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California Energy Commission

CONSULTANT REPORT

Senate Bill 350 Doubling Energy Savings by 2030 Method Report

Prepared for**: California Energy Commission**
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Gavin Newsom, Governor
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California Energy Commission

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ABSTRACT

Senate Bill 350 (de Leon, Chapter 547, Statutes of 2015) (SB 350) requires the California Energy Commission (Energy Commission) to set annual targets to achieve a statewide cumulative doubling of energy efficiency savings in electricity and natural gas end uses by January 1, 2030. The Energy Commission must also report biennially to the Legislature on progress achieved toward meeting these targets and the effects on low-income and disadvantaged communities. This report provides methodology for calculating energy efficiency savings for various programs and background information that feeds into the Energy Commission's report to the Legislature.

Three sources of savings are quantified in the accounting of energy efficiency. The sources of energy efficiency savings include utility (historical and forecasted) programs, codes and standards, and beyond utility programs. This report describes the analysis and assumptions for all three sources of savings, focusing on the analysis for quantifying beyond-utility-program savings. Details on the utility historical program savings (2015-2019) and forecasted savings (2020-2029) are provided in the respective utility reports and potential studies. Beyond-utility programs are programs not administrated or claimed by the investor-owned or publicly owned utilities. The beyond-utility programs may be educational initiatives, financing strategies, and other mechanisms that may drive California energy users to reduce their energy use.

In 2017, the Energy Commission developed the initial SB 350 analysis, which included a set of analysis workbooks. The scope of this study centered around updating the 2017 analysis workbooks to enhance the beyond-utility savings potential identified in the 2017 report.

This report provides the method and program descriptions. Data inputs and analysis algorithms are provided in the program workbooks and SB 350 results slicer tool. Actual results are provided in the Energy Commission's *2019 California Energy Efficiency Action Plan*.

Keywords: SB 350, energy efficiency, potential, method, beyond-utility programs, energy savings, electricity, natural gas, analysis

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TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

EXECUTIVE SUMMARY

Senate Bill 350 (de Leon, Chapter 547, Statutes of 2015) (SB 350) requires the California Energy Commission (Energy Commission) to set annual targets to achieve a statewide cumulative doubling of energy efficiency savings in electricity and natural gas end uses by January 1, 2030. There are three sources of savings quantified in the accounting of energy efficiency:

- **Historical and committed savings:** These savings refer to the energy efficiency savings from utility programs and codes and standards embedded in the baseline forecast of the *Integrated Energy Policy Report (IEPR)*. The IEPR forecast also includes savings forecast from approved utility program budgets.
- **Investor-owned utility (IOU) and publicly owned utility (POU) potential savings:** Savings forecast in the IOU and POU potential studies, including rebated equipment and utility codes and standards advocacy claims. Historically, codes and standards and IOU and POU potential studies were the only source of savings included in the Energy Commission's additional achievable energy efficiency, an accounting for future potential installed energy efficiency savings, in the California energy demand forecast.
- **Beyond-utility savings:** Savings beyond the above-mentioned utility programs calculated for a range of programs that may be counted as part of additional achievable energy efficiency. As programs develop and quantify claimed or verified historical program savings, the Energy Commission will update historical committed savings and forecast savings accordingly.

SB 350 savings claims are relative to a baseline year of 2015. All program savings claims begin in that year and cumulate to 2030. As part of the analysis, the beyond-utility savings must not overlap with utility program savings (historical and forecasted). The analysis of the savings potential per program includes subtracting out overlap.

This report describes the analysis and assumptions used to quantify beyond-utility program savings. Beyond-utility programs are programs not administered or claimed by the IOUs or POUs. The beyond-utility programs may be educational initiatives, financing strategies, and other mechanisms that may drive California ratepayers to reduce their energy use.

The beyond-utility programs considered in this report are:

- **Codes and Standards:** Codes and standards are laws that set a minimum level of efficiency required for new buildings and appliances constructed or sold in California. Analysis of codes and standards in this

SB 350 method may supplant the utility-claimed savings from potential studies and does not include those savings already embedded in the IEPR baseline forecast. The scope of codes and standards savings for SB 350 ignores any utility attribution factors and focuses solely on the actual impact of the codes and standards.

- **Financing:** Financing programs include low-interest loans and grants. There are some cases that projects using financing also leverage utility program incentives. Any savings quantified for financing programs should include an overlap analysis with utility program participation.
- **Behavior and Market Transformation:** Behavior programs are those associated with energy efficiency savings that result from behavioral changes as opposed to installing a physical measure, like new lighting or equipment controls. Market transformation is another opportunity to realize energy savings through accelerating widespread measure adoption. These efforts may provide public education, funding, or other approaches to remove barriers.
- **Sector/Other:** Several other programs have the potential to deliver significant savings in specific sectors or markets. These programs (listed below) may require the Energy Commission to explore new avenues to drive the market to change.

Accompanying this report is a set of beyond-utility tools that enables the Energy Commission to track or calculate historically achieved savings, forecast future savings from existing programs, and forecast new savings potential from future initiatives. The Energy Commission must report biennially to the Legislature on progress achieved toward meeting these targets and the effects on disadvantaged communities. This report provides the method and background information that feeds into the Energy Commission's report to the Legislature toward the SB 350 goal.

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CHAPTER 1: Introduction

Senate Bill 350 (SB 350), the Clean Energy and Pollution Reduction Act (De León, Chapter 547, Statutes of 2015), requires the California Energy Commission (Energy Commission) to set annual targets to achieve a statewide cumulative doubling of energy efficiency savings in electricity and natural gas end uses by January 1, 2030. The Energy Commission must report biennially to the Legislature on progress achieved toward meeting these targets and the effects on disadvantaged communities. This report provides the method and background information that feeds into the Energy Commission's report to the Legislature for the biennial programs toward the SB 350 goal.

In 2017,[1] the Energy Commission developed the initial SB 350 analysis, which included developing a set of analysis workbooks. The scope of this study centered around updating the 2017 analysis workbooks and enhancing the beyond-utility savings potential identified in the 2017 report. Relative to the 2017 study, this study provides:

- Updated methodological analysis for select programs.
- Increased scope of programs analyzed.
- Recommended areas for future improvement and reporting, even beyond 2030.

There are a variety of beyond-utility energy efficiency programs that can contribute to meeting the state's doubling target. The SB 350 analysis includes utility-program and beyond-utility-program savings. The utility-program savings include historically achieved and forecast potential energy efficiency savings. Beyond-utility savings do not overlap with savings forecast as part of the investor-owned utilities' (IOUs') and publicly owned utilities' (POUs') potential studies and savings claims. For this method, programs are broadly grouped into the following categories:

- Codes and standards
- Financing
- Behavior and market transformation
- Sector level

1 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

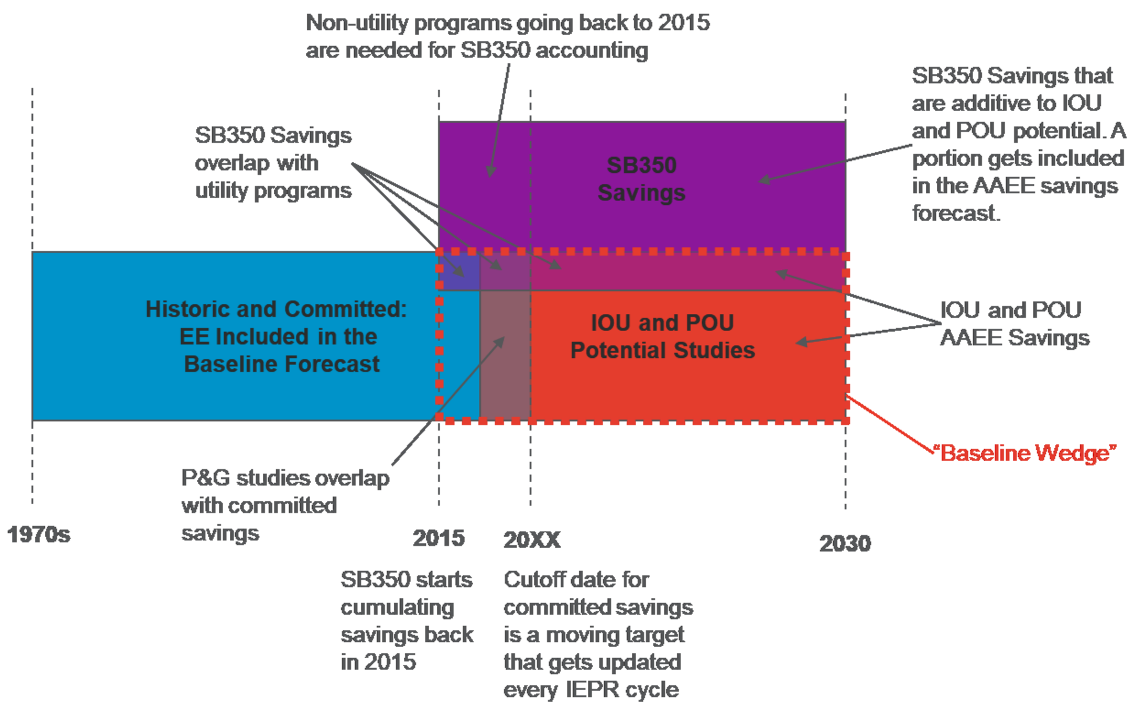
The Energy Commission, other state agencies, local governments, or other entities administer these programs.

This report does not provide results or savings analysis. Instead, this report provides the method and program descriptions included in the SB 350 analysis tools. Energy Commission staff uses these analysis tools to calculate the SB 350 historical achievements and forecast to 2030.

Savings Accounting

Figure 1 summarizes the different categories of energy efficiency savings considered by the Energy Commission's forecasting efforts and how they relate to each other. The relationships are illustrated as a quasi-Venn diagram because savings categories can overlap. Throughout the Energy Commission's forecasting process, every effort is made to avoid overlap because it is important to not double count savings. The Energy Commission also wants to quantify all acquired savings and potential for future energy use reductions.

Figure 1: Savings Accounting Venn Diagram



Sources of savings that count toward SB 350 have the potential to overlap because of the different reporting frameworks used to quantify each set of savings. The historical and committed energy efficiency in the IEPR baseline forecast overlaps with outputs from the potential studies and other beyond-utility program savings forecasts. The SB 350 analysis always starts with a baseline of 2015, whereas the analysis for the IEPR additional achievable energy efficiency has a sliding start year based on the analysis year.

Source: Navigant team

Per Figure 1, the savings accounting definitions are as follows:

- **Historical and committed:** This term refers to the energy efficiency savings embedded in the baseline forecast of the *IEPR*. The IEPR baseline forecast includes energy efficiency savings from historical utility programs and codes and standards; it also includes savings committed to occur from known codes and standards. The IEPR forecast also includes savings forecast from approved utility program budgets.
- **IOU and POU potential studies:** Savings forecast in the IOU and POU potential studies, including rebated equipment, behavioral programs, and utility codes and standards advocacy claims. A portion of IOU and POU potential study savings may overlap with energy efficiency savings in the baseline forecast. Historically, codes and standards and IOU and POU potential studies were the only source of savings included in the Energy Commission's additional achievable energy efficiency forecast.
- **IOU and POU additional achievable energy efficiency savings:** The savings forecast from IOU and POU programs that are incrementally additive to (not double counted) the baseline forecast.
- **Baseline wedge:** A term specific to the SB 350 analysis. This term is a forecast of cumulative savings from utility programs with a start date of 2015 through the date of the existing analysis per SB 350 accounting policy. The forecast includes the additional achievable energy efficiency for IOUs and POUs, as well as a portion of savings that overlap with the baseline forecast.
- **Beyond-utility savings:** Savings beyond-utility programs calculated for a range of programs that may be counted as part of the additional achievable energy efficiency. They may contain some overlap with other historical, committed, or potential savings; thus, analysis to avoid double counting is necessary. As programs develop and quantify claimed or verified historical program savings, the Energy Commission will update historical committed savings and forecast savings accordingly.

Utility Programs

SB 350 requires accounting for IOU and POU savings. Historical and future savings for IOUs and POUs come from four sources:

- IOU actual savings claims
- POU actual savings claims
- IOU potential study forecast
- POU potential study forecast

While this study focuses primarily on beyond-utility programs, these IOU and POU datasets are included for completeness.

Beyond-Utility Programs

Various beyond-utility energy efficiency programs could contribute to meeting the state's doubling target. Many do not have long-term guaranteed funding and have historically been excluded from the additional achievable energy efficiency because of the uncertainty in funding, as well as lack of tracking data.

The SB 350 analysis includes statewide and local government initiatives, financing options, and other initiatives. Some programs exhibit areas of undercounted savings from existing utility programs for the following possible reasons:

- **Misalignment on what is truly industry standard practice.** The IOUs cannot claim savings or provide rebates for projects that may be deemed industry standard practice by the California Public Utilities Commission (CPUC). CPUC treats industry standard practice similar to a code or standard baseline.
- **Barriers to program participation.** In some cases, the programs affect end users,[2] but the program participation requirements cause burdens, which may result in unaccounted for savings. Incentives are not the only drivers to implementing energy efficiency.
- **Nonprogram requirements.** The IOUs do not allow projects mandated by other drivers such as California Air Resources Board (CARB) and air quality management district (AQMD) requirements to count toward IOU program savings. These savings should be captured by the SB 350 analysis.

Table 1 lists the programs quantified within each category in the SB 350 analysis of beyond-utility program savings. The method described in the report captures savings that are either not claimed by utility programs or are outside the scope of a utility program. Any program previously analyzed has the associated original documentation in an appendix to the Energy Commission report *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*.[3]

Codes and Standards

Since the 1970s, the Energy Commission has been responsible for establishing standards for building codes and appliances. Specific codes and standards included in the analysis are Title 24: Building Energy Efficiency Standards

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2 End users are consumers of utility electricity or natural gas.

3 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

(building standards), the California Green Building Standards Code (CALGreen),[4] Title 20: State Appliance Efficiency Regulations (appliance regulations), and federal appliance standards. The codes and standards applicable savings include all those savings not included in the baseline forecast. The codes and standards reported for SB 350 analysis are those attributable to the standards, whether claimed by utilities or not.

Financing Programs

California has several available financing mechanisms for energy efficiency investments. Utility revenue does not fund these programs, which are major contributors to projected energy savings. Utility-funded financing programs are excluded from the analysis. Any analysis of savings associated with financing must consider the synergistic benefits of coordinating with utility program participation. This study attempts to quantify any overlap in claimed or potential savings estimates between financing and utility program savings.

Behavior and Market Transformation

The behavior programs described in the behavior and market transformation category are those associated with energy efficiency savings that result from behavioral changes as opposed to installing a physical measure, like new lighting or equipment controls. These behavioral changes are typically initiated by informing the customer or building owner of energy use patterns. The behavior programs include benchmarking, energy asset ratings, and applications using smart meter data (smart meter and controls), among others. Market transformation is another opportunity to realize energy savings through accelerating widespread measure adoption. These efforts may provide additional public education, funding, or other approaches to remove barriers.

Sector/Other

Several other programs have the potential to deliver significant savings in specific sectors or markets. These programs may require the Energy Commission to explore new avenues to drive the market to change. These avenues include fuel substitution, industrial measures, agricultural measures, and conservation voltage reduction (CVR).

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

Table 1: Beyond-Utility Programs

Category	Program
Codes and Standards	Building Standards (Title 24)
Codes and Standards	Appliance Regulations (Title 20 appliance efficiency standards)
Codes and Standards	Federal Appliance Standards
Codes and Standards	Local Government Ordinances
Financing	Air Quality Management Districts
Financing	Local Government Challenge
Financing	Proposition 39
Financing	Low-Income Weatherization
Financing	Water-Energy Grant
Financing	California Department of General Services Retrofit Program
Financing	Energy Conservation Assistance Act
Financing	Property Assessed Clean Energy
Behavior and Market Transformation	Benchmarking
Behavior and Market Transformation	Behavioral, Retrocommissioning, Operational Savings
Behavior and Market Transformation	Energy Asset Rating
Behavior and Market Transformation	Smart Meters and Controls
Sector/Other	Fuel Substitution
Sector/Other	Agricultural
Sector/Other	Industrial
Sector/Other	CVR

Source: Navigant team

For this study, the Navigant team developed a comprehensive tool that enables the Energy Commission to forecast the savings from utility and beyond-utility programs. The analysis for each program listed in Table 1 and those from utility programs is stored in its own program workbook; postprocessing steps combine the effects of each program and enable scenario analysis. Chapter 2 discusses the overall method of the tool; Chapter 3 discusses the method for calculating the portion of savings attributable to disadvantaged communities and low-income customers. Chapters 4 and 5 provide the IOU and POU historical and forecasted savings. Chapters 6-24 for each program listed in Table 1 provide the following detail:

- Program Overview
- Updates Relative to Previous Study, if applicable
- Method Description
- Forecasting Scenarios
- Areas to Improve

CHAPTER 2: SB 350 Savings Calculation Method

This chapter describes the overall architecture and cross-cutting aspects of the modeling the Navigant team used to forecast savings from utility and beyond-utility programs for the Energy Commission. The savings calculation framework is grounded in a set of Microsoft Excel® workbooks packaged together to calculate SB 350 savings. Each program described in the following chapters has its own stand-alone program workbook that feeds into the overall SB 350-attributed savings to-date and forecast future savings calculations. The intent of the tool is to track savings toward the goal and forecast the remaining potential that may achieve or surpass the goal.

SB 350 Tool Objectives

The SB 350 tool has several overall objectives:

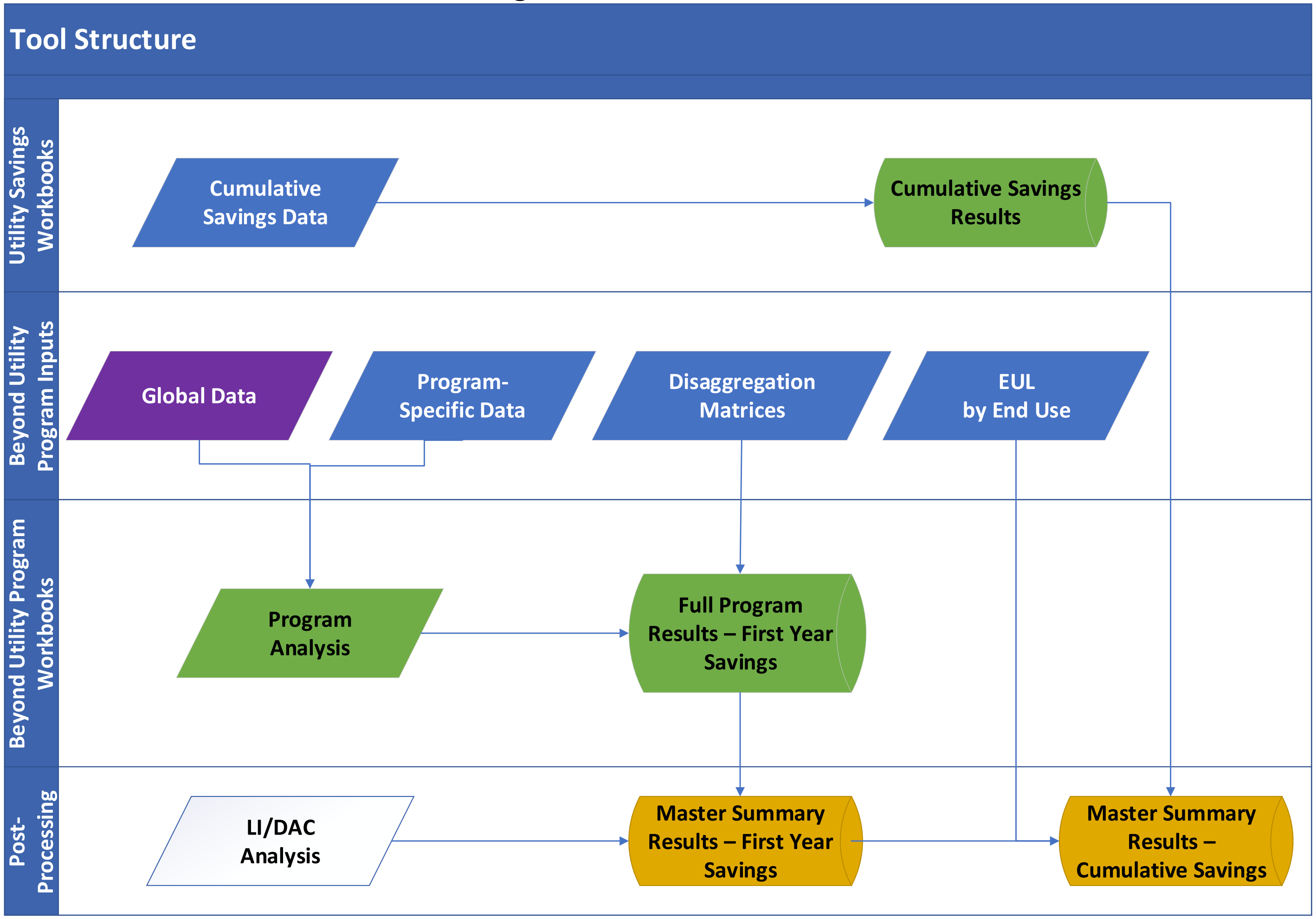
- Allow changes in data inputs that may vary over time.
- Capture historical versus forecast data in the individual program workbooks.
- Streamline data alignment with POU and IOU potential savings forecasts.
- Develop and forecast various scenarios driven by program-specific scenarios and IEPR forecast scenarios.

NORESCO, with other consultants, designed the beyond-utility program workbooks in 2017 to capture a snapshot forecast for the 2017 SB 350 report. The Navigant team built an architecture around these workbooks to streamline the analysis and pull in data from utility programs. The team also migrated the original beyond-utility program workbooks into a new template to better integrate inputs and results. Furthermore, the team updated a subset of the beyond-utility workbooks as identified by the Energy Commission.

The overall SB 350 tool, outlined in Figure 2, has four major components listed below. Each component is described in greater detail following the figure:

- Utility savings workbooks
- Beyond-utility program inputs
- Beyond-utility program workbooks
- Postprocessing

Figure 2: Tool Structure



This high-level flowchart shows the overarching tool architecture and includes utility and beyond-utility savings inputs that feed into the cumulative savings.

Source: Navigant team

Utility Savings Workbooks

The Navigant team developed a common template for taking the cumulative savings results—historical (claimed savings) and forecast (Potential and Goals study)—and transforming them to match the dimensionality of the beyond-utility program analysis. These datasets are discussed in Chapters 4 (IOUs) and 5 (POUs).

Beyond-Utility Program Inputs

These inputs are the set of workbooks that define the necessary inputs for the beyond-utility analysis. Some of these input datasets are commonly used across all programs, some apply selectively to a subset of programs, while others are specific to the analysis of a single program.

Global Data

The datasets from external sources that are common across multiple beyond-utility program workbooks are stored in the master input file to ensure consistency. These datasets, for example, include the IEPR sector-level consumption forecasts.

Program-Specific Data

Each beyond-utility program workbook has its own set of data inputs and assumptions. Each chapter description and the individual program workbooks describe the program-specific data sources used to inform forecast assumptions. Two cross-cutting elements that are present in each program workbook are:

- **Program-Level Scenarios:** Each beyond-utility program workbook has a set of assumptions that help develop three scenarios of savings: conservative, reference, and aggressive.
- **Utility Overlap:** Some of the beyond-utility programs overlap with utility programs, and any potential for double counting must be subtracted out of the beyond-utility program savings forecasts. A utility overlap factor for each program accounts for this dynamic.

Disaggregation Matrices

Outputs of the SB 350 analysis are disaggregated across utility territories. Program workbooks that do not have the input data granularity to support this level of disaggregation use a set of default disaggregation matrices to achieve this goal. Two matrices distribute statewide program savings across utility territories: one for electricity savings and one for natural gas savings.

Effective Useful Life by End Use

Effective useful life (EUL) informs the decay of first-year savings over time to calculate cumulative savings as part of the postprocessing analysis of the beyond-utility program savings. The Navigant team provides default values for

EUL by end use. Programs that have measure-level detail that create distinctive EUL values for an end use may alter this matrix in the program workbook.

Beyond-Utility Program Workbooks

The beyond-utility program workbooks follow a consistent tab structure and data flow, as outlined in the "Beyond Utility Program Workbooks" swim lane in Figure 2, while allowing the savings analysis for each program to fit the available data and appropriate forecasting method. Chapters 6-24 provide the details on the inputs and assumptions, as well as the documentation provided in each workbook.

Postprocessing

First-year savings results by utility, end use, and scenario from the individual beyond-utility program workbooks undergo several postprocessing steps and integration with the utility savings workbooks to produce the SB 350 forecast. These steps include calculating cumulative savings based on the end-use level (EUL) and decay functions, disaggregating to the utility level, allocating savings to low-income and disadvantaged communities, and calculating greenhouse gas emissions.

Low-Income and Disadvantaged Communities

Per the SB 350 legislation, the Energy Commission must explore the barriers to and opportunities for expanding low-income customers' access to energy efficiency. SB 350 also requires examining opportunities located in disadvantaged communities. This step determines savings attributable to these populations of interest. Chapter 3 provides the details for the data sources and method to calculate the allocation of savings that affect low-income and disadvantaged communities.

Cumulative Savings

To appropriately calculate savings from an installed measure continuing beyond the first year and decreasing over time because of various factors, the Navigant team applied a decay formula to each end use that is a function of EUL. Decay does not imply reduced performance of individual pieces of equipment over time, but rather the fractional loss each year of a subset of equipment from the originally installed population.

CHAPTER 3: Disadvantaged and Low-Income Communities

The disadvantaged communities and the low-income market segment represent a large but hard-to-reach population. The classification of disadvantaged and low-income communities represents a subset of the population within a given geographic area, and the characteristics of both groups can make access to energy efficiency programs challenging. This review of forecasting methods for disadvantaged and low-income populations has roots in various definitional and equity concerns and includes:

- Defining disadvantaged and low-income populations as separate though often comingled groups.
- Reviewing datasets of interest in defining disadvantaged and low-income populations.
- Checking the CalEnviroScreen (CES)[5] variables to identify the criteria for defining populations, including comparing CES populations in poverty to the population of residents eligible for the California Alternative Rates for Energy (CARE)[6] program.
- Summarizing differences in disadvantaged and low-income population estimates between datasets.
- Reviewing the analysis used to develop disadvantaged and low-income population metrics and detailing the assumptions used in those analyses.

Definitions of Disadvantaged Communities

This study defines disadvantaged communities according to California state legislation, which characterizes California communities across several criteria, including disproportionate exposure to environmental pollution and population characteristics such as unemployment levels or concentrations of low-income populations. Assembly Bill 32 (Nuñéz, Chapter 488, Statutes of 2006) (AB 32),

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5 CalEnviroScreen helps identify California communities that are affected by pollution; uses environmental, health, and socioeconomic information to produce scores for every census tract in the state; and maps scores to identify impacted communities.

6 CARE program offers a monthly discount of 20 percent or more on gas and electricity. Participants qualify through income guidelines or if enrolled in certain public assistance programs.

the California Global Warming Solutions Act, and the subsequent expansion Senate Bill 535 (De León, Chapter 830, Statutes of 2012) (SB 535) resulted in the California Environmental Protection Agency (CalEPA) designating 25 percent of the highest scoring census tracts via the CES tool as disadvantaged communities.

AB 32: The California Global Warming Solutions Act of 2006[7] directs the state board to, "where applicable and to the extent feasible, direct public and private investment toward the most disadvantaged communities in California."

SB 535: In 2012, the Legislature passed SB 535 and directed that, in addition to reducing greenhouse gas (GHG) emissions, 25 percent of the money allocated from the Greenhouse Gas Reduction Fund also must go to projects that benefit disadvantaged communities.[8] A minimum of 10 percent of the funds must be for projects within disadvantaged communities.[9] CalEPA[10] was given the responsibility to identify disadvantaged communities for this legislation based on geographic, socioeconomic, public health, and environmental hazard criteria. These criteria may include:

- Areas disproportionately affected by environmental pollution and other hazards that can lead to negative public health effects, exposure, or environmental degradation.
- Areas with concentrations of people that are of low-income, high unemployment, low levels of home ownership, high rent burden, sensitive populations, or low levels of educational attainment

Section 39711 of the Health and Safety Code adopted the SB 535 definition of disadvantaged communities and applied it through the CES tool for communities in the top 25 percentile of CES scores.

Definition of Low Income

The Navigant team aligned its definitions of low-income populations for this study with CES 3.0 and the U.S. Census Bureau American Community Survey's (ACS) definitions of poverty. The ACS maintains information on the poverty rate in different areas in California based on the federal poverty level. The federal poverty level defines poverty based on the size of the household and the ages of

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7 Núñez. 2006. *AB 32 Air Pollution: greenhouse gases: California Global Warming Solutions Act of 2006*.

8 De León. 2012. *SB 5353 California Global Warming Solutions Act of 2006: Greenhouse Gas Reduction Fund*.

9 California Environmental Protection Agency Office of Environmental Health Hazard Assessment. 2014. *Approaches to Identifying Disadvantaged Communities*.

10 California Environmental Protection Agency. 2017. *Designation of Disadvantaged Communities Pursuant to Senate Bill 535*.

family members. CES uses these data to determine the percentage of the population with incomes less than two times the federal poverty level based on a five-year estimate from 2011 to 2015. CES uses a threshold of twice the federal poverty level because California's cost of living is higher than many other parts of the country. The widespread use of this definition allows the study to maintain consistency with publicly available datasets, including CES and CARE reporting, using California's definition of low income. These definitions are also consistent with the income thresholds used to define eligibility to participate in the energy efficiency programs designed to address the needs of low-income residents, including the Energy Savings Assistance (ESA) program.[11]

Moreover, the Low Income Home Energy Assistance Program (LIHEAP) defines income thresholds that require an annual household income (before taxes) below 60 percent of the state median income. The LIHEAP threshold generally lines up with the CARE threshold for households of six or fewer persons, though LIHEAP income thresholds are lower for households of seven or more persons. Appendix A discusses LIHEAP, including a comparison of income thresholds between CARE and LIHEAP.

The analysis includes the area median income level as a poverty metric. Although area median income thresholds are available at the state and county levels, more granular data are necessary to forecast at the utility level to address inconsistencies between utility service territories and county boundaries. In this case, the team mapped ZIP codes to utilities. The Method Description section discusses how the analysis used CES census tract, ZIP code, and utility data to define the low-income population.

Dataset Reviews

The research design included defining what low-income and disadvantaged communities mean in the context of the modeling and how different research products and datasets can be combined to characterize completely the energy users and communities that might fall under these definitions; it also includes how energy efficiency projects might be targeted for these populations. The team reviewed several publicly available data sources that are vetted and maintained over time to identify what single or combined sources accurately define low-income and disadvantaged communities to form a forecast at the utility level.

11 The ESA program provides no-cost weatherization services to low-income households that meet the same criteria as the CARE program.

- **ACS:** The U.S. Census Bureau conducts the ACS every year to provide up-to-date information about social and economic needs at the community level (by ZIP code). It gathers information previously contained only in the long form of the decennial census. This research used the 2017 ACS update to understand how CES uses the survey data to develop socioeconomic factor indicators.[12]
- **CES:** CES is a mapping tool that helps identify California communities most affected by many sources of pollution and where people are often especially vulnerable to pollution's effects.[13] CES uses environmental, health, and socioeconomic information to produce scores for every census tract in the state. The research for this study used CES to assist in identifying counties that contain disadvantaged and pollution-burdened communities based on the CES characteristics of their aggregated census tracts.
- **CARE:** The CARE program provides a monthly discount of 20 percent or more on gas and electricity. Participants qualify through income guidelines or if enrolled in certain public assistance programs.[14] CARE is a large, statewide IOU program with a 2017 program budget of $1.27 billion, of which $1.24 billion directly subsidized low-income electricity and natural gas customers.[15] CARE is important because it:
    - Is subject to income verification.
    - Provides service to many California residents.
    - Is reported to the Legislature each year through utility compliance filings.

  This research analyzes CARE's overall county-level low-income population eligibility and population participation for California's four IOUs. Other utilities, such as the Sacramento Municipal Utility District (SMUD), have similar programs, but these may not be subject to the same reporting requirements as CARE. As such, applying CARE would likely be limited to low-income populations receiving electricity or natural gas from California's IOUs.

Table 2 summarizes how the datasets previously discussed might be combined, including geographic coverage and data specificity. The geographic data specificity is at the most granular geographic area provided by the dataset (for

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12 United States Census Bureau. 2019. *American Community Survey (ACS)*.

13 Office of Environmental Health Hazard Assessment (OEHHA). *CalEnviroScreen.*

14 Pacific Gas and Electric Company. 2018. *CARE and FERA Enrollment*.

15 *California Electric and Gas Utility Cost Report*, Public Utilities Code Section 913 Annual Report to the Governor and Legislature. California Public Utilities Commission, Energy Division, April 2018.

example, county, ZIP code, census tract, and so forth). In general, all data sources can be used to define markets in the IOU services territories, followed by county-, city-, and census-tract-level analysis. ACS and CES can be used to define markets in all utility service areas in California.

Table 2: Geographic Coverage and Data Specificity of Research Products Analyzed

Acronym	Dataset Geographic Coverage	Geographic Data Specificity
ACS	National	Census tract
CES	California	Census tract
CARE	California IOU territories	County

Source: Navigant team

Applicability of CES

Because CES is often referred to as the key source for defining low-income and disadvantaged communities, it is necessary to provide an interpretation of the CES tool, including how the scoring is defined and calculated and what the relationship is of CES to the ACS. This report also compares CES to CARE, including what metrics within the CES model might be the most appropriate to use to assess energy efficiency potential.

CES Score Formula

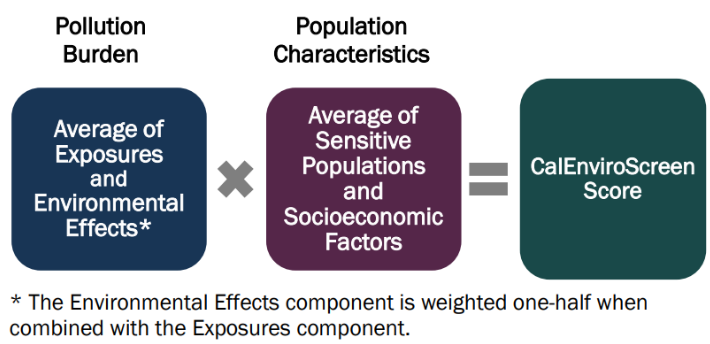
CES uses environmental, health, and socioeconomic information to produce a numerical score for each census tract in the state. The CES scores use a place-based method to assess the relative effects of pollution on communities. The model consists of four components: two pollution burden components and two population characteristics components. Each component is made up of indicators.

- **Indicators:** The model uses 20 indicators (listed in

- Table 3): 12 measure pollution burden, and eight measure population characteristics. Each census tract receives scores for as many of the 20 indicators as possible. For each indicator, the scores are ordered from highest to lowest, allowing a percentile to be calculated for all indicators that have a score in a given census tract. The percentile represents a score relative to other census tracts for the available indicators.
- **Components:** The percentiles are averaged for the set of indicators in each of the four components—exposures, environmental effects, sensitive populations, and socioeconomic factors—to produce a score. The maximum score for all components is 10.
- **Population characteristics:** The population characteristics score is the average of the sensitive populations and socioeconomic components.
- **Pollution burden:** The pollution burden score is the average of the environmental effects and exposures components, where the environmental effects component is weighted by half because CES considers environmental effects to make a smaller contribution to the pollution burden than exposures do.

The CES score is the product of the population characteristics score for a census tract and the pollution burden score of that tract. The CES score can also be the product of the average score of a population's exposure and environmental factors and the average score of the sensitive population indicators and socioeconomic factors. Figure 3 shows the formula the Navigant team used to calculate the CES score. An area with a high score experiences a higher pollution burden than an area with a low score. Appendix A details the equation the team used to provide the CES score at the census tract level.

Figure 3: Formula for Calculating CES Score



Visual of the formula for calculating the CalEnviroScreen Score, which is the result of multiplying the pollution burden and the population characteristics.
Source: CalEnviroScreen 3.0

Table 3: CES Indicators

Pollution Indicators	Population Characteristics
Exposure Indicators • Air Quality: Ozone • Diesel Particulate Matter • Pesticide Use • Traffic Density • Air Quality: PM2.5 • Drinking Water Contaminants • Toxic Releases From Facilities	***Sensitive Population Indicators*** • Asthma • Low-Birth-Weight Infants • Cardiovascular Disease
Environmental Effect Indicators • Cleanup Sites • Hazardous Waste Generators and Facilities • Solid Waste Sites and Facilities • Groundwater Threats • Impaired Water Bodies	***Socioeconomic Factor Indicators*** • Educational Attainment • Linguistic Isolation • Unemployment • Housing Burden • Poverty

Source: Navigant team

CES and ACS

It is important to understand the relationship between CES and ACS when reviewing datasets and assessing the potential to fully profile disadvantaged and low-income populations. CES uses data from ACS for educational attainment, housing-burdened low-income households, linguistic isolation, poverty, and unemployment. All the non-health-related population characteristics are sourced from the annual U.S. Census Bureau survey data. Table 4 compares the CES and ACS metrics most relevant to forecasting energy efficiency on low-income and disadvantaged communities, while a more complete comparison of metrics can be found in Appendix A.

Table 4: Comparison of the Poverty CES and ACS Metrics

Metric	CES	ACS
Poverty	Percentage of the population living below two times the federal poverty level (5-year estimate, 2011-2015)	Number of individuals below 200 percent of the federal poverty level per census tract for the state of California (2011-2015 survey)

Source: Navigant team

Variations in CES Metrics by County

Table 5 outlines the CES population metrics for several counties to compare populations in disadvantaged communities and those in poverty. CES defines the population in poverty as residents earning less than 200 percent of the federal poverty level at the census tract level, regardless of whether they reside in a census tract that is designated as disadvantaged. In many cases, there is a significant disparity in each county between the size of the population in census tracts that are designated disadvantaged communities and the size of the low-income population in poverty.

The team identified this discrepancy in the sample of six counties provided in

Table 5. In those counties, 18 percent of census tracts are designated disadvantaged communities,[16] accounting for 24 percent of the total population. In contrast, 47 percent of residents are low-income. This percentage is notably higher than the 24 percent living in disadvantaged census tracts when defining the census tract population in poverty based on the CES poverty[17] metric (that is, the percentage of the population within a census tract that is living at or below two times the federal poverty level). This finding implies that when forecasting energy efficiency potential within a county, the CES poverty metric defines a larger pool of eligible participants than if the population is defined only as those residents living in disadvantaged census tracts. This research reviewed only six out of California's 58 counties and is not intended to present a state-level view.

16 As defined as adopted in Section 39711 of the Health and Safety Code and is applied through the CES tool to communities in the top 25 percentile of CES scores.

17 See Table 4.

Table 5: Example of County CES Statistics

County	Total Population	Total No. of CTs	% CTs* DAC**	DAC CT Population	% DAC Population	Population in Poverty	% Population in Poverty	Difference in DAC Population and Population in Poverty
Butte	220,000	51	4%	8,674	4%	97,554	44%	88,880
Humboldt	134,623	30	0%	0	0%	60,735	45%	60,735
Kern	839,631	151	45%	403,918	48%	397,647	47%	-6,271
Marin	252,409	55	0%	0	0%	48,292	19%	48,292
Mendocino	87,941	20	0%	0	0%	39,109	45%	39,109
Santa Barbara	423,895	89	0%	0	0%	155,512	37%	155,512
Total	**1,706,090**	**396**	**18%**	**412.592**	**24%**	**798,849**	**47%**	**386,257**

*CT = census tract

**DAC = disadvantaged communities
Source: Navigant team

Comparison of CES and CARE

Table 6 compares CES and CARE, which can be used to assess the applicability of either dataset when identifying low-income populations. The CES tool maps pollution hazards to allow for assessing vulnerabilities to such hazards in communities across California. The CARE program, further defined in Appendix A, was designed to address the needs of low-income households by offering a discount to retail electricity and natural gas rates for residents with income at 200 percent of federal poverty level or less (income being the only metric used to define CARE eligibility). Both datasets provide methods to define low-income and disadvantaged populations, which are useful in forecasting energy efficiency potential.

Table 6: CES and CARE Definitions by Component

Component	CES	CARE
Geographic Area	Uses percentiles to assign relative scores for each of the indicators in a given geographic area (census tract).	Statewide income thresholds that are periodically updated to follow national guidelines.

Component	CES	CARE
Data Reliability	Uses ACS data for non-health-related population characteristics; relies on adequate sampling that is national is scope.	California-specific for IOU territories; income verified and audited.[18]
Minority Representation	None inherent—analysis does show clear disparities with respect to the racial makeup of the communities with the highest pollution burdens and vulnerabilities. One in three Hispanic and one in three black people are likely to live in a tenth decile tract compared to 1 in 14 white people.[19]	None inherent—depends on income and household size. Some relationship between household size and race.[20]
Risk	Accounts for socioeconomic and sensitivity factors as effect modifiers for environmental pollutants and health risk.	Addresses socioeconomic status.
Intended Use	Designed primarily to address health risk and environmental quality.	Designed primarily to allocate rate discounts for energy and as a qualifying criterion for participation in energy efficiency and related programs.

Source: Navigant team

18 Public Utilities Code Sections 382, 739.1, 900, and 2790 require the Public Utilities Commission to establish and manage the CARE program in the most efficient and cost-effective way, including determining utility administrative and outreach expenditures and developing discount rates, penetration goals, and enrollment methods. A variety of related Public Utilities Commission decisions and best practice criteria (such as found in the State Administrative Manual) also speak to similar goals and administrative objectives for the program.

19 Office of Environmental Health Hazard Assessment California Environmental Protection Agency. 2018. *Analysis of Race/Ethnicity, Age, and CalEnviroScreen 3.0 Scores*.

20 Reyes, Belinda. 2018. *A Portrait of Race and Ethnicity in California*. Public Policy Institute of California.

Comparison of Low-Income Population Metrics

Table 7 compares county populations defined by the CES poverty metric and the population eligible for CARE;[21] the table also shows low-income population estimates varied for each county, with a range from -17 percent to 28 percent. At the total sample level, the CES population in poverty estimate was about 3 percent higher than the estimated CARE-eligible population.

Table 7: Comparisons of CES and CARE Populations

County	Total Population	CES Population in Poverty	Eligible CARE Population	% of CES Population in Poverty to Eligible CARE Population
Butte	220,000	97,554	117,998	83%
Humboldt	134,623	60,735	71,543	85%
Kern	839,631	397,647	361,485	110%
Marin	252,409	48,292	56,217	86%
Mendocino	87,941	39,109	44,851	87%
Santa Barbara	423,895	155,512	121,029	128%
Total	**1,958,499**	**798,849**	**773,123**	**103%**

Source: Navigant team

Summary of Population Metrics Analysis

The following summarizes observations from the preceding discussions:

- In developing a forecasting method for disadvantaged and low-income communities, defining the population of households that may qualify for low-income market interventions varies depending on the dataset used or the specific metrics selected within a specific dataset.
- Using the CES disadvantaged community definition alone as the criteria resulted in a significantly smaller population of low-income residents than the estimated CES population in poverty or eligible CARE population.

21 Further defined in Compliance Filing of Pacific Gas and Electric Company (U 39-M), On Behalf of Itself, Southern California Gas Company (U 904-G), San Diego Gas and Electric Company (U 902-M), and California Edison Company (U 338-E), Regarding Annual Estimates of CARE Eligible Customers and Related Information. California Public Utilities Commission February 9, 2018.

- For a sample of six counties reviewed, the CES population in poverty estimate was roughly 3 percent higher than the estimated CARE-eligible population; the variance at the county level ranged from -17 percent to 28 percent.
- In considering which definition to use to forecast energy efficiency impacts on low-income populations:
    - Data availability at the appropriate level varies, and consistency with other state programs for energy efficiency and addressing low-income and disadvantaged community needs is a priority.
    - The CARE-eligible population is a California-specific estimate based on a process that includes income verification and periodic audits to confirm accuracy. Qualifying for CARE is a criterion required to participate in the ESA program, California's primary low-income-focused energy efficiency program.
    - The CES population estimates are based primarily on ACS data, which are based on an ongoing survey conducted by the U.S. Census Bureau. It regularly gathers information previously contained only in the long form of the decennial census.

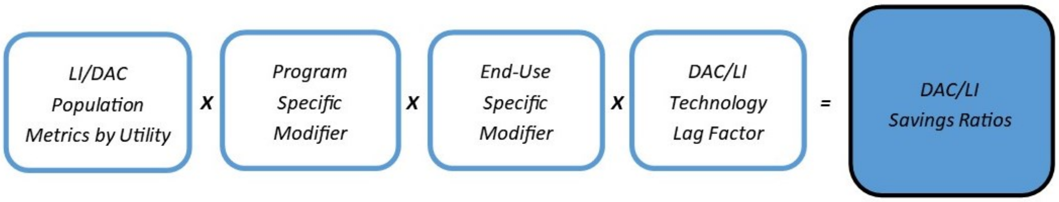
Method Description

The Navigant team designed the savings estimates for the SB 350 workbooks to produce several forecast breakouts based on characteristics such as utility and forecasting scenario. As a postprocessing element of the overall tool, the disadvantaged community and low-income elements interact with three of these variables—utility, program, and end use—while accommodating future updates based on data availability. Producing savings estimates for low-income and disadvantaged community populations involves incorporating four distinct ratios (as shown in the simplified formula in

Figure 4), the results of which are then applied to the products of the program workbooks. The following sections:

- Describe the method used to attribute CES poverty and disadvantaged community data to utilities using ZIP code databases that define utility territories and how this allocation relies on the specific utility list involved in the study.
- Discuss the application of low-income modifiers to residential program workbooks and disadvantaged community modifiers to the full suite of program workbooks, including how this process addresses overlap between the populations.
- Explain how the analysis team used technology adoption lag among low-income populations and disadvantaged communities to address program- and end-use-specific modifiers to savings, and how these assumptions can be modified.

Figure 4: Simplified Low-Income/Disadvantaged Community Savings Ratio Formula



Visual of the formula to calculate a low-income or disadvantaged community savings ratio. The formula includes four parameters multiplied to get a ratio to apply by geographic zone.

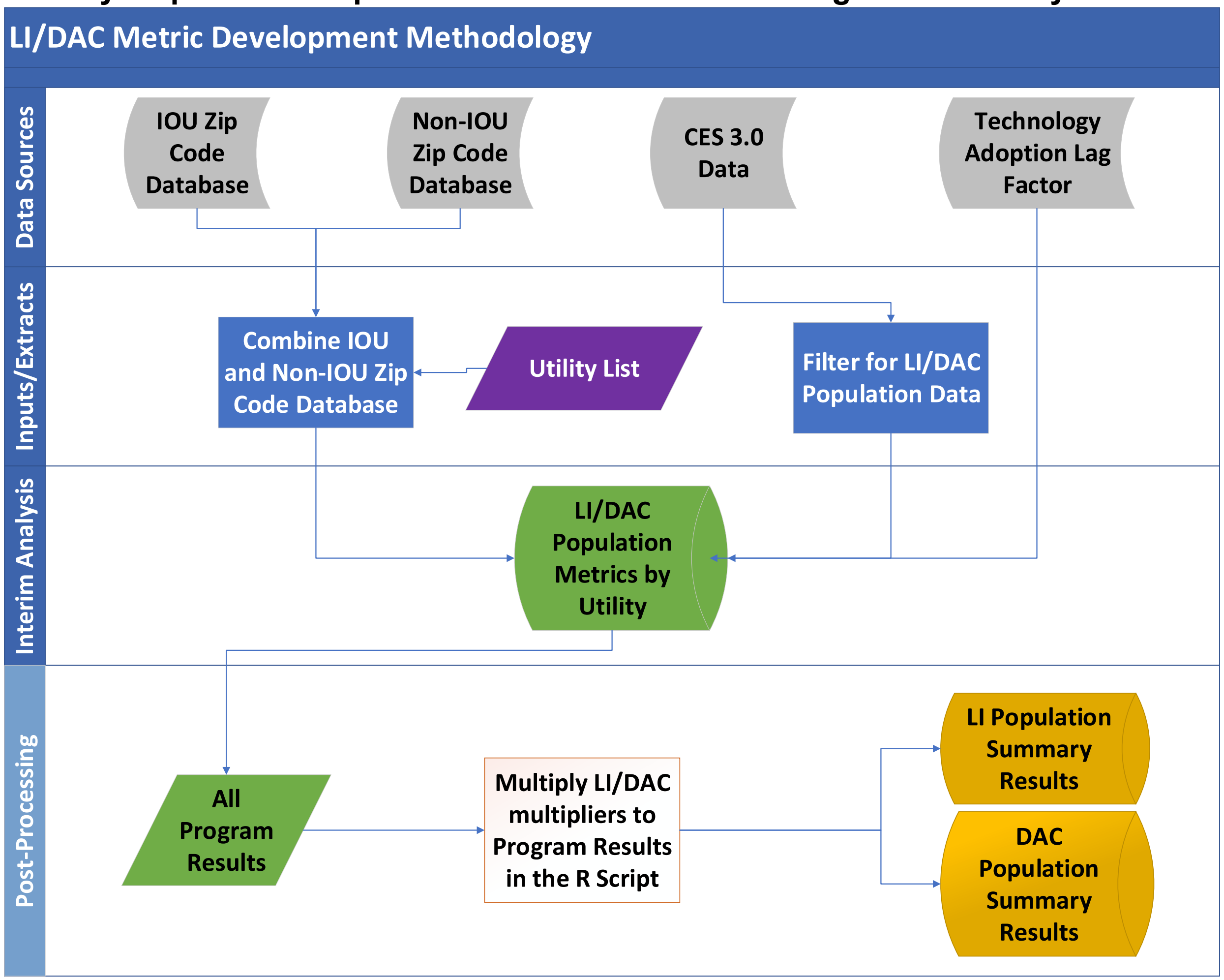
Source: Navigant team

Using ZIP Code Data

The Navigant team derived the aggregated low-income/disadvantaged community population proportion metrics by utility from CES data. Figure 5 summarizes the database inputs and overall process to produce the values for aggregated utility low-income/disadvantaged community population proportion ratios. Although CES data are available down to the census tract level, utility service territories could be mapped only down to the ZIP-code level. The team paired CES census tracts with the corresponding utilities using databases of IOU and non-IOU service areas by ZIP code. These databases were then reviewed to ensure that non-IOU electricity providers not examined in this study were treated consistently. For example, if a POU was coded in the database for a municipality, the corresponding IOU for that service area was instead attributed to that ZIP code. The team used the resulting dataset of CES census tracts, disadvantaged community designations, poverty metrics, and corresponding gas and electric utilities to produce aggregated utility population proportions for low-income and disadvantaged community population metrics, which were then modified according to the formula shown in

Figure 4.

Figure 5: Utility Population Proportion Low-Income/Disadvantaged Community Method Diagram



Flow chart depicting the low-income/disadvantaged community ratio calculation steps and application to the SB 350 savings.

Source: Navigant team

Technology Adoption Lag

The beyond-utility program workbooks include savings by specific technology end uses. The Navigant team applied the end use-specific modifiers to low-income/disadvantaged community energy efficiency savings. It is widely acknowledged that there are structural and policy barriers to technology adoption among disadvantaged community and low-income populations.[22] In the context of energy efficiency program adoption and, in particular, technology end-use adoption, substantive data regarding the rate of adoption are not available.

To address the expected variation in end-use adoption and program participation for these populations, the approach of this study addresses general technology adoption rates and trends for disadvantaged community and low-income populations with a modifier. The team labeled this modifier the low-income and disadvantaged community technology adoption lag factor. The lag factor incorporates analysis of data observed across several technologies, with the adoption rate of low-income individuals at a given time typically being less than general adoption rates by between 30 and 50 percent. Applying the lag factor relies on two key assumptions:

- First, the approach assumes that similar barriers to technology adoption exist for technologies unrelated to energy efficiency.
- Second, it assumes the rate at which technologies are adopted by low-income populations and disadvantaged communities will lag that of other populations at a constant level.

In support of these assumptions, this approach examines data regarding differential technology adoption related to age disparity,[23] rural and urban communities,[24] and the trend of higher-income adults adopting digital technology earlier than their lower-income counterparts (Figure 6).[25] Several of the structural barriers identified by the SB 350 Barriers Study[26] (low home ownership

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22 Scavo, Jordan, Suzanne Korosec, Esteban Guerrero, Bill Pennington, and Pamela Doughman. 2016. *Low-Income Barriers Study, Part A: Overcoming Barriers to Energy Efficiency and Renewables for Low-Income Customers and Small Business Contracting Opportunities in Disadvantaged Communities*. California Energy Commission. Publication Number: CEC-300-2016-009-CMF.

23 Smith, Erin, Pew Research Center. April 2014. "Older Adults and Technology Use"

24 Perrin, Andrew, Pew Research Center. May 2019. "Digital Gap Between Rural and Nonrural America Persists."

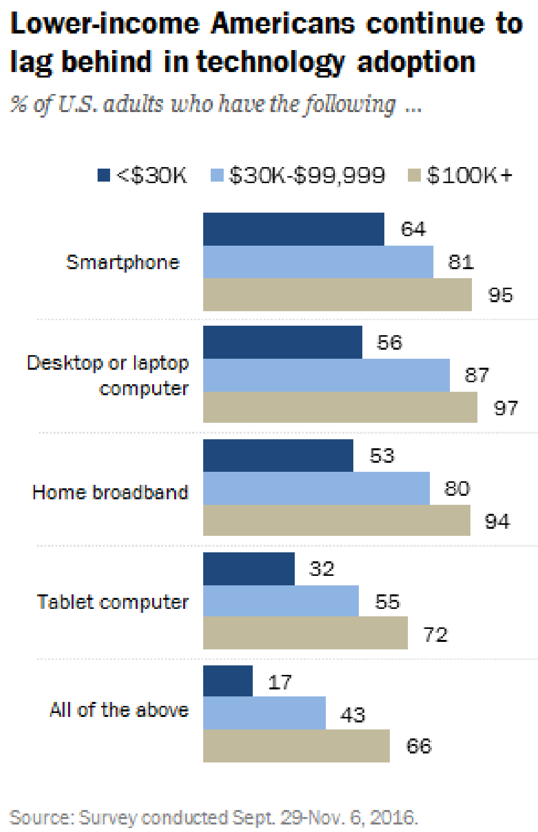
25 Anderson, Monica and Madhumitha Kumar, Pew Research Center. May 2019. "Digital Divide Persists Even As Lower-Income Americans Make Gains In Tech Adoption."

26 Scavo, Jordan, Suzanne Korosec, Esteban Guerrero, Bill Pennington, and Pamela Doughman. 2016. *Low-Income Barriers Study, Part A: Overcoming Barriers to Energy Efficiency and Renewables for Low-income customers and Small Business Contracting Opportunities in*

rate, lack of capital and credit, financing, and living in remote communities) were reflected in well-supported demographic trends. Furthermore, the rate of lag among these populations does not vary significantly over time; it tends to stay at a fixed rate below general adoption rates. Taken together, these trends support using a static lag factor rather than attempting to adjust adoption metrics in the absence of supporting data.

The analysis team included program- and end-use-specific modifiers in the method to incorporate future data relating to low-income and disadvantaged community savings lag and to maintain consistency with the other program workbooks. In the case of end-use-specific modifiers, all were given a value of one, while program-specific modifiers varied, as detailed in the Addressing Low-Income and Disadvantaged Communities by Sector section.

Figure 6: Digital Technology Adoption Trends



Horizontal bar chart depicting the digital technology adoption trends based on household income levels. Greater adoption occurs at higher-income levels.

Source: Pew Research Center

Disadvantaged Communities. California Energy Commission. Publication Number: CEC-300-2016-009-CMF.

Addressing Low-Income and Disadvantaged Communities by Sector

The team also considered the sectoral relevance of the low-income and disadvantaged community definitions to the specific program workbooks. Programs exclusively serving nonresidential sectors will not directly affect low-income populations living in a given census tract. Rather, low-income populations will be affected by programs targeting residential savings, while disadvantaged communities will be affected by any activities occurring within the community. This approach accomplishes several things:

- It acknowledges the place-based nature of the disadvantaged community designation by accounting for the effects of nonresidential and residential programs to a community. Conversely, forecasts for low-income populations will not overestimate savings based on programs with minimal to nonexistent residential impacts.
- It addresses overlap between disadvantaged populations and low-income populations while retaining a sufficiently broad population sample, the need for which is discussed in the Summary of Population Metrics Analysis section.

CHAPTER 4: Utility Program Savings— Investor-Owned Utilities

California's major IOUs—which include Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), and Southern California Gas (SoCalGas)—run extensive portfolios of energy efficiency programs across all sectors. The historical savings and the results of the energy efficiency potential studies are quantified via processes and reporting frameworks set up by the CPUC.

Method Description: Historical Savings

Savings from historical program activities are based on data collected from program reporting mechanisms and the evaluation, measurement, and verification (EM&V) efforts conducted and catalogued by the CPUC. There are two platforms for the data reporting. One is EEStats,[27] which has data that were analyzed for the 2015 program year. For program years 2016 and beyond, the CPUC moved to a different platform called California Energy Data and Reporting System (CEDARS).[28] Gross reported savings by utility, sector, and end use are accessible via these two datasets. Energy Commission staff converted gross savings to net savings for analysis.

Method Description: Future Savings

Savings forecasted from future program activities rely on the work performed for the IOU Potential and Goals (PG) study. This study developed estimates of energy and demand savings potential in the service territories of California's major IOUs during the post-2019 energy efficiency rolling portfolio planning cycle. Historically, the PG study has been updated every two years and provides a 10-year forecast. A key component of the 2019 PG study is the Potential and Goals Model (PG model), which provides a platform to conduct robust quantitative scenario analysis that reflects the complex interactions among

27 "California Energy Efficiency Statistics." California Public Utilities Commission.

28 CEDARS. 2019. "California Energy Data and Reporting System." California Public Utilities Commission.

various inputs and policy drivers.[29] Savings quantified via the 2019 PG Study include:

- Rebate programs.
- Codes and standards.
- Emerging technologies (industrial and agricultural sectors only).[30]
- Behavioral, retrocommissioning, and operations measures (BROs).

Codes and standards savings forecasts from the IOU PG study are an input to the beyond-utility analysis of codes and standards described in subsequent chapters (Chapter 6 – Title 24, Chapter 7 – Title 20, and Chapter 8 – Federal Appliance and Equipment Standards). The rest of this chapter focuses on savings from the other three items (rebate programs, emerging technologies, and BROs).

Forecasting Scenarios: Future Savings

Scenarios in the 2019 PG study were built primarily around policies and program decisions that are under control of the CPUC and IOUs collectively; these are referred to as "internally influenced variables." Variation in externally influenced variables (such as economic and demographic conditions) were not considered in the goals study but are considered in the additional achievable energy efficiency and SB 350 scenarios. A sample list of internally and externally influenced variables can be found in Table 8. Additional details on each of the internally influenced variables can be found in the study team's "Webinar on Potential Study Scenarios" from February 21, 2019.[31]

29 Navigant Consulting, Inc. 2019. *2021 Energy Efficiency Potential and Goals Study*. California Public Utilities Commission.

30 While emerging technologies are also considered in the residential and commercial sectors, they are embedded within the savings forecasted under rebate programs.

31 Navigant Consulting, Inc. 2019. "Webinar on Potential Study Scenarios." California Public Utilities Commission.

Table 8: Variables Affecting Energy Efficiency Potential

Internally Influenced	Externally Influenced
• Cost-effectiveness (C-E) test • C-E measure screening threshold • Incentive levels • Marketing and outreach • 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 • Enacting of future Codes and Standards

Source: Navigant

The 2019 PG study ran five scenarios as discussed in the PG study report.[32] The PG study reference scenario represented business as usual and the continuation of current policies, while the other four scenarios deviated from the reference scenario. The CPUC ultimately adopted the reference scenario as the IOU goals through Decision 19-08-034.

The SB 350 savings analysis relies on the Energy Commission's additional achievable energy efficiency scenario definitions for forecasted IOU program savings. Six additional achievable energy efficiency scenarios were developed; they were built upon the PG study scenarios and use many of the same variables to define each scenario. The SB 350 analysis used savings from two of the six additional achievable energy efficiency scenarios as the reference and aggressive cases; these are detailed in Table 9 and described below.[33]

- **SB 350 Reference Case:** This case used additional achievable energy efficiency Scenario 3, which aligns with the CPUC-adopted goals (the PG study reference scenario). By aligning with CPUC-adopted goals, the SB 350 reference case best reflects current policies and business as usual.
- **SB 350 Aggressive Case:** This case used additional achievable energy efficiency Scenario 6, the most aggressive of the additional achievable energy efficiency scenarios. It assumed increased incentives, increased marketing strength, and aggressive adoption options for BROs, agricultural, and industrial emerging technologies and financing. Moreover, this scenario filters the applicable measures to those passing the cost test at a benefit-cost ratio of 0.65 versus 1.0, allowing more measures to be considered in the forecast.

32 Navigant Consulting, Inc. 2019. *2021 Energy Efficiency Potential and Goals Study*. California Public Utilities Commission.

33 California Energy Commission, Webinar for the Demand Analysis Group, 2019 Additional Achievable Energy Efficiency Preliminary Results (slide 3), October 2019. "2019 Additional Achievable Energy Efficiency Preliminary Results"

No variable significantly affects low-income program savings; therefore, low-income savings are the same across the reference and aggressive SB 350 scenarios.

Table 9: IOU Program Savings Forecast Scenario Definitions

Additional Achievable Energy Efficiency Scenario	**Mid-Mid (Scenario 3)**	**Mid-High Plus (Scenario 6)**
2017 IEPR: Building Stock and Retail Prices	2017 IEPR Mid-Case	2017 IEPR Mid-Case
Agricultural and Industrial Emerging Technologies	Reference	Aggressive
Incentive Levels	Capped at 50% of incremental cost	Capped at 75% of incremental cost
C-E Measure Screening Threshold (TRC using 2019 Avoided Costs)	1	0.65
Marketing & Outreach	Default calibrated value	Aggressive
Financing Programs	Reference	Aggressive
Low Income	PG study result	PG study result
BROs Program Assumptions	Reference	Aggressive

Source: Webinar for the Demand Analysis Group, 2019 Additional Achievable Energy Efficiency Preliminary Results (slide 3), October 2019.

CHAPTER 5: Utility Program Savings— Publicly Owned Utilities

Like the IOUs, California's POUs also run energy efficiency programs. The historical savings and the results of the energy efficiency potential studies are quantified via processes and a reporting framework set up by the California Municipal Utilities Association and rolled up into an annual report. The reporting requirement complies with Senate Bill 1037 (Kehoe, Chapter 366, Statutes of 2005) that each POU must report annually to its customers and the state on its investment in energy efficiency and demand reduction programs. Assembly Bill 2021 (Levine, Chapter 734, Statutes of 2006) added to these policies by requiring the POUs to establish 10-year energy efficiency targets triennially.

Method Description: Historical Savings

Savings contributions to the SB 350 goals from historical program activities are based on data collected from the SB 1037 compliance reports submitted by the POUs to the Energy Commission.[34] Data in these reports include net, gross, and peak annual savings values for 40 California POUs. Savings are reported at the utility, residential and nonresidential, and measure category levels. POUs report units installed by measure category, which includes end uses such as residential lighting and nonresidential lighting.

Energy Commission staff selects net reported savings by utility, sector (residential or nonresidential), and end use (described in the SB 1037 report as measure category) for each POU to quantify historical savings. For SB 350 analysis, the largest 16 POUs, which are required to submit an integrated resource plan,[35] were analyzed at the utility level, and the remaining smaller POU savings were combined and considered as Northern California or Southern California small POUs. POUs vary in customer size and needs, so not all measures reported in the SB 1037 compliance report are rebated by each POU. The POU is able to select which measures to rebate based on the needs of the

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34 California Municipal Utilities Association. 2019. *Energy Efficiency in California's Public Power Sector: 13th Edition*.

35 An integrated resource plan provides the forecasted energy demand, plus some established reserve margin, through a combination of supply-side and demand-side resources over a specified future period.

community served, available funding and staff resources, and other limiting factors as determined by each POU.

Method Description: Future Savings

Savings contributions to the SB 350 goals from future program activities rely on the work performed for the POU Potential Study. The California Municipal Utilities Association, in partnership with the Northern California Power Agency (NCPA) and the Southern California Public Power Authority (SCPPA),[36] collaborated on developing POU 10-year electricity savings projections to establish electricity savings goals.[37] Navigant previously conducted an analysis funded by the Energy Commission to adapt the nonpublic POU model to meet the needs of this analysis. Adaptations to the model included:

- Extending the POU model forecast period to 2029.
- Enabling a common cross-cutting scenario analysis framework for all POUs.
- Apply net-to-gross ratios to POUs that did not report net savings.

When the original POU analysis was conducted, it focused on producing savings for the 16 largest POUs and provided cumulative savings starting in 2015. Two adjustments were needed to the output of these data:

- Cumulative forecasts savings needed to start in 2019 instead of 2015 (since historical data are used for 2015-2018 as described above).
- Savings from the 16 largest POUs needed to be extrapolated to the remaining smaller POUs. This extrapolation was done by applying a scaling factor based on electricity sales in each POU territory, weighted average energy efficiency savings as a percentage of sales for large and small POUs, and an average first-year savings for large and small POUs. Extrapolated total small POU savings were then broken down to the utility level by percentage electricity sales and then the sector level by the annual projected savings percentages for the 16 large POUs.

Forecasting Scenarios: Future Savings

The POU analysis funded by the Energy Commission developed three scenarios, as defined in Table 10.

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[36] NCPA and SCPPA are joint power authorities for the California municipalities or, in other words, POUs.

37 California Municipal Utilities Association. 2017. *Energy Efficiency in California's Public Power Sector: 11th Edition*.

Table 10: POU Rebate Program Scenario Summary

Variable	Low	Mid	High
Expand Measure List	Reference	Reference	Add new measures
Incentive Level	Reference x 75%	Reference	Reference
Promotional Expenditures	Reference x 75%	Reference	Reference x 125%
Behavioral Programs	Remove newly planned programs	Reference	Reference
Early Retirement (ER) Programs	Reference	Reference	Implement ER Programs

The SB 350 reference case selected the mid scenario. For the aggressive case, the analysis used the high scenario.

CHAPTER 6:
Codes and Standards—Building Standards (Title 24)

Title 24, Part 6 (Title 24) is the *California Building Energy Efficiency Standards,*[38] which contains the regulations that govern building construction in California. Title 24 covers regulated energy uses in buildings by setting energy design standards for residential and nonresidential buildings. The Energy Commission establishes and revises the code on a three-year cycle, the most recently implemented version being 2016 (as applicable for the SB 350 beyond-utility analysis, effective January 1, 2017, through December 3, 2019). The 2019 code cycle is on the books, and future versions relevant to this analysis include 2022, 2025, and 2028. For each update of the building standards, the Energy Commission proposes new efficiency measures and improvements to existing measures.[39]

Program Overview

Energy savings projections presented in this section include the 2016, 2019, 2022, 2025, and 2028 building standards. Older vintages of the building standards are not included because the SB 350 analysis starts in 2015, so they are covered in the baseline. In accordance with the CPUC's 2020 and 2030 zero-net-energy goals, the 2019 and 2028 standards will consider the new zero-net-energy requirements for residential and nonresidential buildings, respectively. The 2022 standards will examine low-rise and high-rise multifamily buildings and the potential to establish efficiency measures specific to multifamily buildings distinct from other residential and nonresidential buildings. Local ordinances, such as those meeting targets prescribed in CALGreen, complement the statewide standards and ensure California consumers fully realize the benefits of advancements in energy efficiency.[40] However, voluntary beyond-code programs

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38 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. The code also includes 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).

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

40 Local jurisdictions adopting local ordinances exceeding Title 24 must file findings of the local condition(s) justifying the ordinance and the adopted local building standard(s) with the California Building Standards Commission to become effective. For local ordinances exceeding the building energy efficiency standards set forth in Title 24, Part 6, a demonstration of energy

are not included in this estimate; these are captured in the Local Governmental Ordinances workbook described in Chapter 9.

Title 24 affects the following building markets:

- Residential and nonresidential buildings, excluding certain building types and end uses, such as industrial buildings and noncovered processes including refrigerated warehouse loads and data center uninterruptible power supply power.
- All cases in which an application for a building permit or renewal of existing permit is required; requirements are different for new construction than for additions or alterations to existing buildings.

Updates Relative to Previous Study

For the 2019 SB 350 update, the Navigant team used the IOU PG Study[41] to forecast statewide savings from committed code cycles. Future code cycles continue to use the beyond-utilities framework (developed for the 2017 SB 350 analysis) to forecast savings. For this update, the analysis team modified the output savings estimates to report by code cycle and end use. Results from the POU Potential Study[42] were also added to the utility overlap calculation, though this functionality was not used in the 2019 SB 350 analysis.[43]

In future SB 350 reporting cycles, the Energy Commission will determine the cutoff year for committed versus future code cycles to avoid overlap between code cycles. For every SB 350 analysis update, the Energy Commission should also review and revise, where necessary, key inputs and assumptions for future code cycles regarding naturally occurring market uptake, compliance rates, and end-use assumptions when disaggregating, or breaking down, energy results.

The previous study performed extensive building simulations to produce modeled savings estimates that can be adjusted through this postprocessing spreadsheet analysis in future iterations of SB 350 analysis. Refer to the 2017 *Senate Bill 350:*

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savings and cost-effectiveness must be submitted to the Energy Commission and approved by the Commission under Title 24, Part 1 administrative regulations found in 10-106 before they can be enforced.

41 Navigant Consulting, Inc. 2019. *2021 Energy Efficiency Potential and Goals Study*. California Public Utilities Commission.

42 Sathe, Amul (Navigant), Wikler, Greg (Navigant), Cullen, Gary (Anchor Blue LLC), Penning, Julie (Navigant) 2018. Publicly Owned Utility Electricity Savings Projections. California Energy Commission.

43 For each code cycle, the data come from either the PG Study extrapolated statewide or the BU workbook analysis; there is no need to subtract out any POU data. The functionality is present in case it is needed for future analysis.

Doubling Energy Efficiency Savings by 2030, Appendix A1 Title 24[44] for more detail on the analysis conducted for this program.

Method Description: Committed Code Cycles

Savings contributions to the SB 350 goals from committed code cycles of Title 24 use the work performed for the IOU PG study.[45] The Navigant team modified the PG study analysis to not include IOU attribution factors. The PG study includes codes and standards savings only for those claimable by IOU advocacy work as documented in the EM&V studies. Therefore, the outputs used for this analysis represent total savings, which are the PG study model outputs without attribution factors (that is, total savings represent all savings expected from each IOU's service territory, not only what the IOUs are allowed to claim). The team extrapolated the codes and standards savings statewide based on IOU-to-POU energy consumption ratios to include codes and standards savings in POU service territories. Statewide savings from later codes and standards are forecasted in beyond-utility workbooks.

Forecasting Scenarios: Committed Code Cycles

The PG study model generates three scenarios:

- Reference or default compliance
- Compliance enhancements
- Building 20 percent compliance rate reduction

Compliance rate enhancement takes the current compliance rates in the PG study and ramps them up to 100 percent. The number of years to ramp up is as follows:

- Federal standards: 5 years after codes and standards effective date
- Title 20: 10 years
- Title 24: 6 years

Compliance reduction is 20 percent across the board for every year.

Method Description: Future Code Cycles

Savings contributions to the SB 350 goals for Title 24 use an energy modeling approach, applying the results of a large set of energy simulations for a set of

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44 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF

45 Navigant Consulting, Inc. 2019. *2021 Energy Efficiency Potential and Goals Study*. California Public Utilities Commission.

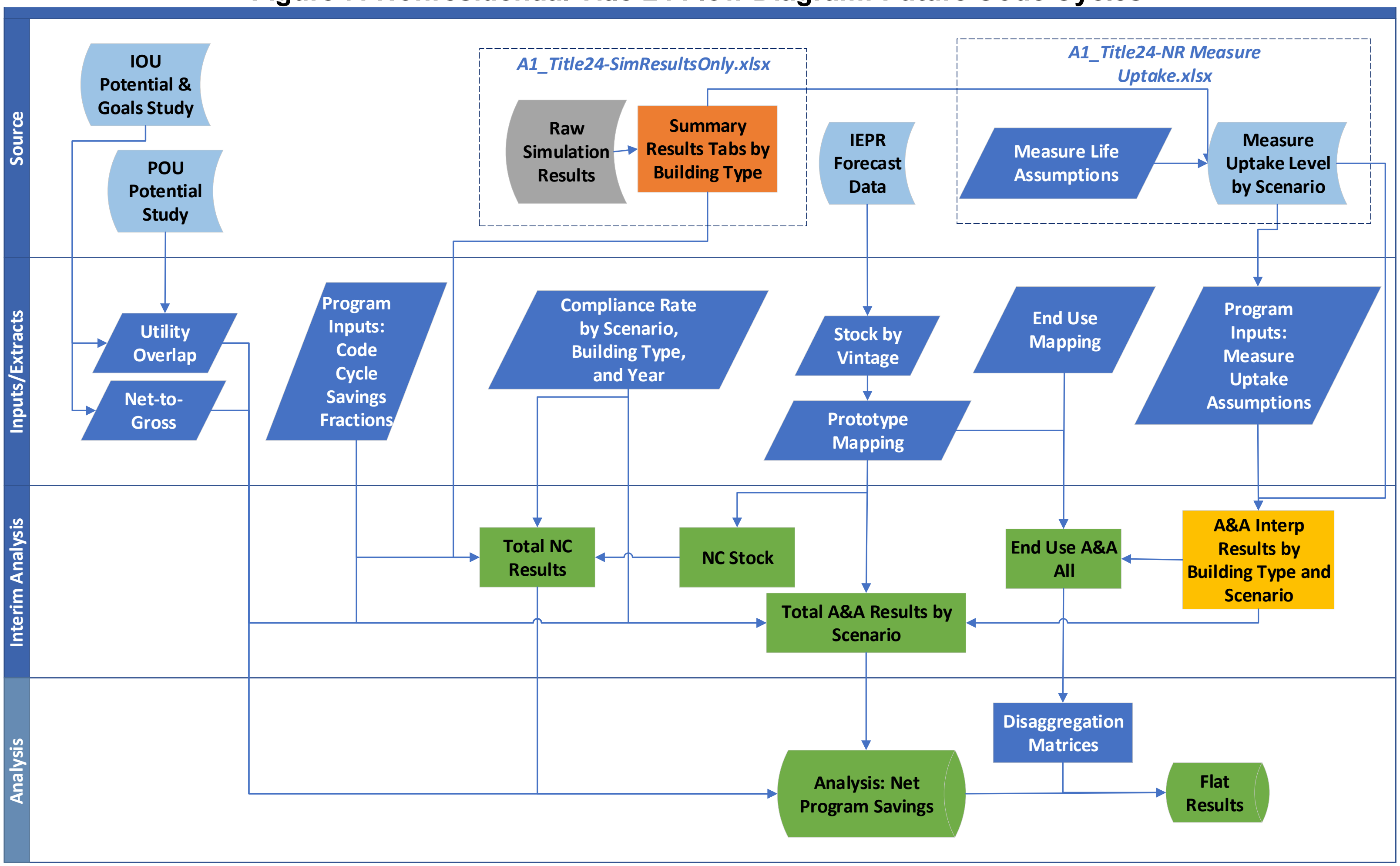
building types and measures for each of the 16 California building climate zones to project energy savings through the 2028 code cycle. Energy savings per building unit[46] of each type is converted to total electricity and gas savings for each climate zone by multiplying the building stock total units. For example, the residential single-family statewide savings equals the savings per household by climate zone times the number of households per the IEPR building stock data. The team estimated savings for each year by interpolating the results between code updates and scaling the energy savings for the given year.

The Title 24 new construction savings estimates may be reported by code cycle. Energy savings results from other data sources (such as the Energy Commission impact analysis) can be compared against these results, and the energy savings can be adjusted at a high level for each code cycle.

Figure 7 and Figure 8 show the overall flow of the method of this workbook for nonresidential and residential, respectively, highlighting the movement of data and calculations throughout the workbook.

46 The building stock metric is square feet for commercial and dwelling for residential.

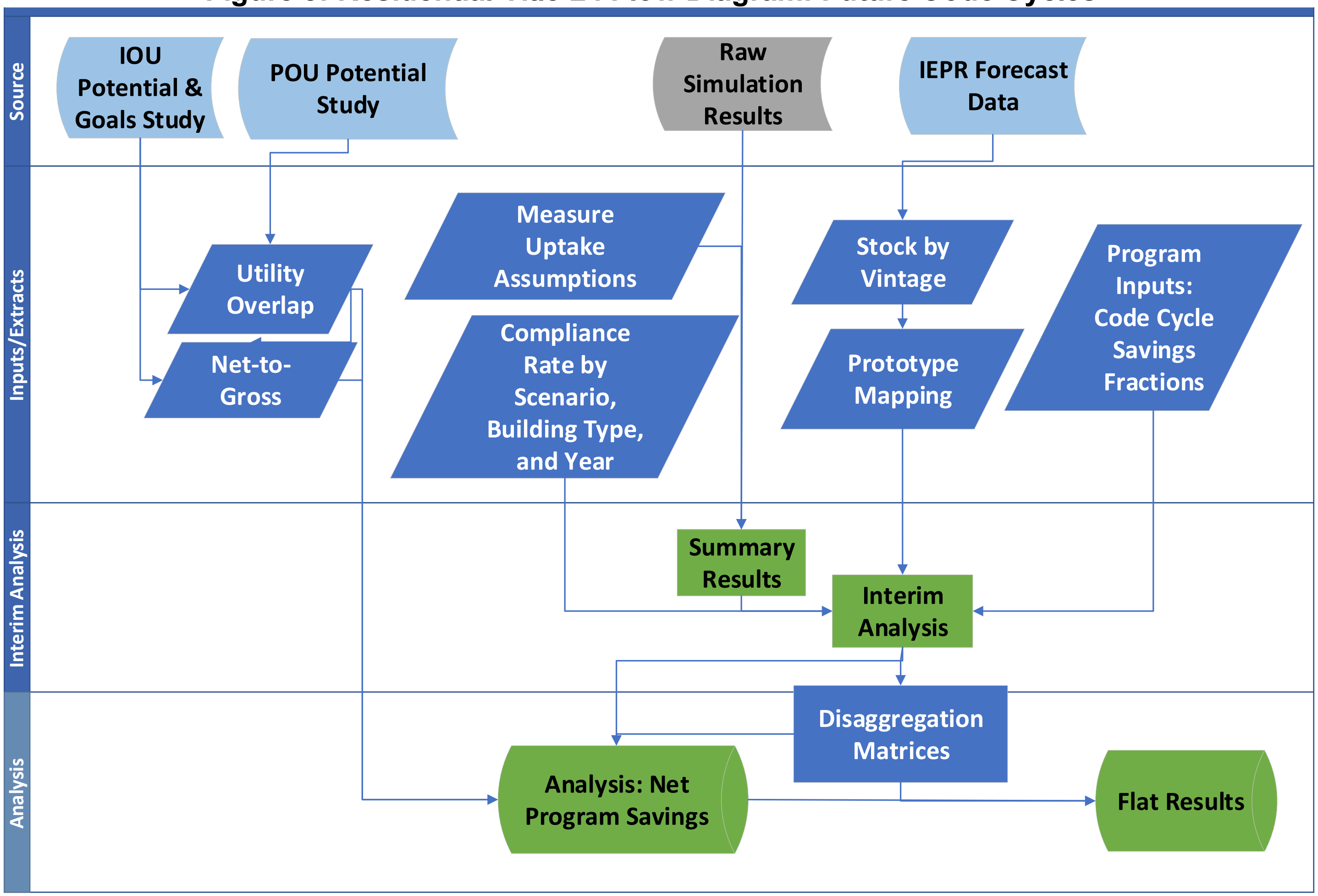
Figure 7: Nonresidential Title 24 Flow Diagram: Future Code Cycles



Title 24 nonresidential method flowchart for calculating forecast energy savings. Flowchart includes the inputs and data sources, high-level analysis steps, and outputs as implemented in the SB 350 Title 24 workbook.

Source: Navigant team

Figure 8: Residential Title 24 Flow Diagram: Future Code Cycles



Title 24 residential method flowchart for calculating forecast energy savings. Flowchart includes the inputs and data sources, high-level analysis steps, and outputs as implemented in the SB 350 Title 24 workbook.

Source: Navigant team

New Construction

The Title 24 workbooks track savings for new construction by code cycle (2019, 2022, 2025, and 2028). The method starts with a 2016 code-compliant building and ends with an estimated 2028 code-compliant building. Working backward from 2028, the analysis builds in assumptions that estimate savings per code cycle as a fraction of the 2028 total estimated savings; current assumptions are shown in Table 11.

Residential Title 24 savings for new construction are not included because the 2019 code cycle requirements are anticipated to be near net zero with renewable energy sources. Moreover, most of the improvements beyond 2020 not provided by renewable generation will be met by Title 20 (that is, lighting and appliances).

Table 11: Code Cycle Savings as a Percentage of Savings Between the 2016 and 2028 Code Cycles

Title 24 Code Cycle	Percentage of 2028 Savings
2019	33%
2022	50%
2025	67%
2028	100% (max potential)

Source: Navigant team

While the percentage assumptions were based on engineering judgment when they were established in 2017, they can be trued up against better estimates of the savings as each code version becomes available. Savings data for true-up can be extracted from any study that estimates Title 24 savings for residential and nonresidential building sectors; such studies include the Title 24 Impact Analysis or IOU evaluation studies. The true-up requires comparing the savings potential suggested by the Title 24 Impact Analysis of that code cycle against the modeled 2028 savings estimate. This comparison will refine the percentage assumptions of savings potential by code cycle and, consequently, the savings projections associated with new construction for the Title 24 program under SB 350.

In updating SB 350 projections, the Navigant team proposes using a relative approach based on another source (such as the Title 24 impact analysis) to true up the incremental savings between code cycles and modify the projected savings for future code cycles.[47] An increase in savings in one code cycle would likely have the effect of decreasing savings for subsequent code cycles. The program workbook estimates total energy savings based on efficiency measure package assumptions in the simulation models. The workbook provides a high-level means of adjusting the savings to match forecast expectations but does not allow the Energy Commission to increase or decrease expected efficiency gains at the building-type level (for example, office, retail, hospital).[48]

The impact analysis estimates cannot be directly input to the SB 350 tool because the SB 350 tool uses a different set of assumptions and a different method from the Title 24 impact analysis approach. Truing up the two estimates would require aligning the assumptions of the two approaches. Some of the key differences include the following:

- The analysis uses a maximum technical potential and associated energy-use intensity (EUI)[49] in 2030 for future energy savings predictions, while the Title 24 impact analysis looks at one code cycle at a time.
- This analysis applies specific net-to-gross (NTG)[50] assumptions and code compliance rates, which do not match impact analysis assumptions.
- This analysis incorporates measures for end uses not regulated by Title 24 (commercial refrigeration, plug loads).

The team recommends using future impact analysis updates to adjust the SB 350 estimate by adjusting the estimate in proportion to increases or decreases in total savings (GWh or therms) from the previous code cycle and adjusting future code cycle estimates to track toward the specified 2030 target efficiency levels from one code cycle to the next.

Existing Buildings

For existing buildings, the analysis approach used a 2028 package of discrete measures applied to each building vintage for each building type and each of the

47 This may require reviewing the program workbook assumptions on uptake, net-to-gross (NTG), and so forth to make sure they align with the assumptions from the other data source. For instance, the impact analysis uses a NTG value of one and a code compliance rate of 100 percent.

48 A building type or end use adjustment would require constructing a new building model.

49 EUI refers to the energy use intensity at the building or end use level, typically expressed as an energy unit per household for residential and per square feet for nonresidential.

50 The NTG ratio is the ratio of the changes in energy use directly attributable to the program intervention to the changes in energy consumption calculated by the program activities. The NTG ratio is calculated as one minus the percentage of percent savings from free riders plus the percent savings from spillover (additional energy savings due to program influences beyond the program participants).

16 building climate zones. The analysis estimates electricity and gas savings between this 2028 code snapshot and a 2016 code snapshot. It applies a set of measure uptake assumptions to determine what percentage of buildings at each existing building vintage are upgraded to newer codes and allocates these savings to each code cycle using the percentages in Table 11.

Forecasting Scenarios: Future Code Cycles

The Navigant team made the following assumptions for the reference, conservative, and aggressive scenarios. Compliance rate is one dimension adjusted to differentiate the scenarios; these rates can vary by sector and new construction versus alterations and additions (that is, existing buildings). The current nonresidential levels for the conservative, reference, and aggressive scenarios are 65 percent, 82 percent for new construction and 86 percent for existing construction, and 95 percent, respectively. The current residential levels (alterations and additions only) for the conservative, reference, and aggressive scenarios are 64 percent, 80 percent, and 95 percent, respectively.

Scenarios for additions and alterations savings are also adjustable through the following measure uptake assumptions:

- Reference scenario assumes equipment turnover rates for estimating additions and alteration savings.
- Conservative scenario assumes a 10 percent reduction in equipment turnover rates compared to the reference case.
- Aggressive scenario assumes a 30 percent increase in equipment turnover rates and enhanced compliance compared to the reference case. Compliance enhancements ramp up to compliance rate of 100 percent within six years.

Areas to Improve

The team recommends that future iterations of the SB 350 savings potential analysis include further research on calibrating savings by code cycles and utility savings overlap.[51] Specific recommendations include:

- **Compliance rates:** Provide data-driven inputs on compliance rates for the three scenarios with as much granularity as available.
- **Measure uptake:** Review and provide updated values on measure uptake.

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51 Savings overlap may occur with other programs within utility portfolios and not just the codes and standards analysis.

- **Review 2030 target efficiency levels:** Review measure package assumptions and verify that forecast nonresidential new construction efficiency levels align with Energy Commission goals and forecasts.
- **Calibration of savings estimates:** Update new construction estimates for each code cycle as more specific impact analysis estimates become available. Provide a reliable means for comparing energy savings estimates from the impact analysis so program estimates can be appropriately updated.

CHAPTER 7: Codes and Standards—Appliance Regulations (Title 20)

Title 20, California Code of Regulations, sections 1601-1609, 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 Energy Commission, which develops and implements these regulations, is not required to update them on any specific interval; the Energy Commission updates individual standards after receiving sufficient data to support new or amended efficiency standards or test procedures for individual appliances. The scope of the standards 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 (EPCA) and related amendments. The EPCA states that no state can adopt appliance standards for products if there is a national standard; however, there are some specific exceptions for individual appliances and states and for situations where a waiver of preemption on a specific encompassing and exception or appliance to a state is granted. Therefore, the Energy Commission can regulate only appliances outside the scope of DOE appliance standards.

Program Overview

The Energy Commission is responsible for establishing and enforcing Appliance Efficiency Regulations (appliance regulations) that set minimum efficiency standards and test procedures, marking, and disclosure requirements for federally and nonfederally regulated appliances.[52] 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.

Updates Relative to Previous Study

The 2019 SB 350 update uses the IOU PG Study to forecast statewide savings from committed standards. The analysis team did not make significant changes to the method from the previous study to capture savings from future standards.

52 Title 20, Sections 1601-1609, California Code of Regulations.

The current spreadsheet includes capabilities to increase analysis sophistication, as described in the Method Description: Committed Standards and Method Description: Future Standards sections. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. The previous study performed a measure-level analysis. This team did not update this analysis, but it can be adjusted in future iterations of the SB 350 analysis. To finalize the 2019 SB 350 reporting, the Energy Commission updated normally occurring market adoption (NOMAD) assumptions and determined which standards fall into the committed versus future categories to ensure there is no overlap. For future standards, the Energy Commission should also review and revise, where necessary, key inputs and assumptions regarding scenarios and compliance rates. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*, Appendix A2 Title 20[53] for more detail on the analysis conducted for this program.

Method Description: Committed Standards

Savings contributions to the SB 350 goals from committed standards use the work performed for the IOU PG study. The model for this effort is run without attribution factors, so savings represent the full savings of the IOU service territories, not only those the IOUs can claim. The full savings are then extrapolated to include the POU territories, so they represent statewide savings.

Forecasting Scenarios: Committed Standards

The PG study model generates three scenarios:

- Reference or default compliance
- Compliance enhancements
- Building 20 percent compliance rate reduction

Compliance rate enhancement takes the current compliance rates in the PG study and ramps them up to 100 percent. The number of years to ramp up is as follows:

- Federal standards: 5 years after codes and standards effective date
- Title 20: 10 years
- Title 24: 6 years

Compliance reduction is 20 percent across the board for every year.

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53 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

Method Description: Future Standards

The analysis team derived Title 20 appliance efficiency standards program savings for SB 350 using a bottom-up extrapolation approach to determine the savings potential for viable Title 20 standards. The savings potential is based on available studies and discussion with members from the Appliance Standard Awareness Program (ASAP) and California IOU statewide codes and standards team, both of which are looking into future appliance standards at the federal and state levels.

The team developed a list of potential Title 20 appliance efficiency standards measures that are viable to develop and include in the Title 20 standards through 2029. This list included any known measures that are identified but not included in the 2018 IOU PG study,[54] 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 discussed with IOU codes and standards staff. The team relied on current analyses and studies, as well as information the Energy Commission provided regarding expected rulemakings.

The current program workbook includes some capability enhancements. While capabilities have been added to increase the sophistication of the analysis, the core method approach remains largely the same as the SB 350 analysis conducted in 2017. The capability enhancements include:

- **Measure EUL:** This capability enhancement permits the measure to persist for a defined period and then expire. It is applied at the end-use level. In the previous spreadsheet, the analysis team assumed the measure EUL to be permanent (that is, the measure never ends).
- **Individual measure sunset date:** This enhancement, along with the implementation date, defines the total number of years that the measure will be active. It will permit the sequencing of measure efficiency tiers in the list, presuming there is an expectation for when the first, second, and any additional tiers are going to be implemented. Most of the measures do not have a specifically designed next tier planned; however, if there are more in the future, the analysis structure can accommodate. If there is no definition for the sunset date, it implies there is not a future tier. In these cases, the measure EUL is used to define total number of years the measure will be active.
- **NOMAD curve capability:** This enhancement permits an actual NOMAD curve, as defined by annual NOMAD, through the life of the measure. Previously, this was fixed as a constant; now, it is possible for it to be a

54 Navigant Consulting, Inc. 2017. *2018 Energy Efficiency Potential and Goals Study*. California Public Utilities Commission.

more common S-curve for NOMAD. This capability is set to the previous fixed values.

- **Tracking of measures by sector, end use, and start date:** This enhancement permits more detailed tracking of the measures than previously possible and enables the Flat Results tab to reflect higher resolution in the measures.

Forecasting Scenarios: Future Standards

Based on this information, the Navigant team made the following assumptions for reference, conservative, and aggressive savings scenarios.

- **Reference case:** The reference case assumes that the Energy Commission will adopt updates to the Title 20 appliance efficiency standards, where feasible, and 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, aligning with the PG study assumption. This equates to an average of roughly one new standard adopted every two years.
- **Conservative case:** In the conservative case, the team assumes that the Energy Commission will adopt updates to the Title 20 appliance efficiency standards, where feasible, and new standards for currently unregulated appliances and products they have interest in, as shown on the Energy Commission Pre-Rulemaking Title 20 docket. The Commission set the compliance factor at 65 percent, aligning with the PG study assumptions. This compliance factor equates to an average of about one new standard adopted every four years, resulting in a smaller number of possible measures included in this scenario.
- **Aggressive case:** The aggressive case assumes that the Energy Commission will adopt updates to the Title 20 appliance efficiency standards, where feasible, as well as 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.

Areas to Improve

The team recommends that future iterations of the SB 350 savings potential analysis include further research on calibrating savings and utility savings overlap.

Specific recommendations include:

- **Utility savings overlap:** Confirm that the subtractions made to account for overlap with Navigant's 2018 PG analysis are appropriate.[55]
- **Code updates:** Appropriately track data availability for new standards, including potential energy savings, timeline of standard adoption and effective dates, compliance rates, and NOMAD assumptions.

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55 Savings overlap may occur with other programs within utility portfolios and not just the codes and standards analysis.

CHAPTER 8: Codes and Standards—Federal Appliance and Equipment Standards

Starting with the Energy Policy and Conservation Act of 1975, the 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. 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.[56] DOE establishes and updates the standards according to the deadlines established in the federal appliance statute on a rolling basis. The national standards program covers the energy requirements of 60 categories of products.

Program Overview

The Federal Appliance and Equipment Standards program requires manufacturers to comply, affecting 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.[57]

As a result, with the exception of certain exemptions, California cannot set standards for products already covered under the federal appliance standards.[58] California typically participates in federal rulemakings to ensure that stringent standards that save Californians money on their utility bills are adopted. The SB 350 savings estimates include measures from the 2015 beyond-utility energy efficiency savings potential, new measures from 2017 through 2029, and any measures that can be updated to provide additional savings.

56 U.S. Department of Energy. May 2017. Federal Appliance Standards.

57 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.

58 Under the general rules of federal preemption, states that 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 enforced by the federal government are subject to the federal standard immediately.

Future savings from new federal standards are focused on high-energy-consumption appliances, including heating and cooling equipment, domestic hot water systems, battery chargers, commercial clothes washers, and lighting.[59] Federal appliance standards are not specific to any building type.

Updates Relative to Previous Study

The 2019 SB 350 update uses the IOU PG Study to forecast statewide savings from committed standards. The analysis team did not make significant changes to the method from the previous study to capture savings from future standards, except some capability enhancements in the spreadsheet tool. The Energy Commission can use the updated beyond-utility program workbook to incorporate any new program data that may be used to update the savings estimates for this program. The previous study performed a measure-level analysis. This team did not update this analysis, but it can be adjusted in future iterations of the SB 350 analysis. To finalize the 2019 SB 350 reporting, the Energy Commission updated NOMAD assumptions and determined which standards fall into the committed versus future categories to ensure there is no overlap. For future standards, the Energy Commission should also review and revise, where necessary, key inputs and assumptions regarding scenarios and compliance rates. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*, Appendix A3 Federal Appliance Standards[60] for more detail on the analysis conducted for this program.

Method Description: Committed Standards

Savings contributions to the SB 350 goals from committed standards use the work performed for the IOU PG study. The model for this effort is run without attribution factors, so savings represent the full savings of the IOU service territories, not only those the IOUs can claim. The full savings are then extrapolated to include the POU territories, so they represent statewide savings.

Forecasting Scenarios: Committed Standards

The PG study model generates three scenarios:

- Reference or default compliance
- Compliance enhancements

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

60 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

- Building 20 percent compliance rate reduction

Compliance rate enhancement takes the current compliance rates in the PG study and ramps them up to 100 percent. The number of years to ramp up is five years after the standard effective date.

Compliance reduction is 20 percent across the board for every year.

Method Description: Future Standards

The analysis team derived Federal Appliance and Equipment Standards program savings for SB 350 using a bottom-up, measure-level approach to determine the savings potential for viable federal appliance standards. The federal appliance standards are based on goals set by the DOE's Building Technologies Office (BTO) to reduce building energy consumption by 30 percent compared to 2010 energy consumption through 2029.[61]

To estimate energy savings potential for future federal appliance standards—both new standards and updates to current standards—the team made high-level estimates based on DOE BTO goals and then refined savings estimates by measure based on measure data or available sources indicated in the program workbook. The analysis used:

- 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.
- NOMAD at the time the standard goes into effect.

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 team estimated California-specific savings by establishing 2010 building EUIs 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 affect

61 U.S. Department of Energy. 2018. Multi-Year Program Plan.

electricity and natural gas usage. The following approach established the high-level estimates:

- Estimated California building EUI for nonresidential and residential buildings in California using Commercial Buildings Energy Consumption Survey (CBECS),[62] Commercial End-Use Survey (CEUS),[63] and Residential Appliance Saturation Study (RASS)[64] data. The team found these datasets to be the most recent at the time of this report. As newer data become published, the team recommends the method and program workbook be updated accordingly.
    - Aligned 2010 EUIs with the BTO reduction goals.
    - Identified trends in nonresidential building consumption using the 2003 and 2012 national CBECS.
    - Used the CBECS trends to adjust 2006 California CEUS data to estimate nonresidential building kWh and therms consumption per square foot (EUI) 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 as CEUS does, so the office building trend data were used for both.
    - Collected 2009 RASS data to use for residential kWh and therms use per square foot.[65]
- Estimated energy reduction from 2010 to 2025 based on the BTO goal of 20 percent reduction by 2025. To achieve 20 percent, the team estimates that appliance standards will reduce energy consumption by 2 percent to 4 percent every two years until 2024.[66]
- Identified affected square footage using the Energy Commission's energy demand forecast new construction and building stock estimates. Appliance standards affect all new construction and equipment replacement or retrofit in existing buildings. The team assumed an EUL of 15 years to estimate the affected existing building square footage, 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 affected square footage.

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62 U.S. Energy Information Administration. 2003. "2003 CBECS Survey Data."

63 Itron. May 2017. *California Commercial End-Use Survey*.

64 DNV-GL. 2010. *California Statewide Residential Appliance Saturation Study*.

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

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

- 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 2 percent to 4 percent every two years and applied the savings to the applicable square footage from 2015 through 2029.
- Assumed that savings will be realized beginning in 2011 and must end by 2024 to achieve 20 percent by 2025; however, the team included only savings starting in 2015 under the assumption that prior savings are captured in previous PG and beyond-utility savings potential studies. The team considered the following limitations for the estimates:
    - Estimated savings based on BTO goals without identifying appliances and equipment standards that will contribute to the savings.
    - Used the 2010 EUIs as the best-available estimates based on survey data.

Similar to the Title 20 appliance efficiency standards program workbook, the current federal appliance standards program workbook includes some capability enhancements, but the core method approach remains largely the same as the SB 350 analysis conducted in 2017. The capability enhancements include:

- **Measure EUL:** This enhancement permits the measure to persist for a defined period and then expire. It is applied at the end-use level.
- **Individual measure sunset date:** This enhancement, along with the implementation date, defines the total number of years that the measure will be active. This enhancement permits the sequencing of measure tiers in the list, presuming there is an expectation for when the first, second, and so on tiers are going to be implemented. Most of the measures do not have a specifically designed next tier planned. If there are more in the future, the tool will accommodate. If there is no definition for the sunset date, it implies there is not a future tier. In these cases, the measure EUL is used to define the total number of years the measure will be active.
- **NOMAD curve capability:** This enhancement permits an actual NOMAD curve, as defined by annual NOMAD, through the life of the measure. Previously, this enhancement was fixed as a constant. Now it is possible for this to be a more common S-curve for NOMAD. This curve capability is set to the previous fixed values.
- **Tracking of measures by sector, end use, and start date:** This enhancement permits more detailed tracking of the measures than previously possible and enables the Flat Results tab to reflect higher resolution in the measures.

Forecasting Scenarios: Future Standards

Based on this information, the team made the following assumptions for the reference, conservative, and aggressive scenarios.

- The reference scenario assumes that DOE will adopt updates to the federal appliance standards, where feasible, and will adopt standards for appliances and products that were out for public review but not fully completed under the Obama administration.[67] As of January 2017, the DOE published a five-year draft plan[68] for federal appliance standards, with expected legislative due dates through 2024. There has not been an update on rulemaking for standards since the 2017 publications.[69] 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 92 percent in alignment with the PG assumption, as requested by the Energy Commission.
- In the conservative scenario, the team assumes that DOE will not adopt updates to the federal appliance standards or adopt new standards, but it will adopt standards for appliances and products that were out for public review but not fully completed prior to 2017. The Energy Commission set the compliance factor at 73 percent in alignment with the PG assumptions.
- The aggressive scenario assumes that DOE will adopt updates to the federal appliance standards, where feasible, and will adopt new standards for currently unregulated appliances and products. The compliance factor is set at 100 percent.

Areas to Improve

The team recommends that future iterations of the SB 350 savings potential analysis include research on calibrating savings and utility savings overlap. Specific recommendations include:

- **Utility savings overlap:** Confirm the subtractions made to account for overlap with Navigant's 2018 PG study analysis are appropriate.
- **Code updates:** Appropriately track data availability for new standards, including potential energy savings, timeline of standard adoption and effective dates, compliance rates, and NOMAD assumptions.

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67 At the end of 2016, rulemakings for some standards were out for review; they are still in the final rulemaking process. These are identified in ASAP's "U.S. DOE Appliance Standards Rulemakings Schedule - 2017."

68 DOE. January 18, 2017. "Draft 5-Year Appliance Standards Rulemaking Schedule."

69 DOE. "Plans and Schedules."

CHAPTER 9: Codes and Standards—Local Government Ordinances

Jurisdictions within California develop and adopt local ordinances requiring that select or all new construction 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 GHG emissions reductions targets, net-zero footprint, and reduced energy consumption.

Program Overview

Each jurisdiction can determine which building types, construction, and market sectors 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 (for example, hospitals, industrial).
- 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.

Updates Relative to Previous Study

The analysis team did not make any changes to the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*, Appendix A4 Local Government Ordinances[70] for more detail on the analysis conducted for this program.

Method Description

The analysis team derived local government ordinance program savings for SB 350 using a top-down extrapolation approach. The team assumed that jurisdictions that adopted a local government ordinance above 2016 Title 24 will

70 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

continue to adopt local government ordinances for future versions of Title 24. The method took the approach of estimating the square footage that will likely be affected by future local government ordinances in each of these jurisdictions and applied the estimated energy savings for future Title 24 code updates.

To estimate potential electricity and natural gas savings for local government ordinances, the analysis team estimated the percentage of new construction affected by a local government ordinance and the estimated energy savings for a local government ordinance in each jurisdiction. The savings from the local government ordinance are achieved until the next version of Title 24 goes into effect. At that point, the team 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 team used the same projected Title 24 efficiency improvements as those used for the 2016 residential and nonresidential Title 24 program analysis and will continue to use them for each future cycle of nonresidential Title 24 analysis from 2019 through 2028. The team gathered data on the jurisdictions that will likely adopt a local government ordinance requiring energy efficiency improvement over Title 24 baselines based on historical data from the Energy Commission.[71] These data help determine savings per square foot. The team calculated the affected square footage based on publicly available permit data from jurisdictions that have adopted, intend to adopt, or are expected to adopt a local ordinance.

The team used the following steps to estimate potential energy savings:

- **Established baseline:** The team used expected energy efficiency improvements for 2016, 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 assumed the same jurisdictions will continue to implement local government ordinances. The team calculated the estimated square footage based on available issued permit data in these jurisdictions and Energy Commission forecast construction data. The team reduced the eligible square footage in each jurisdiction based on historical participation rates for IOU/POU above-code incentive programs, such as Savings by Design (the utility new construction program that requires buildings to be above code), to account for utility overlap.

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71 California Energy Commission. May 2017. "Local Ordinances Exceeding the 2016 Building Energy Efficiency Standards." The Energy Commission provides data on local ordinances requiring efficiency above 2016 Title 24.

- **Estimated energy savings:** 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, the team applied the statewide energy savings estimates from the Title 24 program analysis.
- **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.

Forecasting Scenarios

The team made the following assumptions for the reference, conservative, and aggressive scenarios.

- **Reference case:** The reference case assumes that jurisdictions that 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 that have previously adopted local government ordinances will not continue to pursue ordinances for future Title 24, assuming that it will no longer be 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 assumption may be supported by ongoing 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 program work 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).

Areas to Improve

The team recommends that future iterations of the SB 350 savings potential analysis include further research on calibrating savings by code cycles and utility savings overlap. Specific recommendations include the following:

- Develop a network of local governments, implementers, and stakeholders willing to contribute to the efforts of this program analysis through different methods, such as data sharing, review and verification, focus groups, and surveys.
- Track future adoption (or termination) of local government ordinances across the state and update market penetration assumptions as appropriate.
- Analyze actual percent savings of local government ordinances compared to the code cycle.

CHAPTER 10: Financing—Air Quality Management Districts

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 buildings. AQMDs and air pollution control districts (APCDs) consider energy efficiency measures at the building level that exceed the building standards to qualify. These measures may include installing programmable thermostat timers, upgrading lighting, and installing energy-efficient appliances.[72] Other mitigation efforts could include using energy efficiency measures, such as heating, ventilation, and air-conditioning (HVAC) retrofits, retrocommissioning, envelope upgrades, and other whole-building measures on existing buildings. These types of requirements or encouragement have the potential to capture energy savings and GHG emissions reductions by 2030.

Program Overview

CEQA requires state and local agencies within California to analyze and publicly disclose environmental impacts of proposed projects and adopt all feasible measures to address those impacts. In California, there are 35 air districts: 23 APCDs and 12 AQMDs.

Where any project under CEQA 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:

- Agricultural resources
- Land use and planning
- Air quality
- Mineral resources
- Biological resources
- Noise
- Cultural resources
- Population and housing
- Geology and soils
- Public services
- GHGs
- Recreation
- Hazards and hazardous materials
- Transportation and traffic
- Hydrology and water quality
- Utilities and service systems

72 California Air Pollution Control Officers Association. 2010. *Quantifying Greenhouse Gas Mitigation Measures*. California Air Resources Board.

Guidelines published by air quality districts identify energy efficiency measures that can be applied to reduce GHGs and other criteria air pollutants to below a level of significance. CEQA applies to nearly all projects in California. All public agencies are required to reduce or avoid significant effects on the environment of projects they carry out or approve whenever it is feasible to do so. Moreover, CEQA applies to all private projects that require a government permit or other entitlement for use. While specific guidance about ensuring CEQA compliance varies from district to district, all districts must implement and comply with CEQA.

Updates Relative to Previous Study

The analysis team did not make any changes to the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the previous *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*, Appendix A5 Air Quality Management Districts[73] for more detail on the analysis conducted for this program.

Method Description

The analysis team derived AQMD program savings for SB 350 using a top-down extrapolation approach to determine the savings potential. The analysis team assumed that AQMD requirements could result in an additional 5 percent of electricity and gas savings beyond the savings projected for Title 24, starting with the 2016 code cycle and continuing through 2030 for SB 350.

AQMD criteria pollutant mitigation aligns more closely with codes and standards than with financing or rebate programs. CEQA requires mitigation for significant impacts, and the air quality districts are tasked with identifying and implementing this mitigation. Accordingly, the savings estimation approach for AQMD uses savings developed for relevant codes and standards (that is, Title 24). While the PG study provides much of the data for codes and standards analysis, the study is not expected to include the savings potential associated with regional air quality districts.

Compliance with applicable building and appliance standards will contribute significantly to meeting mitigation requirements. The team's literature review indicated that meeting code-minimum requirements for a new construction or alteration project is not expected to fully satisfy mitigation requirements. A

73 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

memo published by the Shute, Mihaly & Weinberger, LLP[74] law firm indicates that Title 24 "does not extend beyond the buildings themselves" and, therefore, "does not address many of the considerations required under Appendix F of the CEQA Guideline." Indeed, CEQA Appendix F highlights several potentially significant energy implications that extend beyond the scope of Title 24:

- Energy-consuming equipment and processes that will be used during construction, operation, or removal of the project
- Total estimated daily vehicle trips to be generated by the project and the additional energy consumed per trip by mode
- The effects of the project on peak and base demand periods for electricity and other forms of energy

Where a project is anticipated to result in a significant, adverse impact to the environment, mitigation is required. While a wide range of action can contribute to mitigation, energy efficiency interventions factor prominently into recommended strategies. The Bay Area Air Quality Management District's Air Quality Guidelines specifically identify exceeding the energy efficiency requirements of Title 24 as a potential approach to mitigation.

AQMD requirements are assumed to result in an additional 5 percent of electricity and gas savings projected for iterations of Title 24 starting in 2016 and continuing through 2028. The Energy Commission suggested that the proposed program would require projects to pay a fee to address mitigation requirements. This approach would have multiple benefits, including reducing the schedule and resource burden imposed on individual projects by pollution mitigation requirements and enabling money to be pooled into a larger fund that could be used to address large-scale pollution concerns across a district.

Forecasting Scenarios

The team made the following assumptions for the reference, conservative, and aggressive scenarios.

- **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.
- **Conservative case:** The conservative 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.

74 Shute, Mihaly & Weinberger, LLP. "Don't Forget the Energy Implications of New Projects – CEQA Guidelines Appendix F."

- **Aggressive case:** The aggressive 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.

Areas to Improve

For financing programs in general, the analysis team recommends further research on funding projections, utility savings overlap, and market saturation. For the AQMD program, specific recommendations include the following:

- Develop a network of AQMD agencies, local jurisdictions, and stakeholders willing to contribute to the efforts of this program analysis through different methods, such as data sharing, review and verification, focus groups, and surveys.
- Conduct targeted outreach to AQMD agencies and stakeholders that are most prominent and active in implementing and regulating local AQMD requirements.
- Obtain district-specific funding and project data to evaluate the effect that AQMD requirements and related funding have on energy savings.
- Project energy savings potential using program data provided by AQMD agencies and expected funding data.

CHAPTER 11: Financing—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 AB 802 (Williams, Chapter, 590, Statutes of 2015).[75] The LGC uses remaining funds from the American Recovery and Reinvestment Act (ARRA)[76] 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.

Program Overview

This program consists of four awarded energy innovation grants to local governments and several small government grants, directed primarily toward climate action plans, in response to Energy Commission solicitation GFO-16-404. The program awarded Energy Innovation Challenge grants to the following projects:

- Marin Clean Energy—Building Efficiency Optimization Project
- City of San Diego—Smart City Open Urban Platform (SCOUP)
- City of San Leandro—Innovative Energy Efficiency and Renewable Energy Deployment Project
- Stop Waste Energy Council—Accelerating Multifamily Building Upgrades

The program awarded the Small Government Leadership Challenge awards to:

- City of Del Mar—Civic Center Energy Efficiency Enhancements.
- Gateway Cities Council of Governments—Climate Action Planning Framework.
- San Bernardino Council of Governments—Sub-Regional Greenhouse Gas Reduction Plan Update.

75 Williams, Chapter 590, Statutes of 2015.

76 ARRA was a 2009 economic stimulus package including funding for the energy sector.

- County of San Luis Obispo—EnergyWise Plan Energy Section Update including Zero Net Energy Neighborhood Feasibility, Design, and Implementation Study.
- City of Santa Cruz—Deep Energy Efficiency at Municipal Facilities through Advanced Building Controls.
- Ventura County Regional Alliance—Central Coast Energy Plan.
- Marin General Services Authority—Marin Climate and Energy Partnership/Resilient Neighborhoods Grassroots Climate Action.
- City of Galt—City of Galt Climate Action Plan, Corridor Plan, and Master Plan.
- City of Santa Barbara—City of Santa Barbara, ZNE Roadmap and Implementation Plan.

The energy savings estimate will be limited to the projects listed above.

Updates Relative to Previous Study

The analysis team did not make any changes to the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the previous *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*, Appendix A6 Local Government Challenge[77] for more detail on the analysis conducted for this program.

Method Description

The analysis team performed the following calculations and assumptions to project the energy savings potential from 2015 through 2029 using a top-down extrapolation approach. New data are expected to become available as projects are installed and verified. The team recommends that the Energy Commission check with the LGC program administrators to obtain new data for future SB 350 updates.

The team categorized the Energy Innovation Challenge grant projects into two categories: (1) projects with specific energy efficiency measures or targets, and (2) projects with general GHG reduction goals. For programs with specific performance targets, the team extracted electricity and gas savings from relevant project narratives or converted GHG reduction goals. To convert GHG reductions to energy savings, the team assumed an 80 percent electricity and 20 percent gas split for small municipalities. Although the fuel split was an

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77 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

assumption, data on nonresidential buildings show a similar split for nonresidential and residential buildings.

The SB 350 savings estimates do not include PV systems or other renewable or storage technologies. The team did not deem projects for Del Mar and Marin Clean Energy as relevant to this savings estimate because they deal with PV generation and supply-side distributed energy resources (DER)[78] management.

For climate action plans available at the city or county level, the analysis team used the following approach:

- Developed estimates of GHG reduction per capita, either from program data or from a representative city. The team selected the City of Pleasanton climate action plan[79] as the representative model.[80] This plan includes detailed projections of energy savings and GHG reductions by sector. Estimates of existing energy consumption or GHG production for the awarded cities were not available during this analysis.
- Converted GHG reduction targets to energy savings targets and broke down the energy consumption among the buildings, transportation, waste treatment, and industrial sectors from the City of Pleasanton Plan. While the GHG reduction will vary among local jurisdictions, the team considers this a fair starting point for an estimate. The fraction of planned GHG savings that are due to building energy efficiency is nearly 50 percent of the total GHG planned reductions.
- Applied conversions between electricity and gas use and avoided CO_2 emissions based on the method used in the Pleasanton climate action plan, as that was deemed reasonable by the analysis team.
- Applied an estimate of the fraction of the energy savings target that can be attributed to the climate action plan itself.

As part of the savings estimate calculation for other projects, the team determined project baselines. The analysis team collected the proposals and project narrative information from local government officials and used city census estimates and energy use comparisons with similar local governments where information was not available. For San Luis Obispo County, because neither baseline energy usage nor energy savings targets were available, the analysis first estimated the residential population that live in low-income areas as 20 percent of the county. The team then approximated an EUI and home size based on the reasonable assumption that most of the local jurisdiction would

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78 DER refers to any demand-side supply of energy including energy efficiency, demand response, solar PV, and energy storage.

79 City of Pleasanton. 2011. *City of Pleasanton Climate Action Plan*.

80 The City of Pleasanton was not awarded LGC funding.

allocate the grants from this program to assist low-income family energy updates. The team also assumed that 25 percent of single-family homes in this category could receive efficiency upgrades through 2029.

The team evaluated each of the projects through an attribution matrix that considered the following mitigating factors:

- **Solar PV:**
  - Broad PV goals set PV savings to 25 percent.
  - PV was the only identified measure, set to 100 percent.
  - Where targeted measures identified with specific savings targets without any use of PV, PV contribution set to 0 percent.
- **IOU/POU overlap:** To align with other program methods, 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 CAPs addressing GHG reduction identify measures well outside building energy efficiency programs (street lights, transportation, city planning, and so forth). The analysis team estimated the fraction of planned savings attributed to measures other than buildings based on the project narratives and a 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. For more detail on the method of the adjustment factors, refer to the LGC program workbook.

The team used two approaches to set program savings targets: using the specific building targets with specific savings targets as the savings estimate when available and applying a savings multiplier of 33 percent across all programs without a specific target.

Finally, the team calculated the annual incremental savings. For projects with many buildings, the projects savings ramp up in scope steadily from 10 percent of targeted savings in 2021 to 100 percent through 2029.

The team did not adjust for market saturation, as the savings potential of the building sectors relevant to this program likely will not saturate through 2029.

Forecasting Scenarios

The team made the following assumptions for the reference, conservative, and aggressive savings scenarios.

- **Reference case:** Savings level for projects remains steady at 10 percent of targeted savings per year according to the baseline savings embedded in the workbook analysis.
- **Conservative case:** For the conservative case, the team retained the project savings level at 10 percent with different baseline savings embedded in the workbook analysis.
- **Aggressive case:** For the aggressive case, the team assumed that two additional rounds of funding would take place every three to four years, resulting in an aggregate program iteration savings level similar to the current round of awarded projects. Essentially, the savings-level estimates a doubling of the reference case savings beginning in 2025 and then a tripling of the reference case savings beginning in 2028.

Areas to Improve

For financing programs in general, the analysis team recommends further research on funding projections, utility savings overlap, and market saturation. For the LGC program specifically, the team recommends the following improvements:

- Develop a network of local governments, implementers, and stakeholders willing to contribute to the efforts of this program analysis through different methods, such as data sharing, review and verification, focus groups, and surveys.
- Obtain estimates of baseline energy consumption or specifics on the applicable building stock for all or some of the projects.
- Conduct further outreach to local governments and associated consultants to collect sufficient information on projects to evaluate energy savings.
- Confirm the fraction of planned activities for solar PV and non-building activities for newly awarded projects.
- Determine if there could be future iterations of the program beyond the awarded projects and if the projects could be scalable or replicable in other jurisdictions.

CHAPTER 12: Financing—Proposition 39

The California Clean Energy Jobs Act, also known as Proposition 39 (Prop 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).[81] The fund awarded local educational agencies (LEAs), including K-12 school districts, county offices of education, charter schools, state special schools, and California community colleges (CCCs), grants to upgrade existing buildings. The types of energy efficiency upgrades varied greatly. Some examples of the measures include lighting, HVAC, solar PV, and cool roofs.[82]

Program Overview

Prop 39 provides funding for planning and installing energy efficiency upgrades and clean energy generation at schools. 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. In the K-12 system, funds are allocated to specific LEAs according to average daily attendance (85 percent weighting) and the number of students eligible for free and reduced-price meals (15 percent weighting) applicable to a funding year. In the CCC system, funds are allocated according to number of full-time equivalent students.

In general, Prop 39 funds can be applied to energy efficiency retrofits and clean energy installations. Moreover, 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 according to California's loading order of energy resources. Energy efficiency and demand response projects are first priorities, followed by renewable energy generation, distributed generation,

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

82 A cool roof is designed to reflect more sunlight and absorb less heat than a standard roof.

combined heat and power applications, and clean and efficient fossil-fired generation. Projects are also evaluated by the cost-effectiveness criteria, calculated in terms of savings to investment ratio, based on the total energy savings and net project costs over the project life cycle.

Prop 39 funds can be combined with other project financing and funding mechanisms such as utility incentives, utility on-bill financing programs, and the Energy Conservation Assistance Act (ECAA) loan programs. The Energy Commission published a progress report[83] in January 2017 that indicates the appropriation of Prop 39 funds from 2013 to 2017. Navigant recommends that the Energy Commission and the CPUC work closely to identify potential utility program savings overlap.

The building sectors affected by this program are nonresidential, existing construction only:

- K-12 school buildings
- County offices of education buildings
- Charter school buildings
- State special school buildings
- CCC buildings

To give LEAs an opportunity to use any unrequested Prop 39 K-12 program grant funds, the Senate passed Senate Bill 110 (Chapter 55, Statutes of 2017) (SB 110)[84] in June 2017. This bill created three additional grant programs and allocated funds for loans and technical assistance. Although, a continuation of the Prop 39 K-12 Program was also authorized in SB 110, there were insufficient funds for the program. Any additional program funding is subject to appropriation in the annual Budget Act.

Updates Relative to Previous Study

The analysis team did not change the method from the previous study. The Energy Commission used the updated program workbook to incorporate new K-12 program 2017 and 2018 savings data. Other adjustments are possible if new or better data become available. Refer to the previous *Senate Bill 350: Doubling*

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83 Antonio, Marites, Haile Bucaneg, Joji Castillo, Cheng Moua, Armando Ramirez, Elizabeth Shirakh, and Michelle Vater. 2016. *Proposition 39: California Clean Energy Jobs Act, K12 Program and Energy Conservation Assistance Act 2015-2016 Progress Report*. California Energy Commission, Efficiency Division. Publication Number: CEC-400- 2017-001-CMF

84 July 11, 2017. "*SB110 Clean Energy Job Creation Program and citizen oversight board*." California Legislative Information.

Energy Efficiency Savings by 2030, Appendix A7 Proposition 39[85] for more detail on the analysis conducted for this program.

Method Description

The analysis team performed a top-down extrapolation with the following calculations and assumptions to project the energy savings potential from 2015 through 2029.

- For K-12, the first-year data for 2013-2014 demonstrate a relatively slow ramp-up in projects and funding requests. Subsequent years (through 2018) in the program data show an increase in projects and funding requests that align more closely with allocated funding.
- For CCC, the data cover only up to 2016, with partial project data available for 2015-2016. There was no information for 2016-2017 published in the workbook at the time of the 2017 analysis for SB 350. However, Navigant expects the Energy Commission to publish the new annual data that may be incorporated into future iterations of SB 350 analysis.
- The published savings data included both energy efficiency and self-generation projects. The team removed the self-generation projects from projections.
- For savings projections, the team normalized the funding amount 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 (for CCC) and known (for K-12) 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 analysis team evaluated the estimated five-year data for trends. However, the results did not reveal any clear patterns of energy savings or funding levels. The data seem to primarily vary by the approved funding amount, which depends on state budget approval. It appears that energy savings potential may fluctuate based on budget variance for each year.
- The analysis team calculated an average annual funding level based on the five-year estimates. Previously, the forecast assumed that the funding level will remain constant from 2015 through 2029 as the baseline savings level, and further savings adjustments were applied under different

85 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

forecasting scenarios. However, no new funding is in place for future years.
- Publicly available data are limited to the information from K-12 and CCC workbooks.

For future Prop 39 savings analysis, the team expects that more project savings will be reported through 2021 as more projects are verified for completion. The legislation requires that all projects funded by Prop 39 be completed by 2021; however, project implementation delays may be expected as the deadlines have extended multiple times since 2013. The actual funding and energy savings data will better correspond to the approved budget as more data are reported. Averaging funding and energy savings data by normalization can serve as a preliminary method for savings projections, despite many variables yet to be considered.

Forecasting Scenarios

The Energy Commission will need to adjust the scenarios to address funding level changes for Prop 39 programs. The team made the following assumptions:

- **Reference**: The team estimated savings for the reference case according to the analysis approach described above by assuming that Prop 39 program funding will continue indefinitely beyond 2018, as enabled by SB 110. This scenario scales back energy savings projections by 10 percent each year beginning in 2019 to account for a potential funding decrease through 2029.
- **Conservative**: To calculate a more conservative scenario, the team assumed that Prop 39 program funding will continue indefinitely beyond 2018, as enabled by SB 110. However, the energy savings projections are scaled back by 10 percent each year beginning in 2019 to account for a potential funding decrease and additionally by 30 percent annually to account for market saturation based on the team's analysis and assumptions.
- **Aggressive**: To calculate a more aggressive program savings estimate, the team removed the potential funding decrease adjustment from the reference case and assumed that the current savings rate will persist through 2029 unimpeded.

Areas to Improve

For financing programs in general, the team recommends further research on funding projections, utility savings overlap, and market saturation. For the Prop 39 program, the team recommends the following:

- Engage the Energy Commission and Chancellor's Office Prop 39 teams to better understand market potential, market saturation, and future adoption rate.
- Track implementation of SB 110,[86] which extended funding subject to the state budget for Prop 39 indefinitely; collect future data on annual funding level, project adoption rate, and energy savings.
- Collect actual program data and corresponding utility incentive tracking to minimize overlap errors.
- Consider including more disaggregated data of completed projects by utility and end use.

86 California Legislature. 2017. "*SB110 Clean Energy Job Creation Program and Citizen Oversight Board."* California Legislative Information.

CHAPTER 13: Financing—Low-Income Weatherization

Multiple elements of the Greenhouse Gas Reduction Fund (GGRF) result in energy savings, but only two are included in this study: the Low-Income Weatherization (LIW) program (discussed in this chapter) and the Water-Energy Grant (WEG) program (further discussed in Chapter 14).[87] LIW is a statewide program funded through California cap-and-trade auction proceeds. The program aims to implement energy-efficient measures in low-income single-family and multifamily complexes in disadvantaged communities, including PV installations, solar hot water heaters, and other energy-reducing projects.

The LIW program has three overarching goals:

- Reduce GHG 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 Legislature to implement these goals. The program estimates that 17,700 households will benefit from this program.

Program Overview

Three government statutes directed proceeds from the California Cap-and-Trade program into the GGRF. 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.

The federal weatherization program supplements the GGRF funds for LIW. The federal program, administered by the Department of Community Services and Development, targeted different subsets of low-income households in disadvantaged communities.[88] The Single Family/Small Multi-Family Energy Efficiency and Solar Water Heating subprogram provides single-family and small

87 The State Water Efficiency Enhancement Program, which focuses mostly on the agricultural sector, also exists.

88 The three programs are: Single Family/Small Multi-Family Energy Efficiency and Solar Water Heating, (2) Single-Family Solar Photovoltaics, and (3) Large Multi-Family Energy Efficiency and Renewables.

multifamily low-income homes with weatherization and energy efficiency measures.[89]

The Large Multi-Family Energy Efficiency and Renewables subprogram provides low-income multifamily 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. The program expects energy savings from lighting, ceiling fans, appliances, insulation, and microwaves.

The residential sector is the only building sector affected by this program. This program specifically targets 100 percent of the households located in disadvantaged communities, as identified by CES 2.0.

Updates Relative to Previous Study

The analysis team did not make any changes to the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*, Appendix A8 GGRF Low Income Weatherization[90] for more detail on the analysis conducted for this program.

Method Description

The team performed a top-down extrapolation approach with the following calculations and assumptions to project the energy savings potential from 2015 through 2029.

- Identified four full years of historical savings data for 2015-2018. There is no trend in the data—there are alternating increases and decreases in program savings.
- To project savings, the team then applied the average of the total savings for each year (2015-2018) as the savings projections for 2019-2029.
- Assumed annual growth of savings and funding level remain the same as the average of the four years of data.

Because this program targets low-income housing in disadvantaged communities, the team assumes little-to-no natural construction turnover in the

89 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 CES 2.0.

90 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

absence of additional financing. As such, the 2017 analysis of SB 350 savings assumed 0 percent of program savings overlap with 2018 PG study codes and standards estimates.[91] The team recommends further evaluating utility savings overlap by exploring any overlap between this program and other low-income programs funded by the IOUs.

The workbook calculation assumes a percentage of 12.3 million[92] households qualify as low-income and that each project achieves 15 percent electricity savings, on average; the team estimates that the calculated savings projection through 2029 would result in about one-third of low-income households being improved through 2029. Given this estimate, the analysis team did not account for market saturation.

Forecasting Scenarios

Based on this information, the team made the following assumptions for the scenarios:

- **Reference case:** This scenario assumes that new funding does not significantly change savings levels and all savings from 2015 through 2029 will continue.
- **Conservative case:** This scenario assumes all savings after 2018 will be reduced by 50 percent of the reference case.
- **Aggressive case:** This scenario assumes that, beginning in 2019, additional funding will contribute to a 50 percent increase in savings as compared to the reference case.

Areas to Improve

For financing programs in general, the team recommends further research on funding projections, utility savings overlap, and market saturation. For the LIW program, the team recommends the following:

- Partner with the regulatory agency of this program to agree on data parameters that will be made available to support future SB 350 analyses.
- Collect more years of measure-level data detailing savings, funding allocation, or cost-effectiveness data; if measure data are not available, gather annual project data that better support trending methods.
- Collaborate with the CPUC to identify any additional utility savings overlap with low-income programs funded by IOUs.
- Address changes in funding levels over time.

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91 Navigant Consulting, Inc. 2017. *2018 Energy Efficiency Potential and Goals Study*. California Public Utilities Commission.

92 California Energy Commission. *Integrated Energy Policy Report (IEPR) Building Stock Data*. 2016

CHAPTER 14: Financing—Water-Energy Grant

The WEG program, administered by the Department of Water Resources (DWR), aims to improve water and energy efficiency and reduce GHG emissions of residential and commercial buildings through measures such as clothes washers, dryers, and dishwashers. Energy savings result primarily by installing measures to reduce hot water use, which decreases the energy needed to heat water.

Program Overview

The WEG, funded by the GGRF and operated by the DWR, is a statewide program to promote reduced GHG emissions, primarily in the residential and nonresidential sectors and disadvantaged communities. Proceeds from the California Cap-and-Trade program are allocated each year to the WEG program to fund projects that reduce GHG emissions in California; these projects also deliver economic, environmental, and public health benefits for Californians, particularly those in disadvantaged communities. Another key objective of the WEG program is to establish an incentive structure to make climate investments through clean technologies and innovative solutions. Water reduction or conservation is the main criterion for program eligibility, but energy use and GHG reduction are also prioritized.

Updates Relative to Previous Study

The analysis team did not change the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*, Appendix A9 GGRF Water Energy Grants[93] for more detail on the analysis conducted for this program.

Method Description

The team performed a top-down extrapolation using the following calculations and assumptions to project the energy savings potential from 2015 through 2029.

- The historical dataset provides data for the years that had funding and activity through 2018.

93 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

- The analysis team calculated the projected savings for this program by taking the average of electricity and gas savings from the 2014-2018 historical savings data. The team then applied the average savings as the savings projections for 2019-2029 because there was a lack of more granular historical data or other forms to forecast future potential savings.

The program dataset does not indicate that solar thermal projects are included. As such, the team did not correct for savings due to renewable generation.

Because this program targets disadvantaged communities, the team assumes little-to-no natural construction turnover in the absence of additional financing. As such, the 2017 analysis of SB 350 savings assumed 0 percent of program savings overlap with 2018 PG[94] codes and standards estimates. The team recommends further evaluating utility savings overlap by exploring any overlap between this program and other low-income programs funded by the IOUs.

The team estimated that of 12.3 million[95] households, about 18 percent, qualify as low-income. By extending this ratio to disadvantaged communities, biasing toward building types that consume the most water (restaurants, schools, hospitals, and dwellings), and assuming that each project achieves 10 percent[96] electricity savings on average, the team estimates the calculated savings projection through 2029 would result in roughly 40 percent of low-income households being improved through 2029. Given this estimate, the analysis team did not account for market saturation.

Forecasting Scenarios

Based on this information, the team made the following assumptions for the scenarios:

- **Reference case:** This scenario assumes that program funding will persist at the same level, resulting in a steady increase in cumulative savings.
- **Conservative case:** Because of the uncertainty of funding year over year, 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.

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94 Navigant Consulting, Inc. 2017. *2018 Energy Efficiency Potential and Goals Study*. California Public Utilities Commission.

95 California Energy Commission. *Integrated Energy Policy Report (IEPR) Building Stock Data*. 2016

96 This percentage is less than the 15 percent estimate applied to other retrofit programs because only domestic hot water generation is affected.

- **Aggressive case:** Because of the lack of policy or funding projects each year, 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.

Areas to Improve

For financing programs in general, the team recommends further research on funding projections, utility savings overlap, and market saturation. For the WEG program, the team recommends the following:

- Partner with DWR to agree on a set of data parameters that will be made available to support future SB 350 analyses.
- Collect more years of measure-level data detailing savings, funding allocation, or cost-effectiveness data; if measure data are not available, gather annual project data that better support trending methods.
- Collaborate with the CPUC to identify any additional utility savings overlap with low-income programs funded by IOUs.

CHAPTER 15: Financing—California Department of General Services Retrofit Program

The Energy Retrofit Program operated by the Department of General Services (DGS) uses energy service companies to implement energy upgrades in state buildings. DGS funds loans 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 retro-commissioning. An initial $25 million payment from the Energy Commission provided the seed money to begin the Energy Retrofit Program.

Program Overview

The Energy Retrofit Program provides funding to state agencies to fund energy efficiency retrofits in their buildings through the program's loan fund. The funds for this program were originally supplied by the Energy Commission under ARRA. The funding is expected to be paid back from the energy savings that result from the retrofit projects; at that point, the funds will be replenished and then will become available for subsequent projects.

There are several remaining energy efficiency projects in the current funding cycle, but most have been completed. A new funding cycle has been approved.

Updates Relative to Previous Study

The analysis team did not change the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*, Appendix A10 DGS Energy Retrofit Program[97] for more detail on the analysis conducted for this program.

Method Description

The analysis team used a top-down extrapolation approach to determine the savings potential for the DGS Energy Retrofit program. There are several variables that may affect how this program will continue in the future. Assuming funding remains available and the program continues to replenish the funds from

97 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

energy savings, it is possible to calculate the weighted average simple payback for the projects to determine the rate at which funds are recycled into new projects. Combining this rate 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.

Furthermore, the team applied adjustment factors to the energy savings projections 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. DGS should conduct future program evaluation to verify the savings opportunities and implementation.

The analysis team used the savings and annual growth of savings from the Annual Legislative Report and other DGS-supplied information, assuming the program parameters and funding levels remain the same. At this time, the team used the DGS estimates for future annual savings from the program rather than basing the savings on historical trends. The analysis employed the following assumptions:

- Other utility incentive programs for equipment replacement claim nearly 50 percent of the savings in this program. Utility incentive claims will decrease in the future as the oldest buildings are retrofitted and less attractive projects are available for future retrofits; however, the claims may increase (as a percentage) as incentives become available and the buildings approach net-zero energy.
- Feedback from Energy Commission staff indicates investment levels are expected to drop as the revolving fund is paid back and becomes available for new projects. Based on input from the Energy Commission, the team assumed 2 GWh annual savings beginning in 2018. However, actual savings have been higher.
- Beyond the initial drop in funding, the annual 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 the team did not adjust for electrification.
- For cumulative savings, the team assumed all projects have an EUL equal to 15 years. The most recent program reporting document[98] showed the program 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

98 Department of General Services. "DGS ESCO_EE_data_current workbook." Sourced by the Energy Commission. April 12, 2017.

because no renewable energy measures (for example, solar PV) were shown in the program reporting document.

The team conducted initial outreach to the DGS energy efficiency 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. The DGS program manager emphasized that all projections in funding and energy savings were rough estimates. Current funding levels should continue for the next three to four years (until about 2020). After 2020, funding drops by roughly one-third, although the DGS program manager reported that more funding could become available. In the past, DOE programs have ended and provided their remaining funds to the DGS program. Consequently, funding could decrease, increase, or remain about 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 team notes that all projections should be viewed as high level estimates, particularly beyond 2020. The team updated the savings estimates accordingly based on the DGS response.

Because this program targets public buildings, the team assumes little to no natural construction turnover in the absence of additional financing. As such, the 2017 analysis of SB 350 savings, 0 percent of program savings assumed to overlap with 2018 PG[99] codes and standards estimates. The team recommends further evaluating utility savings overlap between this program and savings claimed by the IOUs. It is set at three percent.

The 2015 Existing Buildings Energy Efficiency Action Plan[100] indicates that DGS reports about 125 million square feet of state leased or owned floor space. Given the size of the potential market and assuming that program projects achieve 15 percent savings of baseline electricity consumption, on average, the team estimates the calculated savings projection through 2029 would result in fewer than 10 percent of state-owned buildings being improved through 2029.

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99 Navigant Consulting, Inc. 2017. *2018 Energy Efficiency Potential and Goals Study*. California Public Utilities Commission.

100 California Energy Commission. 2016. *California's Existing Buildings Energy Efficiency Action Plan*.

Forecasting Scenarios

Based on this information, the team made the following assumptions for the different scenarios:

- **Reference case:** The team assumed that current trends would continue. The DGS program manager reported this was the most likely outcome, although increasing and decreasing funds are distinct possibilities.
- **Conservative case:** Building off the reference case, this scenario assumed that funding would decline by 22 percent beginning in 2020 and that energy savings (both GWh and therms) would decline proportionally by the same factor as funding decreases.
- **Aggressive case:** This scenario assumed that funding would increase by 22 percent starting in 2020 and that energy savings (GWh and therms) would increase accordingly. This scenario also assumes that project participation will increase, including from Department of Corrections and Rehabilitation (DCR) projects because the DGS project manager identified DCR facilities as having a significant energy efficiency savings opportunity.[101]

Areas to Improve

For financing programs in general, the team recommends further research on funding projections, utility savings overlap, and market saturation. For the DGS Energy Retrofit program, the team recommends the following:

- Partner with DGS to better understand market potential, market saturation, and future adoption rate.
- Estimate future biennial funding levels while accounting for slow project payback or changes in reinvestment of the funding.
- Revisit the need to account for end use measure life depending on assumptions made in future iterations of this program analysis.

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101 The team conducted a brief telephone interview with a DCR staff member who 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 program, because of the financing cap ($1 million-$2 million, depending on utility), the DGS program often contributes most of the financing for large projects. In addition, about half of DCR projects are outside IOU territory. The list of projects for the 2015-2017 DGS program includes one DCR project for $3 million, for which DGS provided 100 percent of the financing. DCR staff reported it would soon submit another DGS application for a $4 million project outside an IOU territory.

CHAPTER 16: Financing—Energy Conservation Assistance Act

The ECAA loan program administered by the Energy Commission delivers revolving loans to schools, cities, counties, state hospitals, and special districts to finance projects with proven energy or cost savings. Funds for ECAA loans come from repayment of previous funds with additional infusions from allocations by the Legislature and ARRA funds.[102]

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 and colleges, 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 systems.

Program Overview

The ECAA program supports energy efficiency and energy generation projects pursued by public institutions. ECAA provides loans up to $3 million per application. The program is designed to simplify energy project adoption through a process that does not involve credit underwriting, collateral, or fees. 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 to qualify.[103]

102 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.

103 California Energy Commission Website, ECAA program

Public agencies are eligible to receive ECAA funds; the list below indicates which types of public agencies are eligible for zero percent loans and which are eligible for one percent interest rate loans. Residential, commercial, or private nonprofit institutions are not eligible for these funds.

- Eligible for zero percent interest rate loans:
  - School districts
  - Charter schools
  - County offices of education
  - State special schools
- Eligible for one percent interest rate loans:
  - Cities
  - Counties
  - Special districts
  - Public colleges or universities (except community college districts)
  - Public care institutions/public hospitals
  - University of California
  - California State University
  - Community college districts

Updates Relative to Previous Study

The analysis team did not change the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. The program workbook includes historical data through 2018. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*, Appendix A11 ECAA[104] for more detail on the analysis conducted for this program.

Method Description

The team performed a top-down extrapolation approach using the following calculations and assumptions:

- No annual budget funding limit exists; however, the loan limit per application is $3 million.
- No data on utility rebates were applied to the measures in the dataset.
- Because the ECAA datasets included energy efficiency and self-generation projects, this analysis extracted the energy efficiency-only data to serve as the basis for the savings projections.

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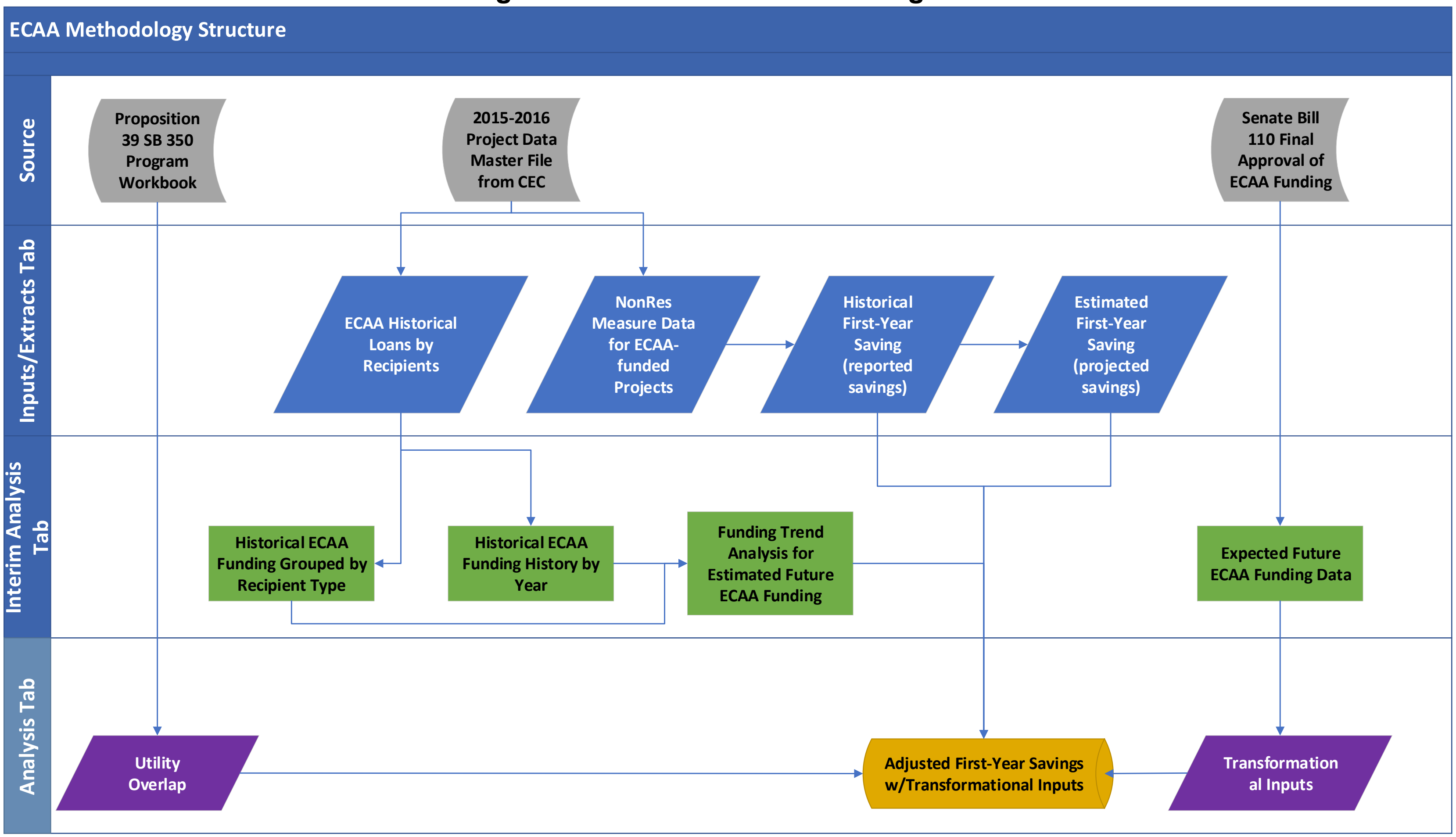
104 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

- Analysis included using historical data based on project year. The analysis checked for electrical and gas savings data project trends for future savings assumptions. There was no clear trend in the data, so instead the team calculated an average value to project out through 2029.
- The analysis tools provided to the Energy Commission showed no ECAA savings claimed for the reference scenario because it used the previous study assumption that savings projections have been captured by the IEPR baseline demand forecast. This assumption may change depending on funding availability and can be updated by Energy Commission staff.

Figure 9 depicts the flow of data that supported the method of this workbook.

Figure 9: ECAA Method Flow Diagram



Flowchart showing the input source data and analysis steps for developing annual ECAA program savings. Input source data include historical project and measure data and funding levels. Future savings are dependent on historical savings and future funding trends.

Source: Navigant team

Forecasting Scenarios

The team made the following assumptions for the different scenarios:

- **Reference case:** This scenario assumes that SB 110 provides additional ECAA-Ed funding. It is unclear if the additional funding has been approved. Conservatively, the reference case assumes that about 10 percent of the total program savings affects SB 350 savings claims, beginning in 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, per conversation with the additional achievable energy efficiency staff from the Energy Commission.
- **Conservative case:** This scenario assumes that the additional funding from SB 110 will not significantly increase the savings level beyond the current funding level and that all savings after 2018 will continue to be claimed by the 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 in 2019 and through 2029, the aggressive case estimates that nearly 30 percent of the program savings may go beyond the historical average claimed in the demand forecast and can be captured as SB 350 savings potential.

Areas to Improve

For financing programs in general, the team recommends further research on funding projections, utility savings overlap, and market saturation. For the ECAA program, the team recommends the following:

- Track implementation of SB 110,[105] which is estimated to provide up to $100 million in additional funding to the ECAA-Ed program; collect future data on annual funding level, project adoption rate, and energy savings.
- Understand participation with utility programs and possible utility rebate savings overlap.

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105 July 11, 2017. *SB110 Clean Energy Job Creation Program and citizen oversight board*. California Legislative Information.

CHAPTER 17: Financing—Property Assessed Clean Energy

In 2008, the California Legislature's Assembly Bill 811 (Levine, Chapter 159, Statutes of 2008) (AB 811)[106] enabled Property Assessed Clean Energy (PACE) financing for energy efficiency and renewable energy projects in the residential and commercial markets. There are 14 active PACE providers in California, with financing more than $2 billion in energy efficiency and renewable energy improvements including hard and soft costs. [107,108]

Program Overview

PACE financing programs provide property owners with financing for energy efficiency, water efficiency, resiliency, and renewable energy projects on existing and, in some cases, new residential and commercial structures through a voluntary special tax assessment on their properties. These financing programs are offered by private lenders—known as PACE providers—and do not rely on public funding. In some instances, customers may choose to combine PACE financing with other incentives such as utility rebate programs.

PACE financing programs do not require a down payment or payment of the full or partial upfront capital cost of the improvement. However, measures installed through PACE must perform better than California Title 24 building codes. 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 the energy projects are implemented. Property owners can amortize loan payments for up to 20 years, with an option to extend the payback period as necessary. By leveraging property taxes, the property improvements funded through PACE are associated with the physical properties rather than the borrowers. In addition, the property owner can transfer the loan when the property is sold or ownership is transferred.

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

107 *PACE Programs*. PACENation Website.

108 Hard costs are those directly related to construction. Soft costs are those not directly related to construction—for example, engineering fees.

The statutory frameworks, Improvement Act of 1911 as amended by AB 811, also known as the Mello-Roos Act under a city's charter authority, provide guidance on how PACE financing programs are set up and administered. Both the improvement act and the Mello-Roos Act authorize creating special tax districts for voluntary contractual agreements for financing between authorized entities and property owners. Property owners residing in cities and counties that have adopted these special tax districts are able to apply for financing from designated PACE providers. Consequently, not all jurisdictions in California have access to PACE financing, and many jurisdictions have approved only a handful of providers to operate in their territory. This patchwork of programs across the state makes it difficult to accurately track PACE investment geographically.

Despite the potential wide reach of PACE financing, PACE providers have not been required by law to publish any loan or project data. In October 2017, Senate Bill 242 (Skinner, Chapter 484, Statutes of 2017), which included data reporting clauses, became law. This bill (details provided in Appendix B) requires PACE providers submit reports to the public agency of each program they administer, detailing various metrics including estimated total energy saved and the percentage of PACE assessments represented by energy efficiency. However, the bill is limited; it "applies exclusively to residential properties with four or fewer units" and is not applicable to "any public agency that does not use a program administrator to administer a PACE program."[109] Despite the limitations, the bill can make future energy savings modeling efforts easier and more precise since the Energy Commission will be able to collect the data reported to local jurisdictions.

Updates Relative to Previous Study

The previous SB 350 report used a top-down approach to estimate the savings potential for the program. Given the lack of project savings data, the update is built on previously available analysis and refined top-down estimates of the savings potential from 2015 through 2029.

Method Description

The 2017 SB 350 analysis applied the following methods to the savings analysis of the PACE program:

- Estimated total annual savings in electricity and gas from the aggregate savings data published by the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) PACE Loss Reserve

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109 Senate Rules Committee – Senate Floor Analysis. Sept. 2017. *Property Assessed Clean Energy program: program administrator*.

Program, which covers only residential programs enrolled in the program as of June 30, 2016.[110]

- Extrapolated total annual savings in electricity and gas for the entire residential market by applying data statistics about residential PACE providers provided by the Center for Sustainable Energy.[111]
- Extrapolated nonresidential savings by using the market data published by PACENation,[112] coupled with the residential data derived from the CAEATFA reports.[113]

The team further adjusted the savings estimates for ratepayer program overlap assumptions. According to the CPUC, the utilities do not claim savings from this program. However, the projects funded by this program likely receive utility incentive and may be claimed by an IOU/POU as ratepayer savings. Because of 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 Prop 39. Therefore, the savings estimates for this program subtracted 4 percent from the raw projections before further adjustments. As more overlap data become available for this program, the Energy Commission will update results accordingly.

Changes to Data Inputs and Assumptions

Due to a lack of actively enforced statewide reporting mandates, there are limited public data sources on PACE financing programs. The most detailed publicly available data are from two sources:

- PACENation's nationwide and regional reporting on total principal and project type for commercial and residential programs
- CAEATFA Loss Reserve Program's reported biannual total enrolled principal, biannual principal from new financing, and self-reported energy savings for California's enrolled residential program providers

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110 California Alternative Energy and Advanced Transportation Financing Authority. March 2018. "Property Assessed Clean Energy (PACE) Loss Reserve Program Enrollment Activity." California State Treasurer.

111 Center for Sustainable Energy. *Property Assessed Clean Energy Programs.* Visited April 2019. The Center for Sustainable Energy is a nonprofit program administrator and advisory services organization.

112 PACENation. *Residential and Commercial PACE Market Data*.

113 California Alternative Energy and Advanced Transportation Financing Authority. March 2018. *Property Assessed Clean Energy (PACE) Loss Reserve Program Enrollment Activity.* California State Treasurer.

The updated method relies heavily on these two sources. However, the analysis team changed the data inputs used to extrapolate savings during this cycle:

- **Foregoing use of CSE data.** As of January 31, 2018, the previously used public data are not being updated, with the web page now referring visitors to PACENation for market data. It is vital to use regularly updated publicly available information for the core inputs and assumptions as much as possible so that additional savings calculations can be updated more easily by the Energy Commission over time.
- **Using CAEATFA's new financing data to calculate residential savings.**[114] The analysis team found several issues after reviewing the residential energy savings by program listed on the CAEATFA Loss Reserve Program's website (the only publicly reported savings estimates available):
  - Self-reported savings with inaccessible methods because most program providers classify them as confidential.
  - Inconsistent reporting format, resulting in many programs providing kWh savings without identifying the share attributable to energy efficiency and renewables.
  - Savings being reported based on the entire enrolled portfolio without a way to identify first-year savings occurring from new efficiency improvements.

  Until standardized statewide reporting mandates allow access to credible historical annual savings estimates, the team extrapolates savings from reported principal amounts because residential investment is submitted biannually to CAEATFA using a standardized reporting framework and includes a breakout of new financings, which can be used to calculate first-year savings.
- **Using the PACENation principal in Western states to calculate commercial savings.**[115] PACENation's commercial data are reported in principal and do not include any reported energy savings. Although the market data on PACENation are not filterable by state, estimating California's share of annual commercial principal is possible using the various metrics they report. These metrics include the percentage of investment attributable to energy efficiency (35 percent), annual commercial investment in Western states ($105 million invested in 2017),

114 California Alternative Energy and Advanced Transportation Financing Authority. March 2018. *Property Assessed Clean Energy (PACE) Loss Reserve Program Enrollment Activity*. California State Treasurer.

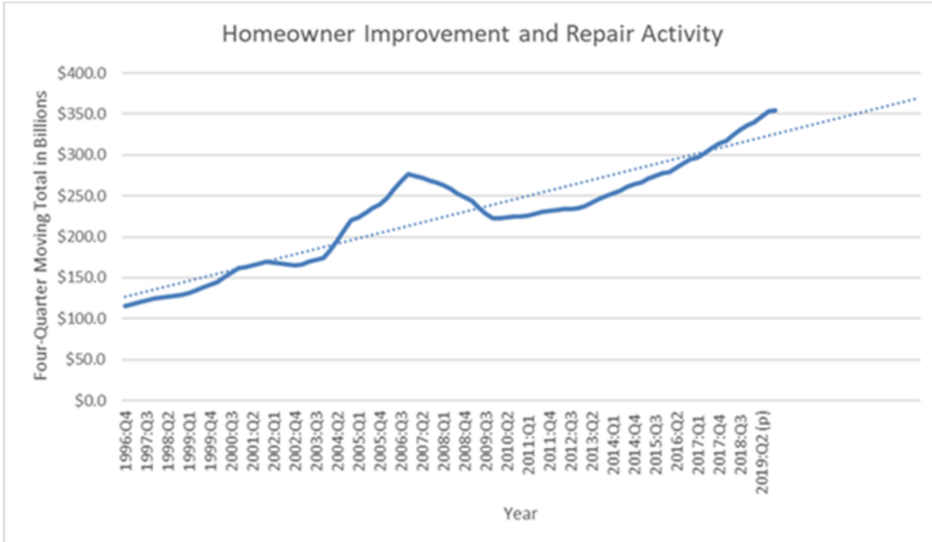
115 PACENation. *Residential and Commercial PACE Market Data*.

and total commercial investment that has occurred in California ($236.6 million, or 95 percent of cumulative investment in western states).

- **Extrapolating savings from loan principal amount using private and publicly available studies.** Because of the lack of quality savings being reported publicly, the team decided that until such data are available that savings should be extrapolated from the historical principal using savings units (kWh or therms) per dollar of principal invested. The team sourced units per dollar of principal invested using data from an under-development Lawrence Berkeley National Laboratory (Berkeley Lab) study. This detailed three-year Berkeley Lab project is analyzing PACE data from energy efficiency projects with a final report pending publication in 2019.[116] This study will report annual kWh and therm savings by Berkeley Lab measure category and the average statewide dollar principle per loan by measure category selected by Berkeley Lab. Until this report is published, the team opted to temporarily use the results of a private detailed energy savings analysis of a PACE program to determine units per dollar of principal invested by Berkeley Lab measure category.
- **Forecasting PACE investment using homeowner improvement and repair activity trends.** The proportion of PACE financing used for energy efficiency measures is a subcomponent of the retrofit market. As such, the analysis team used the Joint Center for Housing Studies' Leading Indicator of Remodeling Activity (LIRA) to project future PACE investment. LIRA measures trends in national spending for improvements and repairs to owner-occupied homes and is benchmarked to historical estimates of remodeling spending based on data from the Department of Housing and Urban Development's American Housing Survey. Figure 10 shows improvement and repair activity over time.

116 The report draft included research through May 2019.

Figure 10: LIRA Historical and Forecast of National Improvement and Repair Activities



Quarterly trends in national spending for improvements and repairs to homes show activities appear to increase over time as the building stock increases and equipment turns over—with drops where recessions occur.

Source: Joint Center for Housing Studies of Harvard University. *Historical_LIRA_Benchmark_Data_and_Input_Correlations_and_Weights_2018_Q4* (Excel File). Downloaded March 2019. https://www.jchs.harvard.edu/research-areas/remodeling/lira

The forecast of PACE investment assumes that PACE maintains the current share of the energy efficiency financing market, and future energy efficiency savings follow the trend in improvement and repair activity found in LIRA. As illustrated in Figure 10, improvement and repair activities appear to increase over time as the building stock increases and equipment turns over—with drops where recessions occur. LIRA does not track commercial improvement and repair activities. Consequently, in these calculations, the team assumes that the commercial market follows the same trend as the residential market on the premise that the commercial market developed at the same time as the residential market and, therefore, renovation rates are similar.

- **Updating ratepayer program overlap assumption.**[117] The PY2014 Finance Residential Market Baseline Study Report, prepared under the direction of the CPUC, included a homeowner general population survey to capture a snapshot of the overall landscape for energy efficiency financing for homeowners in California before the rollout of the residential statewide finance pilots. The survey results documented a baseline for key metrics as defined in the 2013-2014 EM&V Finance Roadmap related to energy

117 CPUC, Opinion Dynamics & Dunsky Energy Consulting. *PY2014 Finance Residential Market Baseline Study Report (Volume II)*. March 2016.

efficiency financing for residential customers. Extrapolating the results of this survey to the homeowner population in California found that "about one-fourth of the 7.4 percent of homeowners who made an upgrade and used financing received an IOU rebate—which means 1.9 percent of California homeowners used financing and received an IOU rebate for their upgrades (Note that this excludes homeowners who used only credit cards as their source of financing)." The team opted to replace the 4 percent utility overlap assumption from Prop 39 data with the 1.9 percent figure from this study. As new studies are published, the analysis team expects this assumption will be updated.

Extrapolation Approach

Using the data inputs and assumptions described in the previous section, the team used a top-down extrapolation approach to estimate incremental savings. For the residential market, the team's approach consisted of the following steps:

1. Applying the percentage of energy efficiency funding to the annual incremental principal to estimate total principal spent on energy efficiency.[118]
2. Extrapolating historical first-year savings by applying the percentage of total principal per Berkeley Lab measure category and the units (kWh/therm) saved per principal by Berkeley Lab measure category to the estimated total principal spent on energy efficiency in the previous step.[119]
3. Forecasting future investment and savings by applying a growth rate based on a linear trend line from the LIRA historical improvement and repair activity data.[120]
4. Adjusting historical first-year savings from step two and forecast savings in step three for overlap with utility incentive programs to produce adjusted first-year savings.[121]

The team's approach to forecasting the commercial market consisted of the following steps:

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118 PACENation. *Residential and Commercial PACE Market Data*.

119 Private PACE Program Study.

120 Joint Center for Housing Studies of Harvard University. *Historical LIRA Benchmark Data and Input Correlations and Weights 2018 Q4* (Excel File). Downloaded March 2019.

121 CPUC, Opinion Dynamics & Dunsky Energy Consulting. March 2016. *PY2014 Finance Residential Market Baseline Study Report (Volume II)*. *PY2014 Finance Residential Market Baseline Study Report (Volume II).*

1. Estimating California's yearly energy efficiency financing by calculating the product of annual commercial PACE financing in western states, California's share of commercial PACE financing in western states, and the percentage of overall energy efficiency investment.[122]
2. Extrapolating historical first-year savings by applying the percentage of total principal per Berkeley Lab measure category and the units (kWh/therm) saved per principal by Berkeley Lab measure category to the estimated total principal spent on energy efficiency in the previous step.[123]
3. Forecasting future investment and future savings by applying a growth rate based on a linear trend line from the LIRA historical improvement and repair activity data. In these calculations, the team assumes that the commercial market follows the same trend as the residential market on the premise that improvement and repair activities are driven primarily by the health of the economy; these activities steadily increase over time as the building stock increases and equipment turns over, with drops when recessions occur.[124]
4. Adjusting historical first-year savings from step two and forecast savings in step three for overlap with utility incentive programs to produce adjusted first-year savings.[125]

Figure 11 outlines how this extrapolation approach is configured in the program workbook, showing the flow of data and information throughout the workbook.

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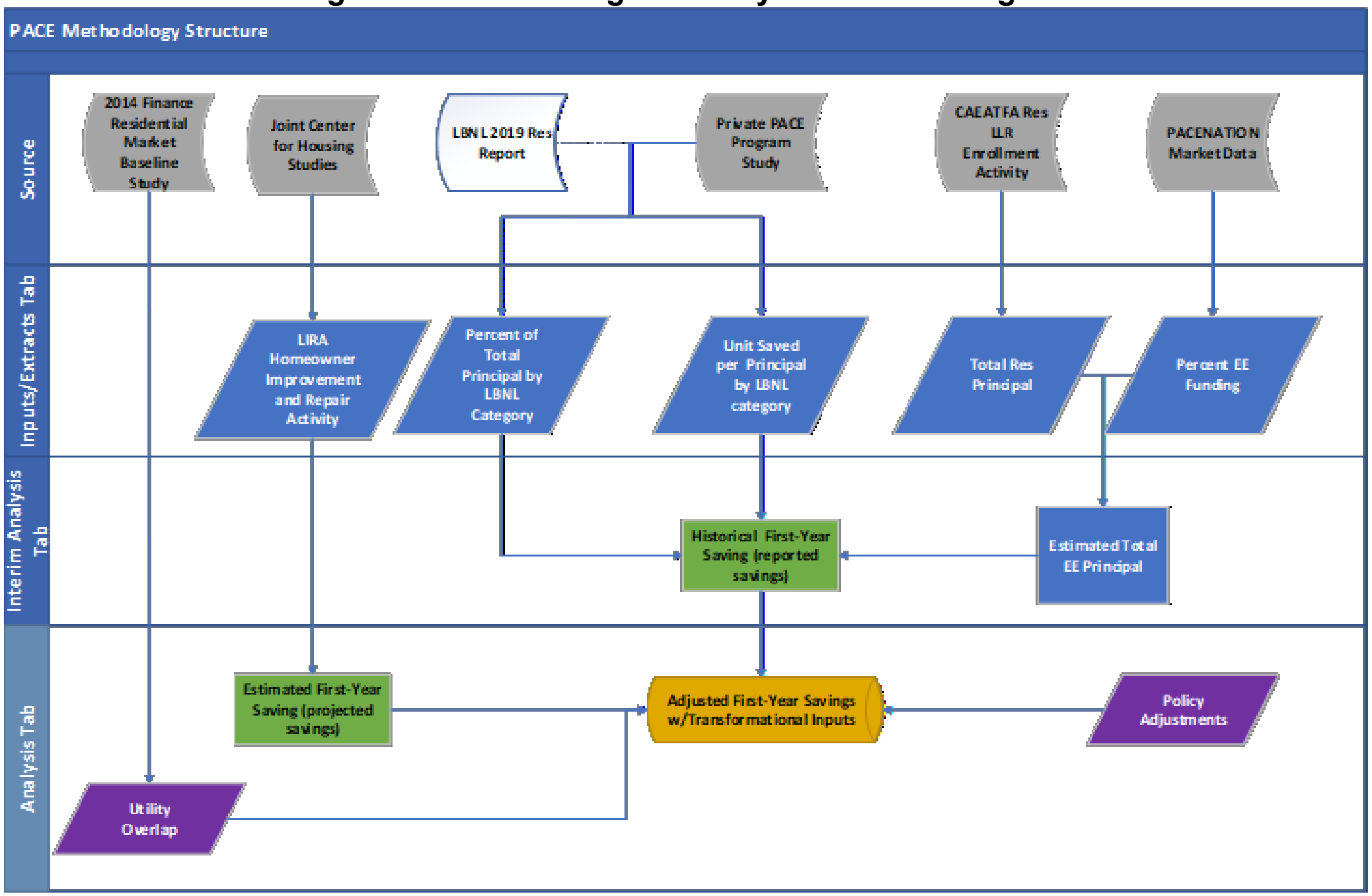
122 PACENation. *Residential and Commercial PACE Market Data*.

123 Ibid.

124 Joint Center for Housing Studies of Harvard University. "Historical LIRA Benchmark Data and Input Correlations and Weights 2018 Q4" (Excel File). Downloaded March 2019.

125 CPUC, Opinion Dynamics & Dunsky Energy Consulting. *PY2014 Finance Residential Market Baseline Study Report (Volume II)*. March 2016.

Figure 11: PACE Program Analysis Method Diagram



Flow chart for source data and analysis for developing annual PACE program savings. Input data include studies on the market baseline, construction trends, research on PACE program activity, enrollment activity, and overall market and funding data.

Source: Navigant team

Forecasting Scenarios

The conservative and aggressive scenarios for PACE financing attempt to model potential changes in energy savings from changes in public policy by applying a modifier to the reference scenario. At this time, it is impossible to predict with a high degree of accuracy whether the Legislature will make further adjustments to the recently passed PACE consumer protection laws or how these laws will affect PACE investment in the future given that only investment data from the first half of 2018 are available. The team's literature review concluded that PACE administrators are discussing with legislative representatives how to curtail the effects of this legislation. The limited available data indicate that the legislative impact has a greater negative effect on investment than what was forecast. Consequently, the modifiers used to determine energy savings under the conservative and aggressive scenarios should be adjusted as necessary when more 2018 data become available and when more is known about whether the Legislature is willing to curtail these consumer protection laws. Below is a description of the assumptions made for each SB 350 forecasting scenario using available 2018 data and the understanding of the current legislative landscape.

- **Reference:** Residential and nonresidential savings, extrapolated from 2015-2017 principal data, will follow the retrofit market represented by the LIRA historical home improvement and repair activity trend line data.
- **Conservative:** PACE as a financing vehicle for residential and nonresidential properties will be reduced by the recent consumer protection legislation, which makes PACE lending more restrictive. A 30 percent modifier is applied to the reference case and was determined by the difference in investment from the first half of 2017 to the first half of 2018.
- **Aggressive:** PACE as a financing vehicle for residential and nonresidential properties will be increased by a curtailment of the consumer protection legislation limiting the use of PACE; the result is PACE will be more widely adopted in the residential and nonresidential markets. A 20 percent modifier is applied to the reference case and assumes the total market share of PACE would increase at an aggressive but still far lower rate than pre-consumer protection legislation.

Areas to Improve

The team identified several areas of improvement for the Energy Commission to consider in the next SB 350 update:

- **Improved reporting of savings from PACE providers.** This analysis reveals that the PACE financing program has large potential to achieve energy savings attributable to SB 350. The estimates of this reporting cycle are an order of magnitude lower than the last cycle. This lower estimate is due to the absence of a statewide standardized energy efficiency savings reporting structure and consequently, low visibility in the components (in other words, energy efficiency versus savings from solar) included in historical savings available at the time of the last update.

- **Standardized estimates of measure savings from PACE providers.** To improve future estimates of incremental savings, publicly available and verifiable savings data from the PACE providers are necessary. The forecast would benefit from a common engineering approach used across PACE providers to estimate measure-level savings and report these savings consistent with the Berkeley Lab measure categories.
- **Ongoing assessment of regulatory impacts.** The recent policy changes regarding consumer protection may stagnate or continue to decrease energy efficiency investment through PACE if the results in the 2018 data are the beginning of a long-term decline in PACE origination. However, with only six months of data, there are no significant historical data to determine accurately if these trends will continue. It is yet to be seen if PACE administrators and legislators will work out a compromise that corrects the larger-than-expected decline in PACE origination seen in the early 2018 data. Future updates will need to re-examine the policy landscape and determine what, if any, adjustments are warranted from these recently passed policies as well as any legislation that emerges before the next update.
- **Include other financing programs when they are determined to be viable in the market.** Additional energy efficiency financing programs have been launched by the CAEATFA or are in development. Although they are not mature enough to be considered now, future updates should examine whether these programs are producing enough savings to be added to the analysis. As such, the following CAEATFA California Hub for Energy Efficiency Financing Pilot Programs[126] warrant ongoing tracking for future inclusion consideration:
    - Residential Energy Efficiency Loan Assistance Program
    - Commercial Loans, Leases, and Energy Service Agreements Program
    - Affordable Multifamily Finance Program

126 CAEATFA. "California Hub for Energy Efficiency Financing Pilot Programs." Accessed March 2019.

CHAPTER 18: Behavioral and Market Transformation—Benchmarking

AB 802 directs the California Energy Commission to create a mandatory benchmarking and public disclosure program for certain commercial and multifamily residential buildings; it also requires making certain building-level energy use information available to building owners, agents, and operators upon request.[127] The Energy Commission has proposed regulations that would implement the benchmarking and public disclosure provisions of AB 802.

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 retro-commissioning or by including smaller buildings) become more common, energy efficiency savings can increase.[128]

Program Overview

The Benchmarking and Public Disclosure (AB 802[129]) program 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 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[130]) are expected to result in cost-effective energy efficiency improvements via behavioral, operational, and building improvements. Mandatory statewide benchmarking first appeared in

127 An earlier benchmarking program established under 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.

128 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.

129 Williams, Chapter 590, Statutes of 2015.

130 ENERGY STAR. April 2019. *Portfolio Manager*.

California in 2007 with the passage of AB 1103 (Saldaña, Chapter 533, Statutes of 2007). 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 encourage all energy savings using incentives, including those resulting from a building being brought up to code[131] and energy efficiency achieved through behavioral and operational efficiency interventions. AB 802 also allows the Energy Commission to receive account-level energy use data from utilities.

Proposed Regulations

The Energy Commission proposed regulations that would implement the benchmarking and public disclosure provisions of AB 802. 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; commercial buildings began in 2018 and residential with 17 or more units began in 2019. The Energy Commission would publish this 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
- Policymakers 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 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,

131 Prior to AB 802, utility rebate programs could claim savings only for above-code improvements in repair-eligible equipment.

Berkeley, and Los Angeles[132] all require energy audits in addition to benchmarking. Other cities, such as Long Beach and Santa Monica, routinely conduct energy audits for municipal buildings and operations, but they are not necessarily required to do so by legislation.[133]

Support for Local Programs

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 statewide requirements (for example, by including smaller buildings or by requiring audits or retro-commissioning) become more common, the Energy Commission's role could shift from the implementer of the statewide program to an advisor to local governments on:

- 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 program will require the owners of commercial buildings larger than 50,000 square feet and residential and mixed-use buildings larger than 50,000 square feet with more than 16 utility accounts to report building and energy use information to the Energy Commission annually.

Updates Relative to Previous Study

The analysis team did not change the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings*

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132 kW Engineering. May 4, 2018. Energy Benchmarking, "It's the Law in California. Here's What you need to know."

133 US Mayors. January 2018. "Energy Audits – Municipal and Commercial Buildings."

by 2030, Appendix A13 Benchmarking[134] for more detail on the analysis conducted for this program.

Method Description

The analysis team derived benchmarking program savings for SB 350 using a top-down extrapolation approach to determine the savings potential. It is not straightforward to estimate the savings attributable to the benchmarking program because the proposed regulations do not require building owners to take any action to reduce energy use. The regulations would only require building owners to report energy performance information to the Energy Commission. However, the increased visibility into building energy performance the program provides may drive building owners and tenants to reduce energy use, either by making behavioral and operational changes or through building improvements.

The team used the following steps to quantify potential energy savings:

- Quantified IOU electricity sales as a portion of statewide electricity sales[135] to estimate the portion of statewide energy consumption in commercial and residential buildings[136] in IOU territories.
- Quantified energy savings from IOU efficiency programs.[137]
- Divided energy savings by consumption to estimate percentage savings from current participation in efficiency programs.
- Assumed that participating in the benchmarking program would cause a doubling of the savings expected from participating in IOU energy efficiency programs for eligible buildings. The eligible buildings are those subject to the statewide benchmarking and public disclosure program minus the buildings already subject to a local mandatory benchmarking and public disclosure ordinance. These local ordinances have more stringent requirements than the proposed statewide program.
- Estimated affected floor area based on the proposed regulations; the regulations include only commercial buildings larger than 50,000 square feet and residential buildings larger than 50,000 square feet with more than 16 utility accounts.
- Calculated consumption expected to be avoided due to the statewide program.

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134 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

135 July 18. 2017. "California Electric Utility Service Areas."

136 US Energy Information Administration. July 18, 2017. "California Portfolio Overview."

137 California Energy Efficiency Statistics. July 18, 2017. "Rolling Portfolio."

- Multiplied the estimated savings rate by the estimated consumption in buildings subject to the program but not to local programs at a 50 percent compliance rate.

Forecasting Scenarios

Based on this information, the team made the following assumptions for the three scenarios:

- **Reference case:** The team estimated savings by first aligning savings with Energy Commission projections through 2021. Beyond 2021, an aggregate whole building savings rate increases by 2 percent per year. This savings rate is an aggregate rate of savings that can be expected to be attributed to the benchmarking program. This savings rate is somewhat lower than other recent studies[138] because of expected overlap between programs and difficulties with attributing savings to benchmarking as distinguished from other programs. This savings rate is somewhat conservative compared to other studies in other cities and jurisdictions, which show confirmed savings levels of 6 percent or higher.
- **Conservative case:** The team assumed a whole-building average savings rate of 1 percent.
- **Aggressive case:** The team assumed that year-over-year savings improvements could increase after certain durations of participation in the program. Whole building savings are increased to 4 percent. 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, which could lead to increased energy savings.

Areas to Improve

For benchmarking and market transformation programs in general, the team recommends more data collection and monitoring of these programs at different stages, including the first three years, and subsequently tracking progress throughout program maturity. This category of programs may also require extra care to account properly for savings overlap to ensure that benchmarking and public disclosure savings are not double counted. For the benchmarking (AB 802) program, the team recommends the following:

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138 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. and Mims, Natalie, et. al. 2017. *Evaluation of U.S. Building Energy Benchmarking and Transparency Programs: Attributes, Impacts and Best Practices*, Lawrence Berkeley National Laboratory, April 28, 2017.

- As the results of benchmarking and data disclosure requirements become available, compare to initial estimates and update savings projections as appropriate.
- Verify the current approach to savings allocation. All savings anticipated to be generated through benchmarking and data disclosure requirements are currently allocated to the benchmarking program itself. In practice, much of those savings are expected to be realized through other analyzed programs. In particular, a high percentage of benchmarking savings are expected to be realized through the implementation of behavioral, retro-commissioning, and operational savings (BROs) measures.
- Leverage more California-specific building stock data and assumptions.

CHAPTER 19: Behavioral and Market Transformation—Behavioral, Retro-commissioning, Operational Savings

The idea behind BROs is to give energy customers greater accessibility to their energy data to better understand their energy usage and to influence them to become more energy efficient. Energy customers can accomplish these goals 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[139] 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 a significant effect on energy use for multifamily and commercial buildings.

Program Overview

The BROs category consists of energy efficiency measures that achieve energy savings through behavioral, retro-commissioning, and operational savings as defined in the 2018 PG study.[140] BROs programs target changes that result in energy savings (for example, changes in thermostat setpoints) and improvements that result in accomplishing the same work more efficiently (for example, space cooling) or reduce/eliminate energy use without relying on installing new energy efficient technologies.

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.

139 Load shifting such as pre-cooling may save energy, too.

140 Navigant Consulting, Inc. 2017. *2018 Energy Efficiency Potential and Goals Study*. California Public Utilities Commission.

Updates Relative to Previous Study

The analysis team did not change the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030* report, Appendix A14 BROs[141] for more detail on the analysis conducted for this program.

Method Description

The team performed a top-down extrapolation approach using the following energy savings analysis to attribute to BROs measures. This analysis assumed no gas savings from POU programs because almost all POUs (including the Los Angeles Department of Water and Power, LADWP, and SMUD) provide electricity only.[142] For POU electricity savings, the analysis consisted of the following:

- This analysis assumed no savings from BROs programs until 2018 because most of the POUs (including the two largest, LADWP and SMUD) did not yet have many BROs programs; examples of these programs include building energy management and information systems (BEIMS)[143] or business energy reports (BERs).[144]
- For 2018 and 2019, this analysis assumed savings from home energy reports,[145] building operator certification (BOC),[146] and industrial strategic

141 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

142 The City of Palo Alto Utilities (CPAU) provides gas, but this utility is relatively small. For example, CPAU's electricity savings made up 1 percent of POU savings (Energy Efficiency in Public Power, 2017), so roughly 0.25 percent of statewide savings.

143 BEIMS are monitoring and control systems that provide information on the performance of some or all energy-using equipment in a building. The BEIMS software allows for changing energy consumption and operation of equipment based on the data collected.

144 BERs are the commercial sector equivalent to home energy reports. Businesses receive reports about their energy use including comparisons to similar businesses, tips to reduce energy use, and messaging about rewards or incentives.

145 Home energy reports are the most prevalent behavioral intervention program. Utilities mail reports to residential customers that provide feedback about their home's energy use, including comparison to similar neighbors, tips to improve energy efficiency, and messaging on rewards and incentives.

146 BOC is an energy efficiency training and certification offering to commercial building operators.

energy management (SEM),[147] which aligns with the POU Potential Study's assessed program list.[148]

- For 2020-2030, the analysis assumed that all POU BROs programs would have similar savings as IOU BROs, adjusted for population— multiplied by 0.33 based on 25 percent of the population in POU territories and 75 percent in IOU territories.[149]

Forecasting Scenarios

Based on this information, the team made the following assumptions for the reference, conservative, and aggressive scenarios.

- **Reference case:** This analysis identified savings from POU programs using the same BROs measures as the 2018 PG study, as described above.
- **Conservative case:** The conservative scenario reduced savings from all programs compared with the reference scenario by 50 percent by 2029, starting from 2021. This scenario reflects the possibility that BROs energy savings will decline per customer in the future because other SB 350 initiatives will reduce total energy use.
  - Assumed the same savings as the reference scenario from 2015 to 2020 because many SB 350 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. Using industry judgement, this analysis selected 50 percent to represent the lower limit of what was considered 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 2021 through 2029 and dividing this value by 10 years.
- **Aggressive case:** This analysis identified the following:
  - For the POUs, this analysis assumed that BROs would increase at the same rate as IOU BROs. For each year, the team took the ratio of IOU savings under the aggressive scenario to IOU savings in the

147 SEM is a long-term, continuous improvement process that educates and trains energy users to develop and execute on energy goal setting and integrating energy management into business practices.

148 Sathe, Amul (Navigant), Wikler, Greg (Navigant), Cullen, Gary (Anchor Blue LLC), Penning, Julie (Navigant) *Publicly Owned Utility Electricity Savings Projections*. California Energy Commission. 2018.

149 Nicolas Chaset. May 10, 2017. Customer and Retail Choice in California. CPUC.

reference scenario and multiplied this ratio by BROs from POUs under the reference scenario.

  - Additional savings from home energy reports (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 smaller control group.

Areas to Improve

For market transformation programs in general, the team recommends more data collection and monitoring of these programs at different stages, including the first three years, and subsequently tracking progress throughout program maturity. This category of programs may also require extra care to account properly for savings overlap to ensure that other programs or savings reductions are not double counted. For the BROs program, the team recommends the following:

- As BROs measures become more widely available, update market penetration estimates as appropriate.
- Refine assumptions on program implementation and uptake rates, as several of the potential BROs efficiency measures are now available in California.
- Collect more data on IOU and POU programs with measures pertaining to BROs implementations.
- Change the analysis if programs become part of the utility program savings portfolio.

CHAPTER 20: Behavioral and Market Transformation—Energy Asset Rating

The California Energy Commission's Existing Buildings Energy Efficiency Action Plan calls for standardized energy asset ratings for residential and nonresidential buildings.[150] 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 the decisions and amend the behavior to achieve the full energy efficiency potential. Several factors affect the underlying efficiency potential:

- Envelope
- Heating, cooling, ventilation, and hot water systems of a building
- Installed lighting and major appliances
- Any offsetting electrical power produced by onsite 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 are attributable to that specific program.

Program Overview

The Energy Asset Rating program consists of two similar but separately funded programs: the California Home Energy Rating System (HERS) Whole House program and the Nonresidential Energy Asset Rating program (a potential program not yet established). Both programs are designed to determine an asset rating of new and existing buildings that measures 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 HERS Whole House program has been active for several years, the Nonresidential Energy Asset Rating program completed a pilot phase but has not been fully rolled out to the marketplace. The rating aspects of the HERS program

150 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.

are assumed to be captured in existing demand forecast estimates; therefore, the HERS savings are not included in the SB 350 incremental savings for the reference case. The measure-specific aspects of HERS such as duct sealing and other tests are included in the Title 24 program estimates.

There are national programs, such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers' Building Energy Quotient (eQ) program, and Ireland, Portugal, and other countries have developed and implemented programs to develop asset ratings for commercial buildings.

Nonresidential Energy Asset Rating

To achieve greater energy savings in existing residential and nonresidential buildings, the Energy Commission, as part of Assembly Bill 758 (Skinner, Chapter 470, Statutes of 2009),[151] developed and implemented a pilot program in 2012 to develop a protocol for asset ratings. The program had several goals:

- Rate the inherent energy efficiency of the envelope, lighting, and HVAC systems of the commercial building relative to code and existing commercial building stock.
- Provide a metric relating to the financial implications of the energy efficiency of the building.
- Communicate the importance of net-zero-energy buildings as a reference point for California's energy policy.
- Communicate the potential of a building 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 ENERGY STAR. ENERGY STAR bases ratings on actual energy performance (bills), while 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. The team estimated savings for Energy Asset Rating to be a small percentage of the entire building sector; as such, any overlap with benchmarking savings is assumed negligible.

A key distinction between energy asset ratings and other efficiency programs is that onsite PV and cogeneration systems could be considered an asset because they provide persistent savings. For this estimate, the analysis considers only energy efficiency aspects; however, the program may have additional benefits. The Energy Commission suspended the Nonresidential Energy Asset Rating

151 AB 758, Skinner, Chapter 470, Statutes of 2009. "Energy Audit."

program after the pilot due to funding availability, but it shows promise and is well-aligned with other programs and Energy Commission goals.

The Nonresidential Energy Asset Rating program would affect most commercial building types, except for 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 define adequately the reference point and the required building inputs. Table 12 shows the planned scope of the Nonresidential Energy Asset Rating program.

Table 12: 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	
Standalone 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

Proposed Building Types	Use Existing DOE Reference Building	Use Modified DOE Reference Building	New Modeling Prototype Required
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.

The program would exclude some buildings because of the lack of available protocols necessary to establish the 100-point reference on the scale. The precise scope of the program would depend on the willingness of the different building sectors to embrace the rating program.

Using a cross-reference comparison between the IEPR building stock and the included building type, the commercial asset rating program would affect an estimated 90.7 percent of commercial building stock greater than 50,000 square feet. The team used this estimate to normalize savings against AB 802 program savings. The analysis applied a similar area estimate to the building stock less than 50,000 square feet, which applies to the asset ratings program but not the AB 802 regulation.

Residential Energy Asset Rating

The 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. Because the whole-house rating element is voluntary and not required for new construction or for existing buildings or at the time of sale, the team expects the participation rate for the rating aspect to be low. The benefits of HERS field verification for building attributes such as duct sealing, air leakage tests, and HVAC system tests are assumed 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 Energy Commission modified the program to require ratings in the future, the participation rate would be higher. With the lack of available data, the analysis estimates the savings rate per building in the same manner as the commercial asset rating program described above, combined with the Energy Commission's benchmarking assumptions and calculations.

The HERS program affects only newly constructed single-family buildings. Through interviews with HERS raters, the analysis team determined that the whole house rating is not typically performed for existing buildings, even at time of sale.

Updates Relative to Previous Study

The analysis team did not change the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030* report, Appendix A15 Energy Asset Rating[152] for more detail on the analysis conducted for this program.

Method Description

The team performed a top-down extrapolation approach using the following calculations and assumptions to project the energy savings potential from 2015 through 2029:

- Determined the floor area applicable to the Energy Asset Rating program by analyzing the existing building stock by end use and comparing it to the total building stock used in the Energy Commission's AB 802 program assumption. This determination results in an estimated 90.7 percent of the building stock applicable to the asset ratings.
- Assumed the weighted average building stock EUI matches the AB 802 program assumptions.
- Identified affected building types and building stock. The estimate includes office, retail, restaurant, warehouse, school, and hotel buildings and excluded high-rise residential, grocery, hospital buildings, and other buildings with significant process loads (labs, data centers).
- Collected the distribution of nonresidential floor area by building type and size from the 2012 CBECS[153] to determine what fraction of floor area by building type is expected to be contained within buildings larger than 50,000 square feet.
- Extracted nonresidential building electricity and gas EUIs from the CEUS.[154] To account for the age of the CEUS data, the team updated the values according to the ratio of energy use data captured by the 2012 CBECS and 2003 CBECS[155] for each combination of fuel and building type.

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152 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

153 U.S. Energy Information Administration. 2012. 2012 CBECS Survey Data.

154 Itron. *California Commercial End-Use Survey*. May 2017.

155 US Energy Information Administration. 2003. 2003 CBECS Survey Data.

- Assumed for buildings larger than 50,000 square feet, for which benchmarking and data disclosure will be required by AB 802, that Nonresidential Energy Asset Rating would increase ENERGY STAR-predicted savings by 50 percent. (The assumption is that savings would increase but at a diminishing rate because of benchmarking data already being available.)
- Assumed for buildings between 25,000 square feet and 50,000 square feet that Nonresidential Energy Asset Rating would be the only form of benchmarking and estimated savings equivalent to -predicted savings.
- Calculated that the savings rate for the commercial building stock due to asset ratings will be 50 percent of the savings rate of AB 802.
- Calculated that the savings rate for the commercial building stock not subject to AB 802 will be twice that of the buildings that overlap with AB 802.
- Assumed only new construction residential building stock is applicable for the HERS program, as there is no established process in place for linking ratings to time of sale or other existing buildings.[156]
- For residential ratings, estimated an average EUI of 29 kBtu/square feet for California single-family construction[157] distributed to 80 percent electricity and 20 percent gas.
- Assumed a 2 percent program uptake rate for the full market potential.
- Assumed the savings rate effectively incorporates the overlap between asset ratings and other programs.

Forecasting Scenarios

Based on this information, the team made the following assumptions for the reference, conservative, and aggressive scenarios.

- **For all scenarios:** The team assumed that the building types affected do not include restaurants, grocery, refrigerated warehouses, and hospitals, adjusting the total building stock to 90.7 percent of the AB 802 commercial building stock. The aggregate building EUI across the building stock matches the Energy Commission's AB 802 assumptions.
- **Reference case:** The team applied similar assumptions to the AB 802 analysis for savings rate across the building stock. The asset ratings program complements the AB 802 benchmarking program, so the savings rate for buildings that overlap with AB 802 (greater than 50,000 square feet, affected building types) is assumed to be 50 percent that of AB 802 for the reference case. For buildings less than 50,000 square feet where

156 Interview with Brian Selby, experienced HERS rater with in-depth knowledge and experience at the building department level.

157 Energy Information Administration. 2009. "Household Energy Use in California."

there is no overlap, the saving rate (percentage) per square foot of building stock is assumed to be equal that of AB 802. The team assumed a 2 percent per year uptake in the program savings due to increased adoption and more effective realization of program savings through implementing capital improvement projects. For HERS whole-house ratings, to estimate savings potential for the rating itself independent from Title 24, Part 6 code requirements, the team assumed an effective penetration rate that increases at 2 percent per year beginning in 2018.

- **Conservative case:** The team assumed that the uptake rate reduces from 2 percent to 1 percent year over year to reflect a more conservative adoption rate. Moreover, the program savings are not expected to begin until 2020, as opposed to 2018 for the reference case. The conservative case reduced the implementation rate for HERS ratings as well. For residential ratings, the team reduced the penetration rate.
- **Aggressive case:** The team assumed there is a 5 percent per year uptake in the program savings because of increased adoption and more effective realization of program savings through implementing capital improvement projects. The team assumed that the savings rate for buildings applicable to the asset rating program is 75 percent of the AB 802 savings rate. For residential ratings, the team increased the penetration rate.

Areas to Improve

For market transformation programs in general, the team recommends more data collection and monitoring of these programs at different stages, including the first three years, and subsequently tracking progress throughout program maturity. This category of programs may also require extra care to account properly for savings overlap to ensure that benchmarking and public disclosure savings are not double counted. For the Energy Asset Rating program, the team recommends the following:

- Compare any collected data to initial estimates and update savings projections as appropriate.
- Determine the likelihood and timeline that the Nonresidential Energy Asset Rating program will be implemented.
- Establish a procedure to link asset rating scores with voluntary efficiency upgrades driven by this program.
- Collaborate with stakeholders from the real estate market to address known concerns and identify potential issues and resolutions.
- Determine if asset ratings will have an effect on property valuation.
- Determine how receptive the building owners are to applying building asset ratings to their building stocks.

CHAPTER 21: Behavioral and Market Transformation—Smart Meter and Controls

Utilities have begun using advanced metering infrastructure (AMI)[158] to enable two-way communications with their customers. Numerous aspects of AMI can contribute to energy savings, including smart meters. The smart meter can communicate through the internet with devices in the building that are connected as part of the Internet of Things (IoT).[159] 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 load shifting and energy savings.

Although smart meters have been widely installed across California, they have not been the focus of specific energy efficiency programs, and much of the related potential remains unrealized.[113] Most of the energy savings from using smart meter data are captured in the other behavioral and market transformation programs (benchmarking, BROs, and energy asset ratings). The focus of this section is automating appliances and other loads in a building by communicating with a smart meter.

Program Overview

The smart meter and controls program is intended to use the smart meters installed in California to encourage reduced energy consumption by providing consumers with real-time information on the costs associated with energy consumption. As energy is reduced during peak-load periods, some of the load may be shed to lower periods, saving the consumer money and saving energy consumption via a direct (IoT) or otherwise-connected device. Smart meters can be installed on electric, gas, and water meters.

While not an established program, supporting evidence suggests that implementing a smart meter and controls program can result in energy savings. As of 2015, more than 80 percent of meters in California are listed as AMI

158 AMI is a system that integrates the end-user smart meters to communication networks, allowing for two-way communication between utilities and customers. AMI also enables collecting consumption data at the sub-hourly level.

159 IoT is the two-way interconnection between devices and internet-based services.

electricity meters. These meters enable variable rate structures, demand response, and improved customer feedback and control.[160]

As the smart meter market develops, feedback can include historical baseline information and control energy consumption in a way that reflects the time-dependent valuation (TDV)[161] of the energy consumed. This communication will be automatic, but the decision-making will initially be made by the consumer rather than the utility. Utilities have chosen to offer incentives for consumer adoption through programs to encourage reduced demand peaks, lower overall energy consumption, and lower overall TDV for the consumption profile. PG&E encourages peak reduction through its SmartRate rate plan,[162] with an incentive of lower overall rates predicated on the consumer reducing electricity usage on certain days of peak demand; the utility is limited to selecting 15 peak demand days per year.[163]

Smart meters are effectively the enabling technology needed to create behavioral programs, meaning there is potential for substantial overlap with the BROs program. For this reason, the team has adopted a narrow interpretation of smart metering: 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). Furthermore, as part of this analysis, the team considered only smart meter-based interventions that reduce energy consumption (not interventions that only shift demand).

Residential buildings are candidates for smart meter savings because they generate a relatively high level of discretionary energy consumption. There is an 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 is not a demand-response event occurring.[164] In some cases, building automation system controls may facilitate

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160 Walton, Robert. December 9, 2015. "How Smart Meters Are Changing Energy Efficiency in California." *Utility DIVE.*

161 TDV is a metric to incorporate nonenergy impacts into the cost of energy during a given hour of the year. The resulting TDV aligns energy savings for the end users with the cost to produce and deliver energy to consumers.

162 PG&E. "Learn About SmartRate™"

163 PG&E. "Discover SmartRate: Determine If SmartRate Is Right for You." Accessed in May 2017.

164 A demand response event is when a utility or an electric grid system operator makes a call to reduce demand during a particular time window. Typically, participants are actively enrolled in a program to receive notice of an event.

action that enables automated smart meter savings; in other cases, building automation system capabilities may determine the necessary efficiency intervention without the need for smart meter input.

Updates Relative to Previous Study

The analysis team did not change the method from the previous study. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030* report, Appendix A16 Smart Meter and Controls[165] for more detail on the analysis conducted for this program.

Method Description

The team performed a top-down extrapolation approach using the following calculations and assumptions to project the energy savings potential from 2015 through 2029.

- Evaluated smart meter and controls potential for buildings of all types and sizes. The source of expected energy savings is reduced consumption associated with the automatic response of IoT or otherwise connected devices to smart meter feedback.
- Extracted floor area data by building type from the IEPR building stock data. For multifamily buildings, IEPR data capture the number of households. To convert the number of multifamily households, the analysis team used the same assumptions as the 2016 impact analysis report:[166] 26 percent of multifamily building types are high-rise units with a floor area of 1,248 square feet; the remaining households are contained within 6,960 square feet, two-story, eight-dwelling buildings (870 square feet per unit). For single-family homes, 45 percent are assumed to be 2,100 square feet, and 55 percent are assumed to be 2,700 square feet.
- Extracted commercial building electricity and gas EUIs from the CEUS.[167] To account for the age of CEUS data, the team updated values according to the ratio of energy use data captured by the 2012 CBECS[168] and 2003

165 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

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

167 Itron. May 2017. *California Commercial End-Use Survey*.

168 U.S. Energy Information Administration. 2012. "2012 CBECS Survey Data."

CBECS.[169] The analysis calculated ratios for each combination of fuel and building type.

- Extracted residential building electricity and gas EUIs from the California statewide RASS for 2009.[170]
- Made assumptions due to the lack of data availability related to the potential for smart meters and controls, as well as the general indication that demand and time-of-use response interventions are the focus area for the technology.
  - Energy savings from smart meter and controls will not begin to be realized until 2020.
  - Approximate savings will increase to about 0.5 percent for electricity and 0.25 percent for natural gas for five years 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 meters and controls each year.
- The team assumed one year for the EUL of real-time programs, so cumulative savings were the same as annual savings.
- Real-time feedback affects primarily electricity savings because California's AMI infrastructure has been installed for electricity. However, some electricity savings measures can provide small ancillary gas savings. The team used the 2018 PG assumptions for gas savings for the two programs included in that study: zero for the in-home display program and 1.5 million therms by 2029 (under the reference scenario) for the Web-based portal program.

The team analyzed energy savings attributed to smart meter and controls based primarily on results from the BROs program. This analysis delineated energy savings that have been captured by the 2018 PG study, which are assigned to the additional achievable energy efficiency baseline, from the energy savings that can be counted as incremental for SB 350.

Forecasting Scenarios

Based on this information, the team made the following assumptions for the reference, conservative, and aggressive scenarios.

- **Reference case:** This analysis assigned 2018 PG reference savings from IOU real-time programs to the baseline forecast. The 2018 PG study includes two residential programs: in-home display real-time feedback and web-based portal real-time feedback. For the SB 350 incremental savings,

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169 U.S. Energy Information Administration. 2003. "2003 CBECS Survey Data."

170 DNV-GL. 2010. *California Statewide Residential Appliance Saturation Study*.

the 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 the IOUs' retrocommissioning savings, adjusted by population— multiplied by 0.33 based on 25 percent of the population in POU territories and 75 percent in IOU territories.[171]
    - The team did not include other real-time programs (beyond those in the 2018 PG study) because of the potential for overlap with other residential behavioral programs or overlap with commercial BROs programs.

- **Conservative case:** This analysis modeled real-time measures that reduce energy savings through conservation efforts such as reducing hours of operation and changes in setpoints (for example, higher temperature setpoints for air conditioning). As other SB 350 measures increase energy efficiency, operational energy declines, and the energy savings from real-time measures declines. The 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, when other initiatives are projected to be ramping up until 2020.
    - Assumed that savings would be 50 percent of the energy savings from the reference prediction for real-time programs through 2029. This analysis selected 50 percent using industry judgement to represent the lower limit of what the team considered 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.
- **Aggressive case:** This analysis assigned 2018 PG aggressive savings from the two IOU real-time programs to the additional achievable energy efficiency baseline. For the SB 350 incremental savings for the POUs, this analysis assumed that smart meter savings would increase at the same rate as IOU smart meter savings.
    - Calculated for each year 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.

171 Chaset, Nicolas. CPUC. May 10, 2017. "Customer and Retail Choice in California."

- Added the 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, through either an online portal or an in-home display.[172] The savings documented in the ACEEE study from real-time feedback programs (4 percent to 7 percent) were higher than the savings estimated for the real-time programs in the 2018 PG study (about 1 percent to 2 percent).
- Incorporated enhanced billing with household-specific information and advice (to achieve an average of 4 percent savings) to achieve additional savings with smart meters. Additional savings may occur from Web-based energy audits with information provided on an ongoing basis (to achieve an average of 7 percent savings).[173]
- Because California has a mild climate compared with the rest of the United States (including a lower cooling load), the team assumed 3 percent savings total from AMI real-time feedback.
- Because the 2018 PG assumed 1 to 2 percent savings from real-time feedback programs, the 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 because this is more conservative than the assumption of 10 percent for online portals.
- The team assumed average household electricity use of 6,296 kWh/year based on the California statewide RASS for 2009. This average use is used to estimate AMI savings for aggressive case.

Areas to Improve

For market transformation programs in general, the team recommends more data collection and monitoring of these programs at different stages, including the first three years, and subsequently tracking progress throughout program maturity. This category of programs may also require extra care to account properly for savings overlap to ensure that benchmarking and public disclosure savings are not double counted. For this program, the team recommends the following:

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172 Ehrhardt-Martinez, Karen, Kat Donnelly, John Laitner. 2010. *Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Savings Opportunities.* ACEEE. Report Number: E105.

173 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.

- As the program is developed and implemented, compare any collected data to initial estimates and update savings projections as appropriate.
- Take steps to isolate savings automatically generated through this program from those resulting from benchmarking and data disclosure requirements.
- Refine assumptions on program implementation and uptake rates, as several potential smart meter and controls efficiency measures are not available in California.
- Collect more data on IOU and POU programs with measures pertaining to smart meter and controls implementations.

CHAPTER 22: Behavioral and Market Transformation—Fuel Substitution

In 2019, few utility fuel substitution programs exist. Fuel substitution can include measures for space heating, water heating, clothes dryers, and possibly additional residential and 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. Most buildings in California use natural gas for water and space heating. Substituting natural gas with electricity-consuming devices could reduce energy consumption and GHG emissions.

Program Overview

The fuel substitution category captures energy savings that can be achieved at the site level by substituting one utility-supplied fuel for another— 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 given that the energy consumption level may remain the same, electrification will be the main area of focus for this program.

For this analysis, the savings are reduced site energy usage for any commercial or residential new construction or retrofit project 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 or funding mechanism (grants, standard loans, no interest loans, on-bill financing, and so forth).

Updates Relative to Previous Study

The team did not change the method from the previous study, but changes will occur in future California Energy Commission analysis. The Energy Commission can use the updated program workbook to incorporate any new program data that may be used to update the savings estimates for this program. Refer to the 2017 *Senate Bill 350: Doubling Energy Efficiency Savings by 2030* report,

Appendix A17 Fuel Substitution[174] for more detail on the analysis conducted for this program.

Method Description

The analysis team derived program savings using a top-down extrapolation. The 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,[175] the team estimated the fraction of this additional natural gas load that would serve space- and water-heating needs. The team assumed that, on average, a fuel substitution program would replace 80 percent efficient natural gas combustion equipment with 3.0 coefficient of performance (COP) heat pump equivalents. [176] The team assumed that a fuel substitution could affect 10 percent of the new construction (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 a corresponding increase in electricity consumption (although, based on the efficiency assumption, a net reduction in both site and source energy is expected).

While the team anticipated pursuing a bottom-up energy modeling analysis, subsequent investigation revealed that energy modeling was not likely to result in a 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 building type and climate zone, the effect of such refinements would be statistically insignificant compared to the effect of relevant market uptake assumptions. The Energy Commission will develop a bottom-up approach for fuel substitution impacts in the next iteration of SB 350 savings forecast.

Two key questions determine potential market impacts:

1. Would an electrification program target existing buildings or only new construction?

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174 Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. *Senate Bill 350: Doubling Energy Efficiency Savings by 2030*. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

175 Palo Alto City Council. 2015. *Fuel Switching/aka Electrification.* City of Palo Alto.

176 Federal standard efficiency for a gas furnace is 80 percent. High efficiency furnaces are 95 percent. A 3.0 COP heat pump is a high efficiency unit.

2. What fraction of the target market could be expected to implement electrification through 2029?

The team assumed that major fuel substitution efforts would be limited largely to new construction because of potential infrastructure limitations for retrofit cases. Analysis scaled back the market penetration assumption, delaying any penetration until 2020 and then ramping up gradually to 10 percent penetration (for the reference case) through 2029. The analysis team did not conduct market analysis to verify the electrification penetration but recommends it for future SB 350 updates.

Forecasting Scenarios

Based on this information, the team made the following assumptions for the reference, conservative, and aggressive scenarios.

- **Reference**: This case assumes that fuel substitution programs would affect residential and nonresidential new construction starting at a penetration rate of 1.5 percent in 2020 and ramping up linearly to a rate of 13.5 percent through 2029.
- **Conservative**: This case assumes that fuel substitution programs would affect residential and nonresidential new construction starting at a penetration rate of 0.5 percent in 2020 and ramping up linearly to a rate of 4.5 percent through 2029.
- **Aggressive**: The aggressive case assumes that fuel substitution programs would affect residential and nonresidential new construction starting at a penetration rate of 2.5 percent in 2020 and ramping up linearly to a rate of 22.5 percent through 2029.

Areas to Improve

The team recommends more data collection and monitoring of these programs at different stages, including the first three years, and subsequently tracking progress throughout program maturity. For this program, the team recommends the following:

- Define fuel substitution more clearly to determine what types of projects should be included. For a program or project to fall under the category of fuel substitution, does a natural gas configuration always define the reference cost case? If a project can qualify for a utility rebate by comparing high-efficiency heat pump equipment against an electric baseline (by indicating that natural gas is not available onsite), would it then be ineligible for consideration as a fuel substitution project?

- Conduct further research on cost-effectiveness and establish an appropriate baseline for the existing penetration of natural gas or electricity.
- When fuel substitution programs start to achieve traction throughout the state, update the market penetration assumptions as appropriate.
- Refine assumptions for efficiency improvement and fraction of natural gas load offset as data become available.
- Include retrofit savings potential.

CHAPTER 23: Sector—Industrial and Agricultural

The industrial and agricultural sectors represent a large opportunity for energy savings through energy efficiency measure deployment. These sectors use a large amount of energy and are often underserved by utility energy efficiency programs. This chapter identifies the gap that exists in the market between what utilities are achieving and what could be achieved through additional program activity.

Program Overview

California, if it were a country, is the fifth largest economy in the world.[177] Manufacturing and other industrial production play a major part in maintaining California's economic success, contributing nearly 11 percent of the state's gross domestic product.[178] California leads the United States in electronics and computer manufacturing.[179] 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 increase in light manufacturing and less energy-intensive industries.[180]

In spite of the decrease in heavy industry, California's industrial sector consumes about 15 percent of electricity and 38 percent[181] of natural gas consumption statewide. This sector has significant untapped potential for energy savings. A

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177 *Business Insider.* 2019. "16 mind-blowing facts about Californian's economy." California is at about $2.9 trillion gross domestic product.

CBS News. 2018. "California now has the world's 5th largest economy."

Statistics Times. 2018. "Projected GDP Ranking (2019-2023)."

178 National Association of Manufacturers (NAM). 2019. "State Manufacturing Data."

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

180 De la Rue du Can, Stephane, Ali Hasanbeigi, and Jayant Sathaye. Lawrence Berkeley National Laboratory. "Analysis of the Energy Intensity of Industrial Sectors in California." ACEEE, *2011 ACEEE Summer Study on Energy Efficiency in Industry.*

181 U.S. Energy Information Administration. 2017. "Natural Gas Consumption Estimates, 2017."

central challenge in tapping those savings is that each industry has unique situations and proprietary information.

California is also home to the nation's largest and most diversified agricultural and food processing sector. California's agricultural abundance includes more than 400 commodities grown on 77,500 farms and ranches; it was collectively valued at more than $50 billion in 2017.[182] 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 factory for processing milk, milk powder, and butter (California Dairies, Inc.); cheese (Hilmar Cheese Company); wine (E & J Gallo); and poultry (Foster Farms). This sector has common loads likely to lend themselves to efficiency improvements, such as refrigeration. Statewide, the agricultural sector uses slightly less than 7 percent of electricity and about 1 percent of natural gas. Agricultural electricity usage is primarily for water pumping.

A mix of POU and IOU programs serve the industrial and agricultural sectors. Utility program activities identified by the POU and IOU potential studies may not be capturing the full energy efficiency activity conducted by the industrial and agricultural sectors. Therefore, this analysis attempts to capture energy efficiency activities that are occurring beyond-utility claimed savings. Some examples of activities not part of the utility studies include:

- Requirements set by the California Air Resources Board (CARB) and the air quality management districts (AQMDs).
- Facility actions that may be considered industry standard practice, which are not considered eligible utility savings.
- Operational improvements that happen organically or via education and training programs.
- Other energy efficiency activities that do not meet the utility program requirements or selection of facilities to not participate.

Industrial and agricultural facilities can achieve beyond-utility energy efficiency savings in these sectors by implementing process improvements, standard energy efficiency retrofits, and operational and behavioral changes through ISO 50001[183] and similar approaches. Barriers prevent or slow down the market

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182 California Department of Food and Agriculture. 2018. "California Agricultural Production Statistics."

183 ISO 50001 (International Organization for Standardization) is a voluntary standard for designing, implementing, and maintaining an energy management system.

adoption of the interventions available to these sectors. These barriers include the following:

- **Lack of knowledge:** Site managers do not know or believe energy efficiency is real and are not taking any action.
- **Financial**: Site managers have tight budgets and believe energy efficiency is not cost-effective; consequently, they will not invest. In many cases, this is an excuse site representatives use, when cost-effective measures often exist at most sites.
- **Safety and product quality:** Site representatives are uncomfortable with changing things that work. Trusted experts are needed and building trust with site representatives is key to the long-term success of these programs. Building trust means programs need to take a long-term approach: installing slowly over time and gradually building trust so that sites are willing to install more expensive and more impactful measures. Trust is slow to build and fast to break, so this barrier is difficult to overcome.
- **Continuous operation cycles and seasonality:** Site operation makes it difficult to install measures. When an operation is seasonal, it makes measures less cost-effective, as load hours may be less typical. Much like the previous barrier, a long-term approach must be developed if change is going to happen. Detailed knowledge of the operation is required to understand what should be installed, when it can be installed, and if it is cost-effective to install it.
- **Organizational barriers:** Industry can be hierarchical, and it can be difficult to complete anything without support from all levels of the operation. Again, the theme is relationship building. It can be difficult to get full support, but it starts at the top. Through group training, clear communication, and long-term planning, change can occur. That training can lead to a change in energy culture, which is important for long-term success.

Education with long-term support, either financially or otherwise, plus buy-in from the top of the organization can lead to increased penetration of efficiency potential.

Additional tactics and new measure development can help promote future savings adoption. One specific area is the promotion and acceptance of SEM. SEM, per CPUC and California IOU design, is a continuous improvement approach that focuses on changing business practices to enable companies to save money by reducing energy consumption and waste through a comprehensive approach to managing energy use. SEM programs are designed to support industrial companies by focusing on several high-level objectives:

- Implementing energy efficiency projects and saving energy, primarily from savings in operations and maintenance.
- Establishing the energy management system or business practices that help a facility manage and continuously improve energy performance.
- Normalizing, quantifying, and reporting facility wide energy performance.
- Getting peers to talk to one another. SEM measures are low-cost, or no-cost measures identified through training and intentional detailed audits of the sites. The goal of the program is to train site representatives to commission their own processes, internally identifying opportunities for improvement each day, week, and year. Savings are calculated at a whole-building level, so it is difficult to estimate individual measure contributions. However, the program saves around 3 percent of total usage on average.

For emerging technologies, development is ongoing for new applications and technologies. These technologies have demonstrated energy benefits to the industrial and agricultural sectors but are not yet widely adopted in the market. The team evaluated emerging technologies at varying stages along the path to market readiness. Some were demonstrated in a laboratory or research setting, while others proved effective through pilot tests and are in early commercial adoption.

Updates Relative to Previous Study

The previous SB 350 target analysis did not include analysis on the industrial and agricultural savings potential.

Method Description

The analysis team used the same method for both sectors to estimate the potential energy savings from activities not funded through utility programs. For this analysis, the team used the 2018 PG study[184] results and historical utility program savings as the committed savings. The analysis took the difference between the theoretical technical savings potential and the committed savings to calculate the incremental difference to determine the SB 350 forecast.

The team initially considered two general approaches to investigate the potential energy savings in these sectors. The theoretical considerations started with the industrial sector because it is more heavily researched and understood than the agricultural sector.

The first was a **top-down approach** that would use total sector savings estimates and apply them to sector energy use. The analysis team reviewed a

184 Navigant Consulting, Inc. 2017. *2018 Energy Efficiency Potential and Goals Study*. California Public Utilities Commission.

variety of sources, including the International Energy Agency (IEA), the U.S. Energy Information Administration (EIA), the DOE's Office of Energy Efficiency and Renewable Energy (EERE), and market reports such as those developed by McKinsey.[185] These reports included a range of energy savings potential from 1 percent to 3 percent for overall sector usage. After reviewing the data sources, the team decided that this approach lacked the detail needed to fully understand the actual potential in these sectors. It was also unclear what amount of this potential savings could be achievable and over what period.

The second was a **bottom-up approach**. The foundation of data varied between the two sectors. The industrial analysis used measure data from the Industrial Assessment Center (IAC)[186] as a key resource. The IAC database includes the results of thousands of industrial audits that are completed each year. During these audits, cost-effective measures were identified and analyzed as part of an audit report delivered to each site. All measure calculation results have been recorded in the database since the late 1970s. Identified energy savings opportunities were categorized at the building-type and end-use level. The team based the agricultural analysis on engineering assumptions.

To estimate the savings for the industrial sector, the analysis team performed the following steps:

- Used IAC data to create savings potential specific to building type and end use. These savings were translated into percentages to reflect the maximum amount of capturable savings per building type and end use. The team weighted these percentages by building type to establish to what fraction of overall building consumption a particular end use should be contributed.
- Used North American Industry Classification System (NAICS) historical data to estimate the average percentage of consumption by building type for each IOU.
- Applied the weighted savings ratios and building type ratios to the historical and potential study forecast to establish the baseline-committed savings.
- Applied the maximum savings potential and building type ratios to forecast IEPR data for the industrial sector to estimate maximum achievable savings by building type and end use.
- Calculated the difference between the maximum achievable savings and the baseline savings to identify the gap that exists between the savings

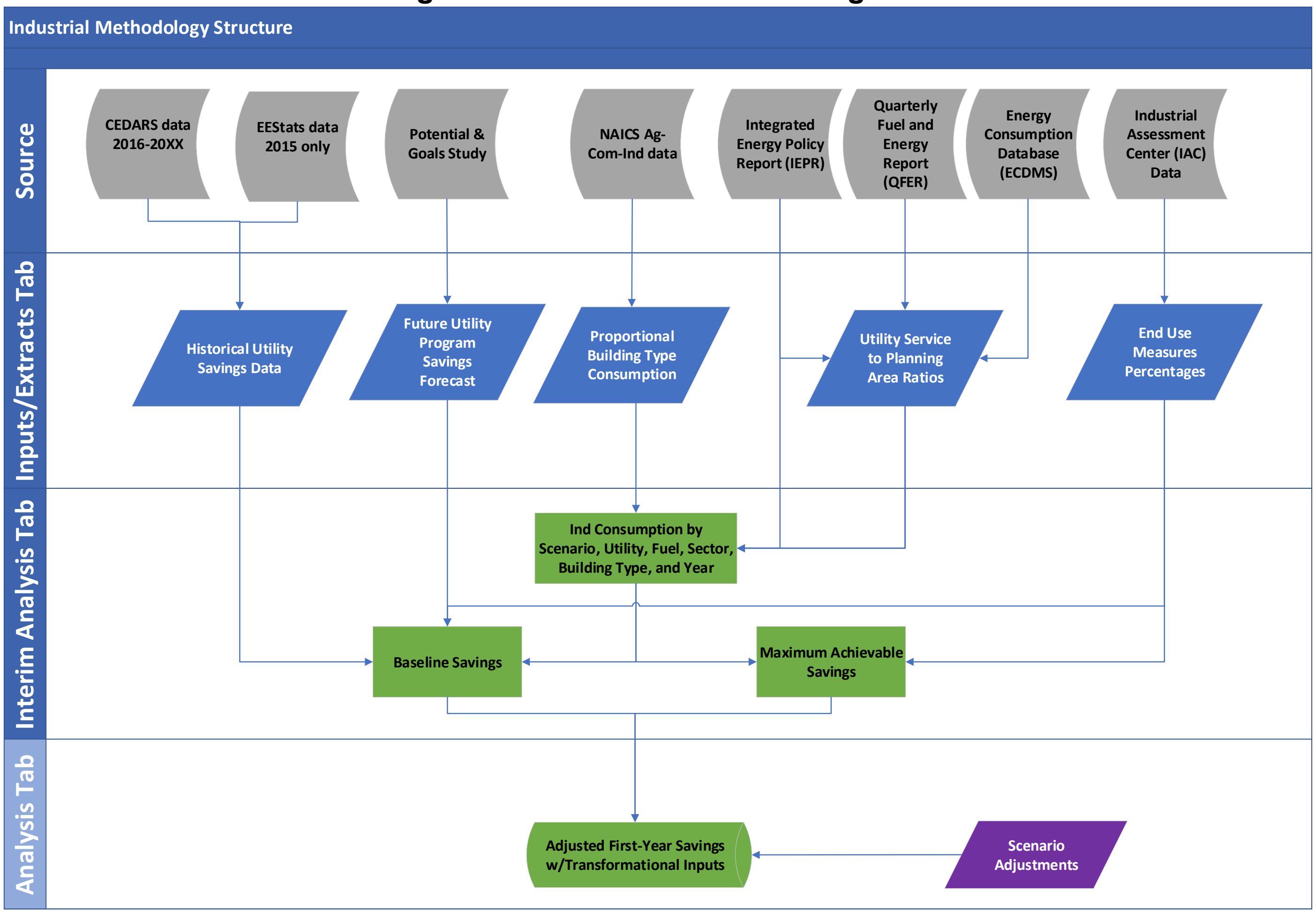
185 IEA. "*Energy Efficiency: Industry*", Energy Information Administration. "*Consumption & Efficiency*", McKinsey & Company. 2010. *Energy Efficiency: A Compelling Global Resource*

186 Industrial Assessment database

occurring and the maximum savings possible. This gap is the potential SB 350 savings for the industrial sector.

Figure 12 depicts the overall flow of the industrial savings method that occurs in the workbook. Specifically, the high-level flow of data and information throughout the structure of the workbook.

Figure 12: Industrial Method Diagram



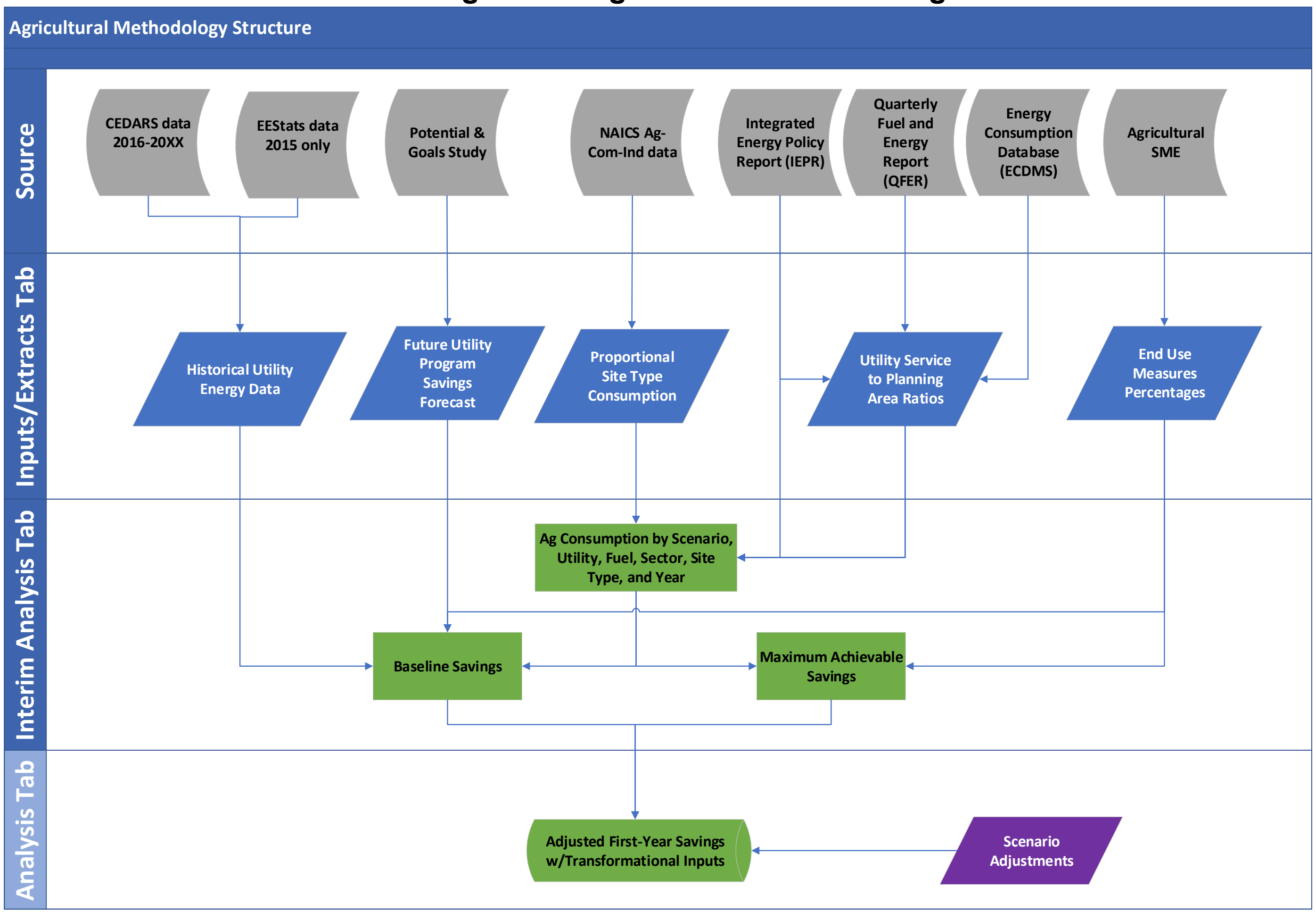
Flow chart of source data and analysis to calculate industrial annual savings potential. Analysis steps net out baseline, which is assumed to be the historical and forecasted utility program savings using source data from the sector consumption and measure level savings potential.

Source: Navigant team

The analysis team calculated the agricultural SB 350 savings in a similar way, except for the savings potential by building type and end use. The agricultural sector was not included in the IAC database, and the team did not identify any other major source of agricultural energy savings. The team calculated savings at the end-use and building-type level using engineering estimates from its agricultural subject matter experts.

In addition to the end use-level measures identified, the team created measures to represent emerging technologies and SEM based on the PG study. The effects of these measures became the target technical potential. Figure 13 depicts the flow of the method for the agricultural workbook.

Figure 13: Agricultural Method Diagram



Flow chart of source data and analysis to calculate agricultural annual savings potential. Analysis steps net out baseline, which is assumed to be the historical and forecasted utility program savings using source data from the sector consumption and end use level savings potential assumption.

Source: Navigant team

Major Data Assumption

The program workbook provides the calculation documentation, including specific assumptions regarding the calculation methods. The team also made the following general assumptions for this analysis:

- **Measures are cost-effective and ready to install.** During the IAC audits, the auditors identify many measure opportunities and discuss them with the customers. The IAC team only analyzes measures once both the auditor and customer agree that they are opportunities that could be reasonably acted on and are cost-effective.
- **Opportunities identified are not regionally specific.** The IAC audits are completed throughout the United States—they are not limited to California. The analysis team felt it was appropriate to assume that industrial energy opportunities such as air compressor upgrades and motor controls would not greatly differ from one region to another. Although some measures are weather-dependent, industrial heating and cooling load is driven primarily by production needs and is less affected by region-specific weather.
- **Opportunities, as a percentage of consumption, remain relevant over time.** Although California has aggressive energy efficiency programs compared to other states, the analysis team assumed that the industrial and agricultural sectors would still have a large amount of opportunity left because of the difficulty of completing projects, evolving technologies, and changing processes, as well as the relative lack of focus on energy efficiency common in these sectors.

Forecasting Scenarios

This section details the assumptions made for each SB 350 forecasting scenario. The conservative scenario provides the minimal scenario, in which no savings outside current utility program efforts are being achieved, equivalent to a zero savings gap. The reference and aggressive scenarios take the maximum savings gap and distribute it across varying timelines while incorporating the effects of a tech-to-market ratio.

- **Conservative**: No savings gap between what is being achieved and what could potentially be achieved.
- **Reference**: The achievable savings gap by building type and end use is achieved in 15 years, with a straight-line projection and an 80 percent technical-to-market adoption ratio.
- **Aggressive**: The maximum achievable savings by building type and end use is achieved in 10 years, with a straight-line projection and an 80 percent technical-to-market adoption ratio.

In the above scenarios, the straight-line projection represents constant savings magnitude per year. The period, constant savings, and technical-to-market adoption ratio are estimated values that reflect plausible future circumstances. However, they are simply projections, subject to change in response to how the industrial and agricultural markets actually perform.

Areas to Improve

The team has identified areas for improvement that should be considered for the next SB 350 update:

- **POU data:** The IEPR data used for industrial consumption are IOU-only data; the POU energy savings performance is predicted based on the IOU performance. Incorporating more POU data could allow for increased precision in POU savings forecasting.
- **Forecast consumption data:** The IEPR forecasting data project only consumption to 2030. The building-type analysis is available only for historical consumption. The industrial and agricultural sectors are sensitive to market trends, and tying the forecast to the building type can help with more accurate analysis.
- **Distribution and reallocation of savings to reflect performance:** Savings distribution is projected over a finite period at a constant rate; however, this projection is subject to variation. This method is complex—it estimates the maximum savings as a percentage, a static ratio rather than a finite amount, and the amount of absolute savings can vary based on consumption. If the savings target for a particular year is not met, the subsequent savings may be readjusted to reach the maximum savings percentage.
- **Large customer savings**: Future savings estimates should consider the effects of large facilities. One facility can result in a high energy-use reduction that can surpass the potential and be significant to the state's overall goals. Tracking large customers and their energy use patterns can provide further insight into achievements and potential.
- **Historical savings:** There is no method to document or verify savings achieved for beyond-utility interventions.

CHAPTER 24: Other—Conservation Voltage Reduction

While CVR has been around for decades, it was included explicitly in the activities listed in California Public Resources Code (PRC) 25310(d)[187] that may be used to satisfy SB 350 energy efficiency goals. Utilities have engaged in various pilots, but there is potential to expand programs in pursuit of the state's energy efficiency goals.

Program Overview

CVR programs work on the principle that certain electric loads consume less power when operated at a lower voltage. While electric service providers are required to maintain end customer voltage within a certain tolerance of nominal, operating at the lower end of this range has the potential for energy and peak savings. For CVR, this lowering of voltage is achieved by changing the settings of distribution system devices, usually at the substation. The degree to which voltage can be lowered is constrained by the lowest customer voltages on the circuit and the ability of the distribution system devices to move to lower settings.

Equation 1: High-Level CVR Impact Calculation

$$CVR\ Impact_{Load\ Type} = Load_{Load\ Type} * Voltage\ Reduction * CVR\ Factor_{Load\ Type}$$

Three major components are included in the calculation:

- $Load_{Load\ Type}$: Amount of load of a given type
- VoltageReduction: How much the voltage serving that load can be lowered
- $CVR\ Factor_{Load\ Type}$: Measured value of the relative decrease in load per decrease in voltage

Updates Relative to Previous Study

The previous SB 350 target analysis did not include CVR potential.

187 "PRC 25310(d)." California Legislative Information.

Method Description

To produce the initial top-down estimate of CVR potential, the team identified the amount of load in each service territory and conducted a literature review to determine the following:

- **Appropriate CVR factors for each region.** The team reviewed the available literature for real-world measurements of the differences in impacts of voltage reduction on residential, commercial, and industrial loads but did not find that specific data. The team did identify region-specific values from reports by several California utilities, shown in Table 13. If values were not available for a particular utility, the team mapped the value from the geographically closest utility. The identified California values were in line with other studies around the country.
- **Reduction amount for individual distribution circuit voltage while staying within the required band.** Utilities are already attempting to perform voltage reduction to the extent possible,[188] but it is expected that there is more room to improve on existing practical applications. If detailed circuit voltage data are unavailable, the team identified expected voltage reduction percentages from previous studies.

Table 13: Identified Voltage Reduction Potential and CVR Factors

Data Name	Utility	Value	Source
Average Voltage Reduction	PG&E	3.05%	Report on Voltage and Reactive Power Optimization (2016)[189]
Average Voltage Reduction	SCE	1.58%	Irvine Smart Grid Demo Project Report (2015)[190]
Average Voltage Reduction	SMUD	1.7%	Analysis of SMUD CVR (2015)[191]

188 PG&E Rules 2, Sheet 4 states "…for the purposes of energy conservation, distribution line voltage will be regulated to the extent practicable to maintain service voltage… on residential and commercial circuits between 114 V and 120 V."

189 Pacific Gas and Electric Company. 2016. *Smart Grid Pilot Program Final Status Reports Pursuant to Decision 13-03-032.*

190 Irwin, Mark, Robert Yinger. 2017. *Irvine Smart Grid Demonstration, a Regional Smart Grid Demonstration Project.* U.S. Department of Energy – National Energy Technology Laboratory

191 EPRI. 2015. *Analysis of Sacramento Municipal Utility District Conservation Voltage Reduction (CVR) Tests: June 2013 – June 2014*.

Data Name	Utility	Value	Source
Average Voltage Reduction	Glendale Water & Power (W&P)	3.13%	Glendale W&P Report (2018)[192]
Average Voltage Reduction	SDG&E	*1.58%*	*Not available, using SCE*
Average Voltage Reduction	LADWP	*1.58%*	*Not available, using SCE*
Average Voltage Reduction	Turlock Irrigation District	*3.05%*	*Not available, using PG&E*
Average Voltage Reduction	Imperial Irrigation District	*1.58%*	*Not available, using SCE*
CVR Factor	PG&E	0.7	Report on Voltage and Reactive Power Optimization (2016)
CVR Factor	SCE	1.0	Irvine Smart Grid Demo Project Report (2015)
CVR Factor	SMUD	0.6	Analysis of SMUD CVR (2015)
CVR Factor	Glendale W&P	0.8	Glendale W&P Report (2018)

Source: Navigant team analysis

In reviewing the CVR factors, the team investigated whether the reported voltage reductions and CVR factors were based on circuits selected for optimal characteristics or to be representative of the service territory. The circuits in the studies were optimistic candidates. For example, the PG&E Volt-VAR Optimization study[193] estimated that the maximum benefit/cost ratio would occur for a deployment across 15 percent of its territory.

As the primary actor to implement these methods will be the distribution utility, modeling adoption is different than other energy efficiency programs. Limited data were available on the extent to which CVR would be economically or technically feasible. Until further information is available, a linear adoption rate

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192 City of Glendale, California. 2018. *Glendale W&P Report.*

193 Pacific Gas and Electric Company. 2016. *Smart Grid Pilot Program Final Status Reports Pursuant to Decision 13-03-032.*

will be assumed at 3 percent, 5 percent, or 8 percent of the calculated potential (using Equation 1) per year for 10 years, depending on the scenario evaluated.

Forecasting Scenarios

The team considered three IEPR load scenarios, along with three rates of CVR adoption. As more data are available about the rate of adoption and as load forecasts are updated, the projected savings can be adjusted as well.

- **Reference:** Utilities implement 5 percent of the total estimated potential for CVR per year for 10 years.
- **Conservative:** Utilities implement 3 percent of the total estimated potential for CVR per year for 10 years.
- **Aggressive:** Utilities implement 8 percent of the total estimated potential for CVR per year for 10 years.

Areas to Improve

While a more complex bottom-up approach was not feasible for this iteration of the savings potential calculation, this description provides the data requirements and method if this type of granular analysis is desired in the future. It also allows analysis of more complex voltage regulation schemes using additional distribution grid devices. These devices would modulate the voltage at many points around a circuit in a coordinated fashion or schemes involving customer-owned smart inverters for maximal control of the voltage. As shown in

Figure 14 (from PG&E's Final Report on Voltage and Reactive Power Optimization),[194] controlling the voltage at additional points down the distribution circuit can enable the average voltage to be reduced.

194 Pacific Gas and Electric Company. 2016. *Smart Grid Pilot Program Final Status Reports Pursuant to Decision 13-03-032.*

Figure 14: PG&E Volt/VAR Control vs. Optimization

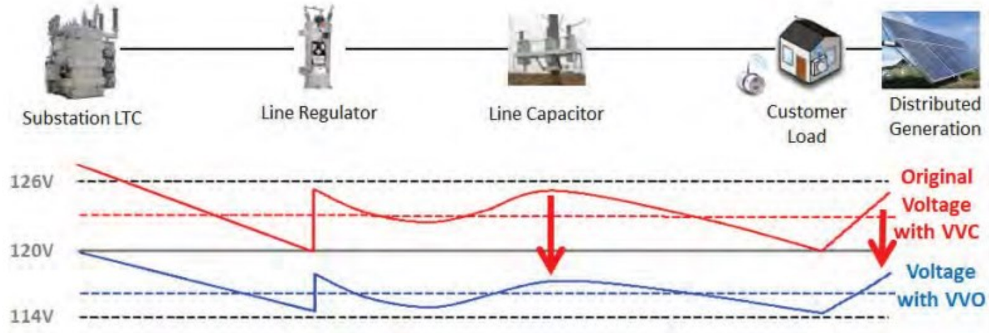

Diagram illustrating distribution level touchpoints where volt/VAR control and optimization can occur resulting in appropriate voltage reductions.

Source: PG&E study[195]

At the first level, these analyses would require the minimum or lowest 1 percent of voltage on each distribution circuit to better assess the voltage reduction value in Equation 1. As the voltage is sensitive to the total loading on the circuit, the amount that voltage is lowered may be greater in seasons where the maximum load is smaller. It may be possible to have voltage reduction schemes that take advantage of these differences more aggressively rather than on an annual calculation. Having customer-level data provides a better sense for how much voltage can be reduced, as opposed to just measuring at the circuit head.

The Energy Commission could request customer AMI data under Title 20 to assess fully the degree to which voltage can be lowered and to conduct a more granular assessment of the different categories of load. If these data were available, the bottom-up approach would use the same equation as above, but with individual circuit annual energy and voltage reduction potential. The bottom-up approach would allow a more precise calculation of the amount of voltage that can be reduced on the circuit rather than just measuring at the substation and applying a heuristic value.

A circuit-specific CVR factor would use the values assessed for the top-down approach because it is difficult to measure that value. Table 14 describes additional data required to make a more granular, bottom-up calculation of CVR potential. The ideal data request includes a full set of 8,760 hourly annual profiles for all customers; however, the analysis can use sampling and include a significantly reduced set of profiles to save on data transfer, storage, and analysis costs. To reduce sensitivity to outliers, the first percentile of voltage reads could be used rather than the minimum of the voltage reads to set the allowable floor.

195 Ibid.

Table 14: Potential Bottom-Up Data Needs

Data Name	Data Description
Customer voltage	First percentile of customer voltage measured across each circuit each season.
Customer load by circuit	Estimate of total energy by circuit to go along with calculated circuit-level voltage reduction potential.
Breakdown of customer load types	If CVR factors are identified or calculated for different types of customer loads, the corresponding breakdown of total energy by load type would also be required.
Rate of utility implementation	If the utility has better information than the linear technical potential assumption then the Energy Commission should adopt the utility analysis.

Source: Navigant team

The CVR scheme, with direct distribution operator cooperation, can operate similar to a demand response impact when turning voltage regulation on and off in a coordinated fashion. This coordinated operation would require usage and voltage interval readings from the customer AMI data. Other factors can potentially limit the CVR benefit:

- Substation devices are already at the lowest possible settings.
- Circuit does not have the required hardware.

The large variability in potential existing conditions and outcomes merits a more granular assessment if the required datasets are available.

APPENDIX A:
Disadvantaged Community and Low Income

California Low Income Home Energy Assistance Program (LIHEAP)

Program Description

The LIHEAP block grant is funded by the federal Department of Health and Human Services and provides two basic types of services (listed below). Eligible low-income persons, via local governmental and nonprofit organizations, can receive financial assistance to offset the costs of heating or cooling homes or have their homes weatherized to make them more energy-efficient. This financial assistance is accomplished through these program components:

- The weatherization program provides free services to improve the energy efficiency of homes, including attic insulation, weather stripping, minor housing repairs, and related energy conservation measures.
- The Energy Crisis Intervention Program (ECIP) provides payments for weather-related or energy-related emergencies.

Program Requirements

To qualify for this benefit program, applicants must be a resident of California and need financial assistance for home energy costs; they also must also have an annual household income (before taxes) that is below 60 percent of the state median income. Table A-1 compares the LIHEAP and CARE[196] qualifying income levels.

Table A-1: Comparisons of LIHEAP and CARE Qualifying Incomes

Household Size	LIHEAP: Maximum Annual Income Level	CARE: Household Income Eligibility Upper Limit
1	$26,049	$33,820
2	$34,064	$33,820
3	$42,079	$42,660

196 Before taxes based on current income sources. Valid through May 31, 2019.

Household Size	LIHEAP: Maximum Annual Income Level	CARE: Household Income Eligibility Upper Limit
4	$50,094	$51,500
5	$58,110	$60,340
6	$66,125	$69,180
7	$67,627	$78,020
8	$69,130	$86,860

Source: California Low Income Home Energy Assistance Program, https://www.benefits.gov/benefit/1540; California Alternate Rates for Energy, https://www.cpuc.ca.gov/General.aspx?id=976

CES Scoring Formula

CES scores combine four metrics—exposure, environmental effects, sensitive populations, and socioeconomic factors—to rank the pollution burden experienced by a given population (Equation A-1).

Equation A-1: CES Score

$$CES\ Score = \frac{(x + 0.5y)}{2} \times \frac{(a + b)}{2}$$

Where:

x = exposure

y = environmental effects

a = sensitive populations

b = socioeconomic factors

The CES score can also be the product of the average score of a population's exposure and weighted (by 50 percent) environmental factors, with the average score of sensitive population indicators and socioeconomic factors.

CARE Program Overview

The CARE program is a rate discount program authorized by CPUC decisions and supporting legislation that provides rate discounts in the range of 30 percent to 35 percent to qualifying low-income participant households on electricity bills and 20 percent on natural gas bills. The large IOUs and smaller multijurisdictional utilities in California are required to maintain CARE or similar programs to assist qualifying low-income residents. CARE is funded by nonparticipating utility customers through a public purpose program charge on ratepayer energy bills.

Although the CPUC itself does not manage the finances of the CARE program (since fees for electricity and natural gas services are collected directly by each participating utility), the agency does review and approve the budget applications, which are submitted every three years by the utilities. Staff also submits data requests, analyzes legislative proposals, reviews advice letter filings related to the program, and advises decision makers on policy and program implementation. The staff of the Energy Division—Residential Demand Programs Section is responsible for budgets, policies, and overall administration of the CARE program for the CPUC.[197]

Table A-2: Annual Estimates of CARE-Eligible Customers

County	Utility	Total Households	Demographic Eligibility Rate[198]	Eligible Households	Participating CARE Households	Estimated CARE Penetration Rate
Alameda	PG&E	565,730	23%	130,442	119,094	91%
Alpine	PG&E	566	48%	274	6	2%
Amador	PG&E	17,385	34%	5,961	4,247	71%
Butte	PG&E	95,096	43%	41,045	36,632	89%
Calaveras	PG&E	26,923	34%	9,218	5,138	56%
Colusa	PG&E	8,163	37%	2,982	3,343	112%
Contra Costa	PG&E	405,693	20%	81,321	84,984	105%
El Dorado	PG&E	64,776	22%	14,572	10,961	75%
Fresno	PG&E	314,365	44%	137,157	152,045	111%
Glenn	PG&E	10,844	49%	5,351	4,666	87%
Humboldt	PG&E	56,113	41%	22,823	17,616	77%
Kern	PG&E	225,588	41%	93,488	106,846	114%
Kings	PG&E	19,634	41%	7,959	9,171	115%
Lake	PG&E	32,644	48%	15,786	12,089	77%
Lassen	PG&E	598	48%	289	172	59%
Madera	PG&E	48,679	41%	19,984	21,893	110%
Marin	PG&E	104,516	19%	19,771	12,253	62%

197 California Public Utilities Commission, Internal Audit Unit California Alternate Rates for Energy (CARE) Program, November 2016.

198 Income at 200 percent of federal poverty guidelines.

County	Utility	Total Households	Demographic Eligibility Rate[198]	Eligible Households	Participating CARE Households	Estimated CARE Penetration Rate
Mariposa	PG&E	9,376	38%	3,536	2,196	62%
Mendocino	PG&E	36,245	41%	14,970	9,832	66%
Merced	PG&E	81,413	46%	37,815	40,397	107%
Monterey	PG&E	133,503	32%	42,568	42,540	100%
Napa	PG&E	53,245	23%	12,252	10,434	85%
Nevada	PG&E	37,771	31%	11,687	8,901	76%
Placer	PG&E	139,502	21%	29,004	20,096	69%
Plumas	PG&E	9,494	33%	3,179	1,756	55%
Sacramento	PG&E	441,722	31%	138,729	101,566	73%
San Benito	PG&E	18,502	28%	5,132	4,831	94%
San Bernardino	PG&E	803	46%	372	281	76%
San Francisco	PG&E	339,962	20%	67,859	62,044	91%
San Joaquin	PG&E	232,688	36%	82,835	88,546	107%
San Luis Obispo	PG&E	114,101	25%	28,678	17,963	63%
San Mateo	PG&E	266,474	17%	44,636	32,951	74%
Santa Barbara	PG&E	55,793	32%	17,751	17,522	99%
Santa Clara	PG&E	596,208	19%	111,180	100,063	90%
Santa Cruz	PG&E	94,982	28%	26,370	19,256	73%
Shasta	PG&E	64,687	39%	25,217	19,064	76%
Sierra	PG&E	919	28%	254	134	53%
Siskiyou	PG&E	36	49%	18	7	39%
Solano	PG&E	155,395	26%	40,057	42,356	106%
Sonoma	PG&E	195,541	22%	43,724	39,024	89%
Stanislaus	PG&E	154,833	37%	57,454	49,271	86%
Sutter	PG&E	33,497	40%	13,530	13,880	103%

County	Utility	Total Households	Demographic Eligibility Rate[198]	Eligible Households	Participating CARE Households	Estimated CARE Penetration Rate
Tehama	PG&E	26,967	45%	12,095	11,561	96%
Trinity	PG&E	1,139	47%	540	286	53%
Tulare	PG&E	15,429	56%	8,567	9,653	113%
Tuolumne	PG&E	29,944	35%	10,551	6,872	65%
Yolo	PG&E	76,358	33%	24,892	20,455	82%
Yuba	PG&E	26,391	44%	11,680	11,502	98%
Fresno	SCE	2,654	11%	302	40	13%
Imperial	SCE	409	50%	206	68	33%
Inyo	SCE	5,260	36%	1,893	1,064	56%
Kern	SCE	72,330	43%	31,162	23,124	74%
Kings	SCE	22,991	33%	7,652	9,090	119%
Los Angeles	SCE	1,777,845	33%	582,609	516,794	89%
Madera	SCE	7	41%	3	0	0%
Mono	SCE	12,135	19%	2,302	794	34%
Orange	SCE	858,019	23%	196,111	155,609	79%
Riverside	SCE	603,359	33%	198,782	172,746	87%
San Bernardino	SCE	654,025	38%	250,989	226,106	90%
San Diego	SCE	9	12%	1	1	94%
Santa Barbara	SCE	74,348	28%	20,684	9,442	46%
Tulare	SCE	129,992	46%	60,291	55,097	91%
Ventura	SCE	276,416	25%	69,237	52,551	76%
Fresno	SCG	22,138	50%	10,995	10,877	99%
Imperial	SCG	36,196	45%	16,320	15,201	93%
Kern	SCG	109,737	38%	41,321	38,272	93%
Kings	SCG	35,426	35%	12,520	13,863	111%
Los Angeles	SCG	2,705,312	35%	933,817	826,114	88%

County	Utility	Total Households	Demographic Eligibility Rate[198]	Eligible Households	Participating CARE Households	Estimated CARE Penetration Rate
Orange	SCG	900,979	21%	192,448	149,073	77%
Riverside	SCG	704,462	33%	235,320	204,424	87%
San Bernardino	SCG	471,177	36%	168,453	161,297	96%
San Luis Obispo	SCG	90,111	25%	22,122	14,278	65%
Santa Barbara	SCG	125,160	30%	37,155	26,678	72%
Tulare	SCG	121,759	47%	57,657	58,562	102%
Ventura	SCG	248,490	24%	59,948	45,487	76%
Orange	SDG&E	107,583	17%	18,048	10,509	58%
San Diego	SDG&E	1,122,186	27%	303,275	271,719	90%

Source: Compliance Filing of Pacific Gas and Electric Company (U 39-M), On Behalf of Itself, Southern California Gas Company (U 904-G), San Diego Gas and Electric Company (U 902-M), and California Edison Company (U 338-E), Regarding Annual Estimates of CARE Eligible Customers and Related Information. California Public Utilities Commission February 9, 2018.

CARE Population Estimates

CARE eligibility is defined at the household level. To translate this into population estimates, the analysis team multiplied CARE-eligible household estimates by an average household size of 2.9 persons.

Full Comparison of Key CES and ACS Metrics

Table A-3 provides a full comparison of the CalEnviroScreen (CES) and American Community Survey (ACS) socioeconomic factor indicators.

Table A-3: Full Comparison of Key CES and ACS Metrics

CES Metric	CES Definition	ACS Application to LI/DAC Analysis
M1 Educational Attainment	Percentage of the population over age 25 with less than a high school education (5-year estimate, 2011-2015).	From the 2011-2015 ACS estimates, a dataset containing the percentage of the population over age 25 with a high school education or higher was downloaded by census tracts for California. This percentage was subtracted from 100 to obtain the proportion of the population with less than a high school education.
M2 Housing Burdened Low-Income Households	Percentage of households in a census tract that are both low-income (making less than 80 percent of the HUD area median family income) and severely burdened by housing costs (paying greater than 50 percent of their income to housing costs). 5-year estimates, 2009-2013.	The team leveraged the 2009-2013 HUD Comprehensive Housing Affordability Strategy dataset containing cost burdens for households by percentage HUD-adjusted median family income (HAMFI) category by census tract for California. For each census tract, the analysis estimated the number of households with household incomes less than 80 percent of the county median and renter or homeowner costs that exceed 50 percent of household income. The team then calculated the percentage of the total households in each tract that are both low-income and housing-burdened.
M3 Linguistic Isolation	Percentage of limited English-speaking households.	From the 2011-2015 ACS, a dataset containing the percentage of limited English-speaking households was downloaded by census tracts for California. This variable is referred to as "linguistic isolation" and measures households where no one speaks English well.
M4 Poverty	Percentage of the population living below two times the federal poverty level (5-year estimate, 2011-2015).	From the 2011-2015 ACS, a dataset containing the number of individuals below 200 percent of the federal poverty level was downloaded by census tracts for California.

CES Metric	CES Definition	ACS Application to LI/DAC Analysis
M5 Unemployment	Percentage of the population over the age of 16 that is unemployed and eligible for the labor force. Excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty (5-year estimate, 2011-2015).	From the 2011-2015 ACS, a dataset containing the unemployment rate[199] was downloaded by census tracts for California.

Source: CES indicators, https://oehha.ca.gov/calenviroscreen/indicators; ACS data, https://data.census.gov/cedsci/?#

199 Unemployment is defined by the Bureau of Labor Statistics as people who do not have a job, have actively looked for work in the past four weeks, and are currently available for work.

APPENDIX B: PACE Program Senate Bill Excerpt

Below is the excerpt from SB 242 Chapter 29.1, Part 3, Division 7, Streets and Highways Code § 5954,[200] which outlines future data collection provisions.

(a) For each PACE program that it administers, a program administrator shall submit a report to the public agency no later than February 1 for the activity that occurred between July 1st through December 31st of the previous year, and another report no later than August 1 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:

> (1) The number of PACE assessments funded, by city, county, and ZIP Code.
>
> (2) The aggregate dollar amount of PACE assessments funded, by city, county, and ZIP Code.
>
> (3) The average dollar amount of PACE assessments funded, by city, county, and ZIP Code.
>
> (4) 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.
>
> (5) The definition of default used by the program administrator.
>
> (6) For each delinquent assessment:
>
> > (A) The total delinquent amount.
> >
> > (B) The number and dates of missed payments.
> >
> > (C) ZIP Code, city, and county in which the underlying property is located.
>
> (7) For each defaulted assessment:
>
> > (A) The total defaulted amount.
> >
> > (B) The number and dates of missed payments.

200 Senator Skinner. February 6, 2017. SB242 Property Assessed Clean Energy Program. California Legislative Information.

(C) ZIP Code, city, and county in which the underlying property is located.

(D) The percentage the defaults represent of the total assessments within each ZIP Code.

(E) The total number of parcels defaulted and the number of years in default for each property.

(8) 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.

(9) 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.

(10) 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 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.

(11) The estimated amount of greenhouse gas emissions reductions.

(12) The estimated number of jobs created.

(13) The average and median amount of annual and total PACE assessments based on ZIP Code, by city, county, and ZIP Code.

(14) The number and percentage of homeowners over 60 years old by city, county, and ZIP Code.

(b) All reports submitted pursuant to this section shall include only aggregate data, and shall not include any nonpublic personal information.

(c) A public agency that receives a report pursuant to this section shall make the data publicly available on its Internet Web site.

(d) This section does not limit another governmental or regulatory entity from establishing reporting requirements.

APPENDIX C: Glossary

AAEE	Additional achievable energy efficiency - an accounting for future potential installed energy efficiency savings, in the California energy demand forecast.
ACS	American Community Survey
AMI	Advanced metering infrastructure - AMI is a system that integrates smart meters, communication networks, and data management systems allowing for two-way communication between utilities and customers. AMI also enables collecting consumption data at the sub-hourly level.
APCD	Air Pollution Control District
AQMD	Air Quality Management District
ARRA	American Recovery and Reinvestment Act - was a 2009 economic stimulus package including funding for the energy sector.
BEIMS	Building energy management and information systems - BEIMS are monitoring and control systems that provide information on the performance of some or all energy using equipment in a building. The BEIMS software allows for changing energy consumption and operation of equipment based on the data collected.
Benefit-cost ratio	Most of the utility programs are measured by a benefit-cost ratio. The benefits are typically energy savings and the costs can be the measure installation costs and program administrator costs.
BERs	Business energy reports - BERs are the commercial sector equivalent to home energy reports. Business receive reports about their energy use including comparisons to similar businesses, tips to reduce energy use and messaging about rewards or incentives.
BOC	Building operator certification - is an energy efficiency training and certification offering to commercial building operators.
BROs	Behavioral, retrocommissioning, and operations measures

BTO	
CAEFTA	California Alternative Energy and Advanced Transportation Financing Authority
CalEnviroScreen (CES)	CalEnviroScreen helps identify California communities that are affected by pollution; uses environmental, health, and socioeconomic information to produce scores for every census tract in the state; and maps scores to identify impacted communities.
CalEPA	California Environmental Protection Agency
CalGreen	California Green Building Standards Code
CARB	California Air Resources Board
CARE	CARE program offers a monthly discount of 20% or more on gas and electricity. Participants qualify through income guidelines or if enrolled in certain public assistance programs.
CBECS	Commercial Buildings Energy Consumption Survey
CCC	California community colleges
CEDARS	California Energy Data and Reporting System
CEQA	California Environmental Quality Act
CEUS	Commercial end-use survey
CPUC	California Public Utilities Commission
CVR	Conservation voltage reduction
DGS	Department of General Services
DOE	U.S. Department of Energy
DWR	Department of Water Resources
ECAA	Energy Conservation Assistance Act
EEStats	California Energy Efficiency Statistics
EM&V	Evaluation, measurement, and verification
End user	Consumers of utility electricity or natural gas
ESA	Energy Savings Assistance program
EUI	Energy use intensity - EUI refers to the energy use intensity at the building or end use level, typically

	expressed as an energy unit per household for residential and per square feet for non-residential.
EUL	Effective useful life
GGRF	Greenhouse gas reduction fund
GHG	Greenhouse gas
GWh	Gigawatt hours (1,000,000 kWh) - unit of electricity use
HER	Home energy reports are the most prevalent behavioral intervention program. Utilities mail reports to residential customers that provide feedback about their home's energy use, including comparison to similar neighbors, tips to improve energy efficiency, and messaging on rewards and incentives.
HERS	Home energy rating system
HVAC	Heating, ventilation, and air conditioning
IEPR	Integrated Energy Policy Report
IoT	Internet of Things is the two-way interconnection between devices and internet-based services.
IOU	Investor-owned utility
kWh	kilowatt hours - unit of electricity use
LADWP	Los Angeles Department of Water and Power
LEAs	Local educational agencies
LGC	Local Government Challenge
LIHEAP	Low Income Home Energy Assistance Program
LIRA	Leading Indicator of Remodeling Activity
LIW	Low income weatherization
NOMAD	naturally occurring market adoption
NTG	Net-to-gross - NTG is the ratio of the changes in energy use directly attributable to the program intervention to the changes in energy consumption calculated by the program activities. The NTG ratio is calculated as one minus the percentage of percent savings from free riders plus the percent savings from spillover (additional energy savings due to program influences beyond the program participants).

PACE	Property Assessed Clean Energy
PG	Potential and goals
PG&E	Pacific Gas and Electric
POU	Publicly owned utility
PRC	Public Resources Code
RASS	Residential Appliance Saturation Survey
SCE	Southern California Edison
SDG&E	Sand Diego Gas & Electric
SEM	Strategic energy management - is a long-term, continuous improvement process that educates and trains energy users to develop and execute on energy goal setting and integrating energy management into business practices.
SMUD	Sacramento Municipal Utility District
SoCalGas	Southern California Gas
TDV	Time-dependent valuation - is a metric to incorporate non-energy impacts into the cost of energy during a given hour of the year. The resulting TDV aligns energy savings for the end users with the cost of producing to produce and delivering energy to consumers.
therms	Unit of heat used to measure gas consumption
WEG	Water-Energy grant