 2021-2030, this analysis assumed that all POU BROS programs would have similar savings as IOU BROS, adjusted for population – i.e., multiplied by 0.33.

For IOU electricity savings beyond those captured by 2018 PG study, the analysis consisted of the following:

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302 CPUC presentation, "Customer and Retail Choice in California", Nicolas Chaset, May 10, 2017. Available at: http://energy.nv.gov/uploadedFiles/energynvgov/content/Programs/TaskForces/2017/Agenda%20item%204%20-%20California%20Presentation.pdf

- P4P Program: PG&E recently launched the P4P program as one of its High Opportunity Program and Projects (HOPPs). The P4P program works with aggregators -- parties responsible for managing a portfolio consisting of numerous residential homes that receive energy efficiency interventions – to maximize energy savings from those sites. The aggregators work directly with residential customers and contractors to achieve energy savings through retrofits in addition to operational and/or behavioral interventions. Aggregator payments are determined based on gross energy savings through a PG&E facilitated weather normalized pre/post analysis of each participating customer's metered energy consumption. PG&E pays each aggregator a set rate per therm and kWh. The NORESCO team took information on program savings and participation from the California Energy Data and Reporting System (CEDARS) (CPUC, 2017) and the HOPPs program filing (PG&E, 2016), to assume that 2,000 customers participated in 2015, with 6 percent electricity and 16 percent natural gas savings. For all other years (2016-2030), this analysis assumed a 5 percent increase in savings, due to a 5 percent increase in PG&E customers' participation. This analysis multiplied total P4P savings by 0.5 to estimate that half the savings would be behavioral, and the other half measure-based (which are already accounted for in deemed programs).
- MAS Program: The MAS program is an SDG&E residential behavioral program that provides comparative reports via mail or email and personalized tips on how to save energy and information regarding their energy usage. Customers earn points by completing the suggested tips, saving energy and enrolling in other SDG&E programs, and can redeem points for products or experience awards. The 2018 PG study did not include savings from MAS, but the 2018 PG study assumes savings from residential competitions beginning in 2019. Consequently, the NORESCO team assumed the savings values for MAS from the 2015 impact evaluation of the program for SDG&E for 2015-2018. Beginning in 2019, the NORESCO team assumed zero savings from MAS, based on the assumption that MAS would be phased out and replaced with a residential competition program that is already included in the 2018 PG. This analysis assumed that all savings would be behavioral and did not apply an adjustment factor for measure-based savings, since the most recent impact evaluation found little overlap with deemed or upstream programs.[303]

Table B-25: Savings Assumptions for BROS Programs Outside the 2018 PGT

Scenario	Program	% kWh Savings per participant	% Therm Savings per participant	Participation Assumption	EUL (years)

[303] http://www.calmac.org/publications/DNVGL_SDGE_HERs_2015_final_to_calmac.pdf, Table 40.

Reference, Aggressive, and Conservative	MAS: Source: MAS Impact Evaluation[304]	1%	0.4%	Reference and Aggressive: 200,000 households for 2015-2018, 0 in 2019 (replaced with other behavioral programs) Conservative: Half the savings as reference by 2029	1
Reference, Aggressive, and Conservative	Res P4P	6%	16%	Reference: 2,000 households initially, with participation increasing by 5% annually in PG&E territory only: 4,200 households by 2030. Aggressive: All IOUs and POUs implement P4P in 2019 -2020, and participation increases 5% each year: 50,000 households by 2030. Conservative: Half the savings as reference by 2029	1
Aggressive	Smart Thermostat	0%	3%	1%, with growth according to population growth	1

Cumulative Savings: To calculate cumulative savings, this analysis assumed the following EUL for BROS programs. The EUL values for programs in the PG 2018 study align with the PG 2018 EUL assumptions. The NORESCO team used the assumption of 1 year as the EUL for the MAS, P4P, and smart thermostat programs, since residential behavioral programs generally have a 1 year EUL.

Table B-26: EUL Assumptions

Program	EUL (years)

HER	1
Small Comp.	1
Large Comp.	1
SEM	1
BOC	1
BEIMS	1
BERs	1
RCx	1
MAS	1
P4P	1
Smart Thermostat	1

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

- Reference Case: This analysis assigned 2018 PG reference savings from IOU programs to the bottom wedge. For the middle wedge, NORESCO team identified the following sources of BROS:
    - Savings from POU programs,
    - Savings from the MAS and P4P, since they were not included in the 2018 PG study. In general, savings from these programs were small compared with programs in the 2018 PG.

- Conservative Case: The conservative scenario reduced savings from all programs compared with the reference scenario by 50 percent by 2029. This scenario reflects the possibility that BROS energy savings per customer will decline in the future, because other SB350 initiatives will reduce total energy use, thereby reducing energy savings opportunities from BROS measures.
    - Assumed the same savings as the reference scenario from 2015 to 2020, because many SB350 initiatives are projected to be ramping up until 2020.
    - By 2029, assumed that savings would be 50 percent of the energy savings from the BROS reference prediction for 2029. This analysis selected 50 percent using industry judgement, to represent the lower limit of what

the NORESCO team considered to be feasible for reduced energy savings opportunities for BROS.

- Developed a smooth curve for energy savings from 2021 through 2029, using the difference in BROS from 2020 through 2029 and dividing this value by 10 years.

- Aggressive Case: This analysis assigned the 2018 PG aggressive scenario savings to the bottom wedge. For the middle wedge, the NORESCO identified:
  - Savings from POU programs. For the POUs, this analysis assumed that BROS would increase at the same rate as IOU BROS. For each year, the NORESCO team took the ratio of IOU savings under the aggressive scenario to IOU savings in the reference scenario, and multiplied this ratio by BROS from POUs under the reference scenario.
  - Additional savings from HER (beyond the 2018 PG savings) from increasing the penetration rate by an additional 12.5 percent statewide (from 37.5 percent to 50 percent) through a reduction in the number of households used as a control
  - Savings from the MAS, P4P (with higher P4P savings due to increased penetration compared with the reference scenario), and a smart thermostat measure (for natural gas savings only). Savings from all of these programs are small compared with 2018 PG savings and savings from the HER penetration increase.

Results:

Overall, this analysis found that there is little significant BROS beyond what is included in the 2018 PG study. The 2018 PG study found that the HER program delivers the majority of BRO savings. Besides adding savings from the POU BROS programs, the NORESCO team found that most of the additional BROS could come from an expansion in the HER program by moving some households from the control group to treatment. Savings from IOU programs not included in the 2018 PG study (including MAS, P4P, and smart thermostat programs) were small.

This analysis developed a conservative scenario by assuming that BRO savings would drop by half per customer by 2029, because the success of other SB 350 programs would reduce savings opportunities from BROS measures. This reduction in energy savings per customer is likely to occur to some degree under all scenarios (reference and aggressive). On the other hand, the use of smart meters may assist customers in continuing to achieve savings through BROS programs from 2020 through 2029 at the

same levels as they achieved from 2015 to 2020. It is difficult to project how much each factor will affect BROS. The NORESCO team did not discount savings in the BROS reference and aggressive scenarios for reduced savings potential. However, the team was conservative in our assumptions for smart meter programs – i.e., assumed almost no incremental savings from smart meter programs, as described in the Smart Meter Appendix. However, due to reduced savings opportunities, it is possible that savings will fall somewhere between the conservative and reference scenario under current program plans, and somewhere between the reference and aggressive scenario if the aggressive actions described above are taken for BROS programs.

Table B-27: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for Behavioral, Retrocommissioning, and Operational Programs

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	32	39	47	55	67	84	129	152	178	205	234	258	282	308	336
NG (MM therms)	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Source: California Energy Commission staff.

ENERGY ASSET RATINGS

Program Description:

This program consists of two similar but separately funded programs, the California Home Energy Rating System (HERS) Whole House program, and Nonresidential Energy Asset Rating Program (a potential program that is not currently established). Both programs are designed to determine an asset rating of new and existing buildings that are measures of building performance, decoupled from operational details such as operating hours and building controls. Energy asset ratings characterize the major energy uses of the building through surveying and energy modeling. The program also provides some level of information on recommended efficiency measures to improve building performance. While the residential HERS Whole House program has been active for a number of years, the Nonresidential Energy Asset Rating program completed a pilot phase but was not fully rolled out to the marketplace. The rating aspects of the residential HERS program are assumed to be captured in existing forecast estimates. The measure-specific aspects of HERS such as duct sealing and other tests are included in the Title 24 program estimates.

Other national programs, such as ASHRAE's Building Energy Quotient (eQ) program, and international programs present in Ireland, Portugal and other countries have developed and implemented programs to develop asset ratings for commercial buildings.

Nonresidential Energy Asset Rating:

As part of a comprehensive program (AB 758 – 2009) to achieve greater energy savings in existing residential and nonresidential buildings, the Energy Commission developed and implemented a pilot program in 2012 to develop a protocol for asset ratings. The goals of the program were:

- Rate the inherent energy efficiency of the commercial building's envelope, lighting and HVAC systems relative to code and existing commercial building stock;
- Provide a metric relating to the financial implications of a building's energy efficiency;
- Communicate the importance of zero net energy buildings as a reference point for California's energy policy;
- Communicate a building's potential for an improved energy efficiency infrastructure, by comparing performance to other buildings of similar type and location;
- Be a reasonably priced rating for building owners to obtain.

The program complements an operational rating, such as EnergyStar. EnergyStar bases ratings on actual, energy performance (bills), but the Nonresidential Energy Asset Rating is intended to normalize for operational effects and provide insights to relative building performance and potential energy efficiency capital improvement projects.

At an individual building level, the rating process required the following steps:

- Data collection: an auditor collected high-level information about existing HVAC equipment, lighting, and building envelope performance from available information onsite (actual nameplate information and model information, for example). Where information was not available, defaults would be specified based on building vintage.

- Data analysis: the collected data would be fed into a streamlined building performance model, applying intelligent defaults and applying fixed operational data. The building's performance is compared against a fixed benchmark for a given building type and climate. The benchmark can be based on either historical data (CEUS or CBECS, for instance), or based on a code-vintage basis (a building that minimally complies with2005 Title 24 code, for example).
- Rating Calculation: a performance rating on a 0-100 scale is provided, and can be paired with a letter grade (A-F).
- Rating Communication: A certificate is generated, explaining the rating. The certificate can also include some possible insights into energy efficiency upgrades. While the Nonresidential Energy Asset Rating is not intended to take the place of an audit, it can provide some good guidance on energy end uses and relative efficiency of different building systems and features.

A key distinction between energy asset ratings and other efficiency programs is that onsite photovoltaics and cogeneration systems could potentially be considered an asset, as they provide persistent savings. For this estimate, only energy efficiency aspects are considered; however, the program may have additional benefits. The program was suspended after the pilot due to funding availability, but shows promise and is well-aligned with other programs and with Energy Commission goals.

Residential Energy Asset Rating:

The Home Energy Rating System (HERS) program consists of two functions: to provide a certified authority to perform field verification of code requirements for Title 24 new construction, and to conduct the necessary field data gathering and energy modeling to generate a whole-house rating for the building. As the Whole-House Rating element is voluntary, and required neither for new construction nor for existing buildings nor at time-of-sale, the participation rate for the rating aspect is expected to be very low. The benefits of HERS field verification for building attributes such as duct sealing, air leakage tests, and HVAC system tests are assumed to be wholly incorporated in the Title 24 program benefits.

For this analysis, a participation rate for residential ratings, combined with the energy savings level, is estimated to be 50 percent of the participation rate for commercial energy asset rating programs. If the program were modified in the future to require ratings, the participation rate would be much higher. With lack of available data, the savings rate per building is estimated in the same manner as the commercial asset

rating program and CEC benchmarking estimate. Because the program is voluntary and impacts the homeowner primarily for newly constructed buildings, it is assumed that existing buildings will not receive a rating.

Buildings Affected:

The Nonresidential Energy Asset Rating Program would affect most commercial building types, with the exception of some buildings with process loads, including labs, data centers and likely refrigerated warehouses, grocery stores, and hospitals. Mixed use buildings could fall into the scope, but would require additional research to adequately define the reference point and the required building inputs. The table below shows the planned scope of the Nonresidential Energy Asset Rating Program.

Table B-28: Proposed Nonresidential Energy Asset Rating Building Type Classification

Proposed Building Types	Use Existing DOE Reference Building	Use Modified DOE Reference Building	New Modeling Prototype Required
Large Office	X		
Medium Office	X		
Small Office	X		
Data Processing/Computer Center		X	
Lab/R&D Facility			X
Quick Service Restaurant	X		
Full Service Restaurant	X		
Bar/Tavern/Nightclub/Similar		X	
Supermarket	X		
Convenience Store		X	
Stand-alone Retail	X		
Strip Mall	X		
Refrigerated Warehouse		X	
Unconditioned Warehouse		X	
Conditioned Warehouse		X	
Small Hotel	X		
Large Hotel	X		
Primary School	X		
Secondary School	X		
College or University		X	
Religious Assembly			X
Health/Fitness Center			X
Theater/Performing Arts			X
Library/Museum			X
Conference/Convention Center			X

Other Recreational/Public Assembly			X
Service			X
Assembly/Light Mfg.			X
Police/Fire Stations			X

Source: Crowe, Elliot, et. al. 2012. California's Commercial Building Energy Asset Rating System (BEARS): Technical Approach and Design Considerations, ACEEE 2012 Summer Study Proceedings.

Some buildings would be excluded due to the lack of available protocols necessary to establish the "100" reference point on the scale. The precise scope of the program would depend on the willingness of the different building sectors to embrace the rating program.

A cross-reference comparison between the IEPR building stock and the included building types results in an estimated 90.7 percent of commercial building stock greater than 50,000 sf is affected by the commercial asset rating program. This estimate is used to normalize savings against AB802 program savings. A similar area estimate is applied to the building stock less than 50,000 sf in area, which applies to the asset ratings program but not the AB802 regulation.

The HERS program impacts only newly constructed single-family buildings. Through interviews with HERS raters, it was determined that the whole-house rating typically is not performed for existing buildings, even at time-of-sale.

Methods

Relevant Measures:

While a building energy asset rating does not replace an energy audit of the building, a secondary benefit of this program is to identify potential energy upgrade projects. Efficiency improvements that would result in savings beyond normal end-of-life replacement projects could include:

- Equipment upgrade replacement (chiller, boiler, packaged rooftop units)
- Lighting upgrades
- Control upgrades – upgrade to DDC controls
- Envelope Upgrades

- Plug-load controls

The granularity of recommendations depends upon the detail of energy audits performed as a part of the rating process. This program assessment requires an estimate of the net increase in probability that rated buildings would undergo efficiency improvement projects sooner than buildings not rated by the program. A possible benefit as well is a richer source of data for portfolio management, for companies that have a number of similar facilities in California.

Data Sources:

The team will leverage a number of data sources for the Nonresidential Energy Asset Rating program estimates. Where possible, interviews and other correspondence with various actors in the programs (administrative staff, raters, and energy efficiency upgrade providers) will yield supporting information for the savings estimates.

Data sources include:

- NORESCO and Energy Commission Data on Nonresidential Energy Asset Rating Pilot Project
- Other Asset Rating Programs (DOE, ASHRAE Building eQ, Massachusetts DOER)
- CEUS[305] and CBECS[306] Databases for historical energy performance of existing buildings by type
- Estimates of site energy use intensity (EUI) by building type and building vintage, from the Urban Footprint project
- Interviews with HERS raters with in-depth knowledge of both the practical implementation of the HERS program and its application to new and existing residential construction

Methodology:

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305 Itron. California Commercial End-use Survey. May 2017. Available online at: http://capabilities.itron.com/CeusWeb/Default.aspx

306 US Energy Information Administration. "2012 CBECS Survey Data." Available online at: https://www.eia.gov/consumption/commercial/data/2012

Approach:

Phase 1 Approach:

- Because HERS Whole House is an established program, the NORESCO team assumed that associated savings would already by captured in the state demand forecast, and therefore not contribute to SB 350 savings goals. This assumption will be revisited in Phase 3.
- Identify affected building types and building stock. The estimate includes office, retail, restaurant, warehouse, school and hotel buildings. High-rise residential, grocery, hospital buildings and other buildings with significant process loads (labs, data centers) are excluded.
- Floor area data by building type were extracted from the IEPR building stock data.
- Distribution of non-residential floor area by building type and size was collected from 2012 CBECS. Data were collected to determine what fraction of floor area by building type is expected to be contained within buildings larger than 50,000 ft2.
- Nonresidential building energy use intensities (for electricity and gas, separately) were extracted from the California Commercial End-Use Survey (CEUS). To account for the age of CEUS data, values were updated according to the ratio of energy use data captured by 2012 CBECS and 2003 CBECS307 (ratios were calculated for each combination of fuel and building type.
- Annual benchmark savings are derived from ENERGY STAR data collected from 2008 to 2011 for buildings in Portfolio Manager. While ENERGY STAR reports results of 2.4 percent annual savings, the data seem to indicate diminishing year-after-year returns308; accordingly, the NORESCO team's savings estimates are based on a logarithmic data fit that assumes savings decrease in out years once the low-hanging fruit have been harvested. Based on a 60/40 distribution between electricity and gas across the non-residential and multifamily building stock, the NORESCO team assumes that the majority of savings due to benchmarking would be electricity savings. Based on a 60/40 distribution between electricity and gas across the non-residential and multifamily building stock, assuming first-year benchmarking savings of 3.9 percent for electricity and 1.3 percent for gas results in an 80/20 split between electricity and natural

307 US Energy Information Administration. Available online at: "2003 CBECS Survey Data." Available online at: https://www.eia.gov/consumption/commercial/data/2003/

308 The most significant opportunities for savings will be addressed first, leaving lesser opportunities for additional savings in future years.

gas savings and total savings that align with the logarithmic fit to the ENERGY STAR data.

- For buildings larger than 50,000 ft2, for which benchmarking and data disclosure will be required by AB 802, the NORESCO team assumed that Nonresidential Energy Asset Rating would increase ENERGY STAR-predicted savings by 50 percent (assumption is that savings would increase but at a diminishing rate due to benchmarking data already being available).
- For buildings between 25,000 ft2 and 50,000 ft2, the NORESCO team assumed that Nonresidential Energy Asset Rating would be the only form of benchmarking and estimated savings equivalent to ENERGY STAR-predicted savings.
- Amongst the selected building types, the NORESCO team assumes that an additional 2 percent of the existing building stock would get Nonresidential Energy Asset Rating each year and begin to realize energy savings.
- The research team assumes that 90 percent of Energy Asset Rating savings would ultimately be realized through a financing or incentive program (the other 10 percent are assumed to occur naturally according to the initiative of the building owner or operator). For this phase, to make a clear distinction between savings expected to be claimed by utilities and those expected to be attributed to programs run by the state, the NORESCO team assigned a portion of the 90 percent of Energy Asset Rating savings expected to be realized through financing and incentive programs to expected enhanced IOU and POU programs according to the ratio of projected cumulative IOU and POU savings (both known and expected) to the total projected cumulative savings across all programs. The remainder of Energy Asset Rating savings is currently attributed to Energy Asset Rating itself; however, it may be appropriate for later phases to assign a portion of that savings to other state-run programs.

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: The NORESCO team updated the analysis approach as follows:

- The floor area applicable to the asset ratings program was determined by analyzing the existing building stock by end use, and comparing it to the total building stock used in the CEC AB802 program assumption. This results in an estimated 90.7 percent of the building stock applicable to the asset ratings.
- Weighted average building stock energy use intensity (EUI) is assumed to match the AB802 program assumptions, for consistency.

- Similar assumptions to the AB802 analysis for savings rate across the building stock will be applied. Since the asset ratings program is believed to be complementary to the AB802 benchmarking program, the savings rate for buildings that overlap with AB802 (greater than 50,000 sf, affected building types) is assumed to be 50 percent that of AB802 for the reference case. For buildings less than 50,000 sf where there is no overlap, the saving rate (percent) per square foot of building stock is assumed to be equal that of AB802. The "aggressive scenario" assumes a higher savings rate for both building categories. (It is assumed that while the asset ratings program can have a potentially much greater savings level per building, the number of a buildings rated that receive a high-level audit, a component of the asset ratings program,
- For the commercial building stock that is subject to AB802 jurisdictions, it is assumed that the savings rate to due asset ratings will be 50 percent of the savings rate of AB802.
- An increase in savings rate to 1 percent, 2 percent and 3 percent for commercial buildings subject to AB802 is assumed to occur in 2022, through increased program adoption.
- Overlap between asset ratings and other programs is effectively incorporated in to the savings rate.
- For the building stock NOT subject to AB802 but for which asset ratings can be performed, the savings rate is assumed to be twice that for buildings that overlap with AB802 (e.g., the same savings level as AB802).
- For the HERS program, the residential building stock affected is assumed to be new construction only, as there is no established process in place for linking ratings to time-of-sale or other existing buildings.[309]
- For residential ratings, an estimated average end use intensity of 29 kBtu/ft^2 for California single-family construction is estimated.[310] An electricity-gas breakdown is assumed to be 80 percent electricity, 20 percent gas.
- For residential ratings (HERS), the following adoption rate over time is assumed:
    - Reference Case: increasing from 2 percent in 2018 to 24 percent in 2029, in 2 percent increments per year
    - Conservative Case: 0.7 percent in 2020, increasing to 1.7 percent in 2029, in 1 percent increments

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309 Interview with Brian Selby, experienced HERS rater with in-depth knowledge and experience at the building department level.

310 Energy Information Adminstration 2009. Household Energy Use in California, https://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ca.pdf.

    - Aggressive Case: 5 percent in 2020, increasing to 60 percent in 2029
- Participation Rate and Response Rate assumptions are based on an assumed 2 percent program uptake rate.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario. All values have been rounded.

For All Scenarios: The NORESCO team assumed that the building types affected exclude restaurants, grocery, refrigerated warehouses, and hospitals, adjusting the total building stock to 90.7 percent of the AB802 commercial building stock. The aggregate building energy use intensity (EUI) across the building stock matches the CEC AB802 assumptions.

Reference Case: The NORESCO team assumed that there is a 2 percent year-over-year uptake in the program savings, due to increased adoption and more effective realization of program savings through implementing capital improvement projects. The team also assumed that the savings level across the affected building stock would be 50 percent of the AB802 savings for buildings greater than 50,000 square feet and 100 percent of the AB802 savings rate (per ft^2) for buildings less than 50,000 square feet. A reference case was added for Home Energy Rating (HERS) System whole-house ratings, to estimate savings potential for the rating itself, independent from Title 24 Part 6 code requirements. For residential ratings (HERS), NORESCO assumed an effective adoption rate that increases from 2 percent in 2018 to 24 percent in 2029.

Conservative Case: The NORESCO team assumed that the uptake rate is reduced from 2 percent to 0.5 percent year over year, to reflect a more conservative adoption rate. Moreover, the program savings are not expected to begin until the year 2020, as opposed to 2018 for the reference case. The conservative case reduced the rate of implementation for HERS ratings as well. For residential ratings, NORESCO reduced the adoption rate as previously described.

Aggressive Case: The NORESCO team assumed that the savings rate for buildings applicable to the asset rating program is doubled: 100 percent of the AB802 savings rate for buildings greater than 50,000 sf, and 150 percent of the AB802 savings rate for buildings less than 50,000 sf not impacted by AB802. The aggressive case assumed a 50 percent increase in building stock adoption, which incorporates an assumption that a fraction of existing homes will obtain a rating, and apply the rating results to initiate

energy efficiency measures. For residential ratings, NORESCO increased the adoption rate as previously described.

Results:

Overall, the NORESCO team estimates Asset Rating cumulative savings of 549 GWh in the 2029 program year, and 6.2MM therm gas savings. Conservative and aggressive estimates of electricity savings for PY 2029 are 369 GWh and 1,046 GWh, respectively. The HERS rating program constitutes about 1 percent of the total program savings, primarily due to the reduced applicable building stock and reduced use of ratings in existing residential buildings. Moreover, the energy use intensity (EUI) for residential buildings is roughly one-third of the estimated EUI of the commercial buildings that are eligible for commercial asset ratings.

The asset ratings should provide very persistent savings. Improvements in rating scores require changes to either physical attributes (window replacement, for example) or other HVAC equipment that has a degree of permanence. In this sense, the program is a good complement to AB802 benchmarking. The table below shows the estimated breakdown of measures by type and their useful life.

Table B-29: Measure Savings Decay Assumptions

Measure Category	Weighting	Expected Useful Life (yrs)
HVAC Equipment	30.00%	15
HVAC Control Equipment	10.00%	8
HVAC Control Operations	0.00%	3
Lighting Equipment	50.00%	15
Lighting Control	10.00%	8
Other	0.00%	10

A procedure was applied to decrement savings of measures after their useful life using the assumptions above. The net effect is a attenuation of cumulative savings of about 12 percent of the total without degradation, indicating a strong degree of persistence.

There are a few unknowns with this program that will affect savings, such as the date the program resumes and the building types that are affected by this program. The

potential savings level is significant, but there will also be significant overlap with other efficiency programs that involve capital improvement projects (such as financing).

Table B-30: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for Energy Asset Rating

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	-	-	-	176.0	179.0	182.5	520.1	529.8	539.7	549.8	560.1	553.0	563.3	573.8	551.0
NG (MM therms)	0.0	0.0	0.0	2.0	2.0	2.1	5.9	6.0	6.1	6.2	6.4	6.3	6.4	6.5	6.3

Source: California Energy Commission staff.

SMART METER AND CONTROLS

Program Description:

This program is intended to leverage the smart meters that have been installed in California to encourage reduction in energy consumption by providing consumers with real-time information on the costs associated with energy consumption at that time. As energy is reduced during peak load periods, some of the load may be shed to lower periods, saving the consumer money, and also saving energy consumption via the employment of a direct, Internet of Things (IoT) or otherwise-connected device. Smart meters can be installed on electric, gas, and water meters.

While not a currently established program, there is support to suggest that implementation of a smart meter and controls program can result in energy savings. As of 2015, over 80 percent of meters in California are listed as Advanced Metering Infrastructure (AMI) electricity meters. These meters enable the variable rate structures, demand response, and improved customer feedback and control[311].

311 Walton, Robert. "How smart meters are changing energy efficiency in California." Utility DIVE. December 9, 2015. http://www.utilitydive.com/news/how-smart-meters-are-changing-energy-efficiency-in-california/410489/

As the smart meter market develops, there is potential for feedback to include historical baseline information, and enable the control of energy consumption in a manner that reflects the Time Dependent Valuation (TDV) of the energy consumed.

Further, the smart meter may be able to communicate through the internet with devices in the building that are connected as part of the IoT. For example, the air conditioner can be sent a signal to only operate minimally when the electricity rates are above a threshold, or the clothes dryer can be set to run as soon as the electricity rate drops below a desired level. This communication will be automatic, but the decision-making will initially be made by the consumer, rather than the utility. Utilities, however, have chosen to incentivize this through programs to encourage reduced demand peaks, lower overall energy consumption, and lower overall TDV for the consumption profile in some circumstances. For example, PG&E uses this to encourage peak reduction through their SmartRate rate plan, with an incentive of lower overall rates predicated on the consumer reducing electricity usage on certain days of peak demand; which is limited to 15 per year[312].

Note that smart meters are effectively the enabling technology needed to create behavioral programs, which results in a potential for substantial overlap with the Behavioral, Retrocomissioning, and Operational Savings (BROS) program. For this reason, the NORESCO team has adopted a narrow interpretation of smart metering; that is, the employment of a direct, IoT or otherwise-connected device. Energy efficiency opportunities that involve semi-active or ongoing participant decision-making fall outside the scope of this definition (such opportunities are included in the BROS program). Additionally, as part of this analysis, the NORESCO team only considered smart meter-based interventions that reduce energy consumption (not interventions that only shift demand).

Buildings Affected:

Residential buildings are candidates for smart meter savings because they generate a relatively high level of discretionary energy consumption. There is opportunity for smart meter savings in nonresidential buildings as well. For example, a facility manager may choose to reduce light levels when the energy cost crosses a threshold, even if there isn't a demand response event occurring. In some cases, BAS controls may facilitate

312 PG&E. "Discover SmartRate: Determine if SmartRate is right for you." Accessed in May 2017. Available online at: https://www.pge.com/en_US/residential/rate-plans/rate-plan-options/smart-rate-add-on/discover-smart-rate/discover-smart-rate.page?

action that enables automated smart meter savings; in other cases, BAS capabilities may be able to determine the necessary efficiency intervention without the need for smart meter input at all.

Methods

Relevant Measures:

The NORESCO team focused on savings from real-time programs in existing, residential buildings. Although commercial buildings can also use real-time programs, there is potential for double-counting savings from other commercial BROS programs and measures for energy management systems (EMS) and other operational tools.

Data Sources:

- Savings from real-time programs in the PG 2018 study
- Advanced metering initiatives and residential feedback programs: a meta-review for household electricity-saving opportunities[313]

Methodology:

The analysis of this program was conducted through a phased approach as follows:

Phase 1 Approach:

- The research team evaluated smart meter and controls potential for buildings of all types and sizes, including all non-residential buildings and all multifamily and single-family homes. The source of expected energy savings is reduction in consumption associated with automatic response of IoT or otherwise connected devices to smart meter feedback.
- Floor area data by building type were extracted from the IEPR building stock data. For multifamily buildings, IEPR data capture number of households. To convert number of multifamily households, the research team followed the same assumptions leveraged by the 2016 Impact Analysis Report[314]: 26 percent of multifamily households are high rise units with a floor area of 1,248 ft^2; the

[313] Ehrhardt-Martinez, Karen, *et al.* "Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities." June 2010.

[314] NORESCO; Nittler, Ken. "Impact Analysis: 2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings," 2015.

remaining households are contained within 6,960 ft^2, two-story, 8 dwelling buildings (870 ft^2 per unit). For single family homes, 45 percent of homes are assumed to be 2,100 ft^2 and 55 percent are assumed to be 2,700 ft^2.

- Commercial building energy use intensities (for electricity and gas, separately) were extracted from the California Commercial End-Use Survey (CEUS)[315]. To account for the age of CEUS data, values were updated according to the ratio of energy use data captured by 2012 CBECS[316] and 2003 CBECS[317] (ratios were calculated for each combination of fuel and building type.
- Residential building energy use intensities (for electricity and gas, separately) were extracted from the California Statewide Residential Appliance Saturation Study (RASS) for 2009[318].
- Due to the lack of data availability related to the potential for smart meter and controls, as well as the general indication that demand and time-of-use response interventions are the area of focus for the technology, the NORESCO team made the following conservative assumptions regarding the energy efficiency potential of smart meter and controls:
    - Energy savings from smart meter and controls will not begin to be realized until 2020.
    - Approximate savings will increase to approximately 0.5 percent for electricity and 0.25 percent for natural gas by year five and then flatten out after that. A logarithmic fit is applied to determine savings by year.
    - Starting in 2020, an additional 2 percent of buildings will begin to realize savings via smart meter and controls each year.

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: The NORESCO team analyzed energy savings that can be attributed to Smart Meter and Controls primarily based on results from the BROS program. This analysis delineated energy savings that have been captured by the 2018 PG Study, which

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315 Itron. California Commercial End-use Survey. May 2017. Available online at: http://capabilities.itron.com/CeusWeb/Default.aspx

316 US Energy Information Administration. "2012 CBECS Survey Data." Available online at: https://www.eia.gov/consumption/commercial/data/2012

317 US Energy Information Administration. Available online at: "2003 CBECS Survey Data." Available online at: https://www.eia.gov/consumption/commercial/data/2003/

318 DNV-GL. "California Statewide Residential Appliance Saturation Study." 2010. Available online at: https://webtools.dnvgl.com/rass2009/

are assigned to the bottom wedge, from the energy savings that can be counted as "incremental" for SB 350.

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

- Reference Case: This analysis assigned 2018 PG reference savings from IOU real-time programs to the bottom wedge. The 2018 PG study includes two residential programs: In Home Display (IHD)- Real Time Feedback and Web-Real Time Feedback. For the middle wedge, the NORESCO team added savings from POU programs, based on the assumption that POUs would launch similar real-time programs as the IOUs beginning in 2019.
    - For 2019 through 2029, this analysis assumed the POUs' savings were the same as IOUs' RCx savings, adjusted by population – i.e., multiplied by 0.33, based on 25 percent of the population in POU territories / 75 percent in IOU territories.[319]
    - The NORESCO team did not include other real-time programs (beyond those in the 2018 PG study) in the middle wedge, because of the potential for overlap with other residential behavioral programs, or overlap with commercial BROS programs.

- Conservative Case: this analysis modeled the following: Real-time measures reduce energy savings through conservation efforts such as reducing hours of operation and changes in set-points (e.g., higher temperature set-points for air conditioning). As other SB 350 measures increase energy efficiency, operational energy declines, and the energy savings from real-time measures declines. The NORESCO team considered how real-time measure savings would decline in the future as follows:
    - Assumed the same savings as the reference scenario from 2015 to 2020, because many SB350 initiatives are projected to be ramping up until 2020.
    - For 2029, assumed that savings would be 50 percent of the energy savings from the reference prediction for real-time programs through

319 CPUC presentation, "Customer and Retail Choice in California", Nicolas Chaset, May 10, 2017. Available at: http://energy.nv.gov/uploadedFiles/energynvgov/content/Programs/TaskForces/2017/Agenda%20item%204%20-%20California%20Presentation.pdf

2029. This analysis selected 50 percent using industry judgement, to represent the lower limit of what the NORESCO team considered to be feasible for reduced energy savings opportunities.

- Developed a smooth curve for energy savings from 2021 through 2029, using the difference in real-time savings from 2020 through 2029 and dividing this value by 10 years.
- Real-time feedback primarily affects electricity savings, since California's AMI infrastructure installed to date has been for electricity. However, some electricity-savings measures can provide small ancillary gas savings. The NORESCO team used the 2018 PG assumptions for gas savings for the two programs included in that study: 0 for the IHD program and 1.5 MM Therms by 2029 (under the reference scenario) for the web-based portal program. For the additional savings in the aggressive scenario, this analysis assumed zero natural gas, because the ACEEE study findings were for electricity savings only.
- The NORESCO team assumed 1 year for the EUL of real-time programs, so cumulative savings were the same as annual savings.

- Aggressive Case: This analysis assigned 2018 PG aggressive savings from the two IOU real-time programs to the bottom wedge. For the middle wedge, for the POUs, this analysis assumed that smart meter savings would increase at the same rate as IOU smart meter savings.
  - For each year, the NORESCO team took the ratio of IOU savings under the aggressive scenario to IOU savings in the reference scenario, and multiplied this ratio by smart meter savings from POUs under the reference scenario.
  - The NORESCO team also included additional savings from enhanced smart-meter programs, based on a meta-analysis conducted by the American Council for an Energy Efficient Economy (ACEEE). The ACEEE study estimated savings from advanced metering initiatives that provide real-time feedback, either through an on-line portal or in-home display (ACEEE, 2010). The savings documented in the ACEEE study from real-time feedback programs (4-7 percent) were higher than the savings estimated for the real-time programs in the 2018 PG (approximately 1-2 percent).
  - To achieve these additional savings, smart meter programs use enhanced billing with household specific information and advice (to achieve an average of 4 percent savings) or web-based energy audits with

information provided on an ongoing basis (to achieve an average of 7 percent savings) (ACEEE, 2010).

- Because California is a mild climate compared with the rest of the U.S. (including a lower cooling load), the NORESCO team assumed 3 percent savings total from AMI real-time feedback.
- Because the 2018 PG assumed 1-2 percent savings from real-time feedback programs, the NORESCO team assumed an incremental savings of 1 percent. For participation assumptions, the team used the 2018 PG assumption for in-home display programs of 4 percent, since this is more conservative than the assumption of 10 percent for on-line portals.
- The NORESCO team assumed average household electricity use of 6,296 kWh/year based on the California Statewide Residential Appliance Saturation Study (RASS) for 2009.

Results:

Except for assuming proportional savings from POU programs, this analysis assumed no additional savings beyond those included in the 2018 PG study from smart meter programs in the reference scenario. The NORESCO team made these conservative assumptions to avoid potentially double-counting savings between smart meter programs and BROs programs. The NORESCO team views smart meters (either delivered through a program or used as a tool by customers) as an important enabling mechanism for customers to continue to achieve the same electricity savings through BROS programs from 2020 through 2029 as they currently save, despite reduced savings opportunities in the future as other SB 350 initiatives reduce energy use. In other words, smart meters will be an important tool for guiding customers to achieve BROS, but this analysis accounted for these savings in the BROS programs (not in Smart Meter programs).

This analysis assumed small additional savings in the aggressive scenario, from an increase in energy savings per participating customer compared with the 2018 PG study. To achieve the aggressive savings, smart meter programs would need to use enhanced billing with household specific information and advice, or web-based energy audits with information provided on an ongoing basis. Savings increase by 16 GWh by 2029 from these additional measures.

This analysis also developed a conservative scenario by assuming that smart meter savings in the 2018 PG study would drop by half per customer by 2029, because the success of other SB 350 programs would reduce savings opportunities from smart meter measures. Smart meter savings in the conservative scenario are half the reference scenario savings by 2029.

Table B-31: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for the Smart Meters and Controls

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	-	-	-	-	10.7	11.7	12.8	14.1	15.5	17.0	18.7	20.5	22.6	24.7	27.0
NG (MM therms)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: California Energy Commission staff.

FUEL SUBSTITUTION (ELECTRIFICATION)

Program Description:

While not a program per se; the Fuel Substitution category captures energy savings that can be achieved at the site level by substituting one utility-supplied fuel for another. By definition, that means substituting electricity for natural gas, or vice versa. Because it is not anticipated that substituting natural gas for electricity would result in net site energy savings, electrification will be the main area of focus for this category of savings.

Buildings Affected:

Any commercial or residential new construction or retrofit project for which site energy usage can be reduced by replacing existing natural gas-powered equipment with electrical equivalents. Because there is no specific program in place, the current approach is to not limit the potential savings to any particular building sector. Additionally, as it relates to projecting savings potential, different funding mechanisms (grants, standard loans, no interest loans, on-bill financing, etc.) will be considered.

Methods

Relevant Measures:

Anticipated energy efficiency measures include replacing natural gas-powered equivalents with the following electrical alternatives:

- Standard efficiency electrical equipment
    - Electric resistance heating
    - Electric resistance clothes dryers
    - Electric resistance domestic hot water heaters
- High efficiency electrical equipment
    - Heat pump heating and cooling systems, including min-split systems
    - Heat pump domestic hot water heaters
    - Combined space and water heating heat pumps
    - Heat pump clothes dryers

Data Sources:

- Electrification Technology White Papers[320]. White papers detailing anticipated energy performance are available for a number of relevant high efficiency technologies, including: (1) variable capacity heat pumps, (2) ducted and space-decoupled heat pump water heaters, (3) combined space and water heating using CO_2 refrigerant air-to-water heat pumps, (4) ductless mini-split heat pump systems, and (5) heat pump clothes dryers. Such papers will facilitate the specification of energy efficiency measure energy modeling inputs.
- City of Palo Alto Electrification Work Plan[321]. This report recommends 10 tasks to reduce Palo Alto's use of natural gas and gasoline and to electrify its buildings and vehicles over a 5 year period. The subset of the 10 recommended tasks that relate to building energy consumption are as follows: (1) promote heat pump water and space heating in existing homes; (2) provide resources to homeowners to convert existing homes to all-electric homes; (3) explore the development of retail electric rate schedule for homes that electrify; (4) explore additional residential and commercial building code changes to expedite electrification; (5) evaluate utility connection fees and permitting fees associated with electrification projects; (6) explore opportunities to electrify existing and new city buildings; (7) explore new financing sources to expedite electrification; and (8) analyze options for district heating to reduce natural gas in commercial buildings. Additional relevant tasks recommended to be deferred include: (1) facilitate electrification of space heating in existing large commercial buildings, and (2) study electrification as a potential element in any future residential or commercial energy efficiency ordinance.
- Space and Water Heating Electrification in Palo Alto: Code Feasibility and Cost Effectiveness Analysis[322]. Palo Alto engaged TRC Energy Services to provide analysis for electrification of new and existing buildings within the city. The scope of the analysis includes: (1) consideration of potential ramifications on electrical service at the building level, (2) evaluation of the cost effectiveness of a number of different electrification strategies by building type (single family residential, low-rise multifamily, small office, and medium office); and (3) evaluation of potential code, technical and operational barriers to electrification in both the residential and commercial building sectors.
- Urban Footprint Energy Modeling Analysis[323]. NORESCO recently executed a large scale analysis that evaluated the potential impacts of a number of perspective policy changes; electrification was amongst the policy changes analyzed. The analysis spanned a number of different building types and climate zones.

320 Southern California Edison. Electrification Technology White Papers.

321 City of Palo Alto. City Council Staff Report. "Fuel Switching/aka Electrification." August 17, 2015.

322 City of Palo Alto. TRC Energy Services. "Palo Alto Electrification Final Report." November 16, 2016.

323 California Energy Commission. Urban Footprint Energy Modeling Analysis. 2015-2016.

- Sacramento Municipal Utilities District (SMUD)[324]. SMUD offers heat pump water heater rebates, indicating that the adoption of measures that enable fuel substitution is incentivized in certain cases

Methodology:

The analysis of this program was conducted through a phased approach as follows:

Phase 1 Approach: The NORESCO team estimated the energy savings potential for a statewide fuel substitution program by analyzing the additional natural gas heating load that is expected to be added to the utility grid from 2018 through 2029. Based on data presented in Palo Alto's Electrification Work Plan[321], the NORESCO team estimated the fraction of this additional natural gas load that would serve space and water heating needs. With respect to efficiency, the NORESCO team assumed that, on average, a fuel substitution program would replace 80 percent efficient natural gas combustion equipment with heat pump equivalents with a heating COP of 3. With respect to market penetration, the NORESCO team assumed that a fuel substitution could impact 10 percent of the new construction (both residential and nonresidential) market moving forward, starting in 2018. Because electrification replaces natural gas load with electricity load, the net effect is a decrease in natural gas consumption and corresponding increase in electricity consumption (although, based on the efficiency assumption, a net reduction in both site and source energy is expected to be achieved).

Phase 2 Approach: This program was not included in Phase 2.

Phase 3 Approach: The Phase 3 approach is a refinement of the Phase 1 approach, where the potential for natural gas savings through electrification was based on an estimate for the heating load that could be offset in new construction, both residential and nonresidential.

- While the NORESCO team had anticipated pursuing a bottom-up energy modeling analysis for Phase 3, subsequent investigation revealed that energy modeling was not likely to result in substantially more accurate savings estimate. While energy modeling could provide a slightly more accurate indicator of seasonal performance for heat-pump technology and better predict the variation in the fraction of natural gas use that could be offset for each combination of

324 Sacramento Municipal Utility District. 2017. https://www.smud.org/en/index.htm

building type and climate zone, the impact of such refinements would be in the noise compared to the impact of relevant market uptake assumptions.

- The key questions that determine potential market impact are: (1) would an electrification program target existing buildings or only new construction, and (2) what fraction of the target market could be expected to implement electrification through 2029. To facilitate the Phase 3 analysis, the NORESCO team assumed that major fuel substitution efforts would be largely limited to new construction due to potential infrastructure limitations for retrofit cases. Additionally, based on feedback from the Energy Commission, the NORESCO team scaled back the market penetration assumption from the Phase 1 approach, delaying any penetration until 2020 and then ramping up gradually to 10 percent penetration (for the reference case) through 2029. See the Scenario-based Approach section for more details on the scenarios analyzed

Scenario Approach:

Based on this information, the NORESCO team made the following assumptions for a reference, conservative, and aggressive savings scenario.

Reference Case: The reference case assumes that fuel substitution program(s) would impact residential and nonresidential new construction starting at a penetration rate of 1 percent in 2020 and ramping up linearly to a rate of 10 percent through 2029.

Conservative Case: To account for a potential scenario in which fuel substitution does not become cost effective through 2029, the conservative case assumes no savings.

Aggressive Case: The aggressive case assumes that fuel substitution program(s) would impact residential and nonresidential new construction starting at a penetration rate of 2.5 percent in 2020 and ramping up linearly to a rate of 25 percent through 2029.

Results:

The big question with respect to fuel substitution is if, and when, technology costs, renewable penetration, and utility costs converge to make it cost effective. While the general consensus is that it the market has not reached that tipping point, the NORESCO team believes it is likely to occur in the near future. Accordingly, while the conservative case allows for a scenario in which no fuel substitution savings are achievable through 2029, the reference and aggressive cases assume that cost-effective fuel substitution will be enable at least limited uptake of fuel substitution programs at the municipality level starting in 2020.

Table B-32: Electricity (GWh) and Natural Gas (MM therms) Savings Projected From 2015 Through 2029 for Fuel Substitution

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Elec (GWh)	-	-	-	0.0	0.0	-14.3	-43.5	-88.0	-148	-223	-314	-420	-543	-683	-841
NG (MM therms)	0.0	0.0	0.0	0.0	0.0	1.8	5.6	11.3	18.9	28.6	40.2	53.8	69.6	87.5	107.7

Source: California Energy Commission staff.

Standard Savings Included in the *2016 IEPR Update* Managed Demand Forecast

The analyses described in the previous sections for Energy Commission and federal standards do not include savings for the impacts of standards adopted in 2015 and futures up to 2019 that are embedded in the Energy Commission's managed demand forecast last adopted in the *2016 IEPR Update* proceeding.

Methods

Staff reviewed the baseline demand forecast and the corresponding AAEE projections (subtracting AAEE from the baseline makes the managed demand forecast) from the *2016 IEPR Update* proceeding to determine the size of these impacts. The *2016 IEPR Update* cycle did not include new AAEE analyses; rather, the AAEE analyses developed in the *2015 IEPR* proceeding were simply scaled down by the first year of savings (added into the 2016 baseline forecast) and extrapolated out one additional year into the future. [325] Table 12 of the *2015 California Energy Demand Update* report summarizes the vintages of Title 24, Title 20, and federal appliance efficiency standards that were assessed in that proceeding.[326]

As the five AAEE cases are defined to include some of the same vintages of prospective Title 24 building standards that have been reassessed and described earlier in this report, staff selected the Mid Baseline-Mid Low AAEE case to obtain savings projections for just 2016 updates to Title 24 Building Standards, Title 20 Appliance Standards, and federal appliance standards enacted, but not yet effective. Further, since the CPUC is now implementing revised programs to address AB 802 requirements to use existing baseline in most instances, staff believes that some portion of the Title 24 Building Standards savings reported in the *2016 IEPR Update* duplicates behavior, retrocommissioning, operational efficiency (BROs) savings projections included in the staff companion paper describing utility target setting. Thus of the selected AAEE case, only appliance standards have clearly incremental savings that do not duplicate other

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325 California Energy Commission, *California Energy Demand Updated Forecast, 2017-2027*. Publication Number: CEC-200-2016- 016-CMF, p. 47. See http://docketpublic.energy.ca.gov/PublicDocuments/16-IEPR-05/TN215745_20170202T125433_FINAL_California_Energy_Demand_Updated_Forecast_20172027.pdf

326 California Energy Commission, *California Energy Demand 2016-2026, Revised Electricity Forecast*. Publication Number: CEC-200-2016-001-V1., p. 58. See http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-03/TN207439_20160115T152221_California_Energy_Demand_20162026_Revised_Electricity_Forecast.pdf

assessments in the two utility potential studies[327] or the assessments of future standards described above in this paper.

Table B-33 reports the electricity and natural gas savings for recently adopted Title 20 and federal appliance standards affecting appliances purchased in 2015 and future years. In staff's judgment these are incremental savings to those reported earlier in this paper.

Results:

Table B-33: Electricity (GWh) and Natural Gas (MM Therms) Savings Projected from 2015 Onwards for Recently Adopted State and Federal Appliance Standards

Energy Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	202
Elec (GWh)	92	242	502	851	1200	1541	1864	2185	2505	2769	3029	3287	350
NG (MM Therms)	3.9	11.4	15.5	18.8	22.1	25.5	29.1	32.6	36.2	40.4	44.7	49.0	53.3

Source: California Energy Commission staff.

Agricultural and Industrial Methodology

The same methods are used to estimate potential energy savings from both industry and agriculture sectors. This is an approximation of the potential energy savings that can be captured by programs not funded through utility rates. For this estimation, staff used the recently published Total Resource Cost with greenhouse gas (GHG) adder #1 (TRC GHG #1) and Program Administrator Cost test-Aggressive (PAC-Aggressive) scenarios from the Navigant/CPUC 2018 Potential and Goals Study.[328] 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 utility's costs.[329] The GHG adder #1 scenario uses business-as-usual incentive levels but with an additional cost included for GHG emissions. Whereas the PAC is a test measures the net costs of a demand-side management program as a resource option based on the costs incurred by the program administrator, including incentive costs but excluding any net costs incurred by the participant.[330] In the aggressive scenario, the PAC has more

327 California Energy Commission, *Senate Bill 350 Energy Efficiency Target Setting for Utility Programs*, Chapter 2, forthcoming.

328 Navigant, Energy Efficiency Potential and Goals Study for 2018 and Beyond, Prepared for the California Public Utilities Commission, June 2017.

329 California Public Utilities Commission, California Standard Practice Manual, page 18. 2001. Available at: http://www.cpuc.ca.gov/egyefficiency/

330 California Public Utilities Commission, California Standard Practice Manual, page 23. 2001. Available at: http://www.cpuc.ca.gov/egyefficiency/

incentives available and a greater marketing strength beyond what is modeled in the reference case.

Methods

These tests represent a slightly above business-as-usual and a most aggressive energy efficiency market potential scenario, respectively. The energy savings estimated for the programs not funded through utility rates, is the difference between the PAC-Aggressive and TRC GHG #1 cost-effectiveness test scenarios. Staff has chosen this increment of savings because it has already been determined to be cost-effective and, since it is an aggressive scenario reliant upon additional funding for incentives, it is possible that the funding and additional savings could come from programs non-utility entities. To estimate these energy savings, staff summed the individual measures from the Navigant industrial and agricultural market potential results viewer to get electricity and natural gas savings. The PAC-Aggressive electricity totals for both sectors are subtracted from the TRC GHG #1 electricity totals. The same process is done for natural gas totals for both sectors. The differences that result from this subtraction are the incremental energy savings. **Table B-34** shows the expected electricity and natural gas savings potential up to 2029 for the industrial sector and **Table B-35** shows these savings for the agricultural sector. The incremental energy savings were then converted to Quad BTUs to show the overall incremental energy savings that are potentially available from these two sectors (**Table B-36**). To capture the incremental energy savings, the Energy Commission will need to collaborate with stakeholders in the industrial and agricultural sectors to determine which measures have the greatest potential for energy savings and the best means through which, a program not funded through utility rates, can implement those measures.

Results:

Table B-34: Industrial Sector Incremental Savings: A- Electricity (GWh), B- Natural Gas (MM Therms)

1A

Industrial Sector Incremental Electricity Savings (GWh)															
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
TRC GHG #1	136.3	294.2	415.7	533.9	619.3	625.6	611.4	569.1	512.1	465.2	436.0	422.7	419.5	424.1	438.0
PAC-Aggr	138.1	314.3	450.5	592.9	697.0	700.9	677.6	624.2	550.1	489.8	450.2	430.6	426.1	436.0	459.3
Incremental Savings	1.8	20.2	34.8	59.0	77.7	75.3	66.1	55.1	38.0	24.6	14.2	8.0	6.6	11.9	21.2

Source: Navigant and California Energy Commission staff.

1B

Industrial Sector Incremental Natural Gas Savings (MM Therms)															
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
TRC GHG #1	4.8	14.3	24.3	35.0	46.0	54.3	63.3	75.1	89.8	103.0	114.5	124.6	133.3	135.2	137.5
PAC-Aggr	5.1	14.6	24.8	35.8	47.2	55.9	65.3	78.9	94.0	107.4	119.1	129.6	135.3	141.8	147.7
Incremental Savings	0.2	0.3	0.4	0.8	1.2	1.5	1.9	3.8	4.3	4.4	4.5	5.0	2.1	6.6	10.2

Source: Navigant and California Energy Commission staff.

Table B-35: Agriculture Sector Incremental Savings: A- Electricity (GWh), B- Natural Gas (MM Therms)

2A

Agricultural Sector Incremental Electricity Savings (GWh)															
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
TRC GHG #1	27.7	97.1	170.9	238.6	315.9	388.3	454.9	515.4	569.8	618.8	664.6	709.0	754.2	803.0	856.8
PAC-Aggr	28.0	109.9	194.3	274.9	356.7	434.2	505.2	569.5	626.2	677.4	726.6	776.4	829.7	890.6	962.1
Incremental Savings	0.3	12.8	23.4	36.2	40.8	46.0	50.3	54.1	56.4	58.6	62.0	67.4	75.5	87.6	105.3

Source: Navigant and California Energy Commission staff.

2B

Agricultural Sector Incremental Natural Gas Savings (MM Therms)															
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
TRC GHG #1	0.3	1.6	2.8	4.3	5.9	7.4	9.0	10.6	12.4	14.2	16.1	18.0	20.0	22.0	24.2
PAC-Aggr	0.3	1.6	2.9	4.4	5.9	7.5	9.1	10.7	12.5	14.3	16.2	18.2	20.3	22.5	24.8
Incremental Savings	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.6

Source: Navigant and California Energy Commission staff.

Table B-36: Agricultural and Industrial Energy Savings (Quad BTUs)

Energy Savings (Quad BTU)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Industrial	2.83E-05	0.000207	0.000403	0.000676	0.000943	0.001149	0.001127	0.001415	0.001886	0.002271	0.00257	0.002651	0.002516	0.00248	0.002366
Agricultural	4.26E-06	0.000191	0.000385	0.000576	0.000742	0.000919	0.001091	0.001267	0.001443	0.001625	0.001818	0.002025	0.002251	0.002503	0.002793

Source: Navigant and California Energy Commission staff.