Opinion Dynamics

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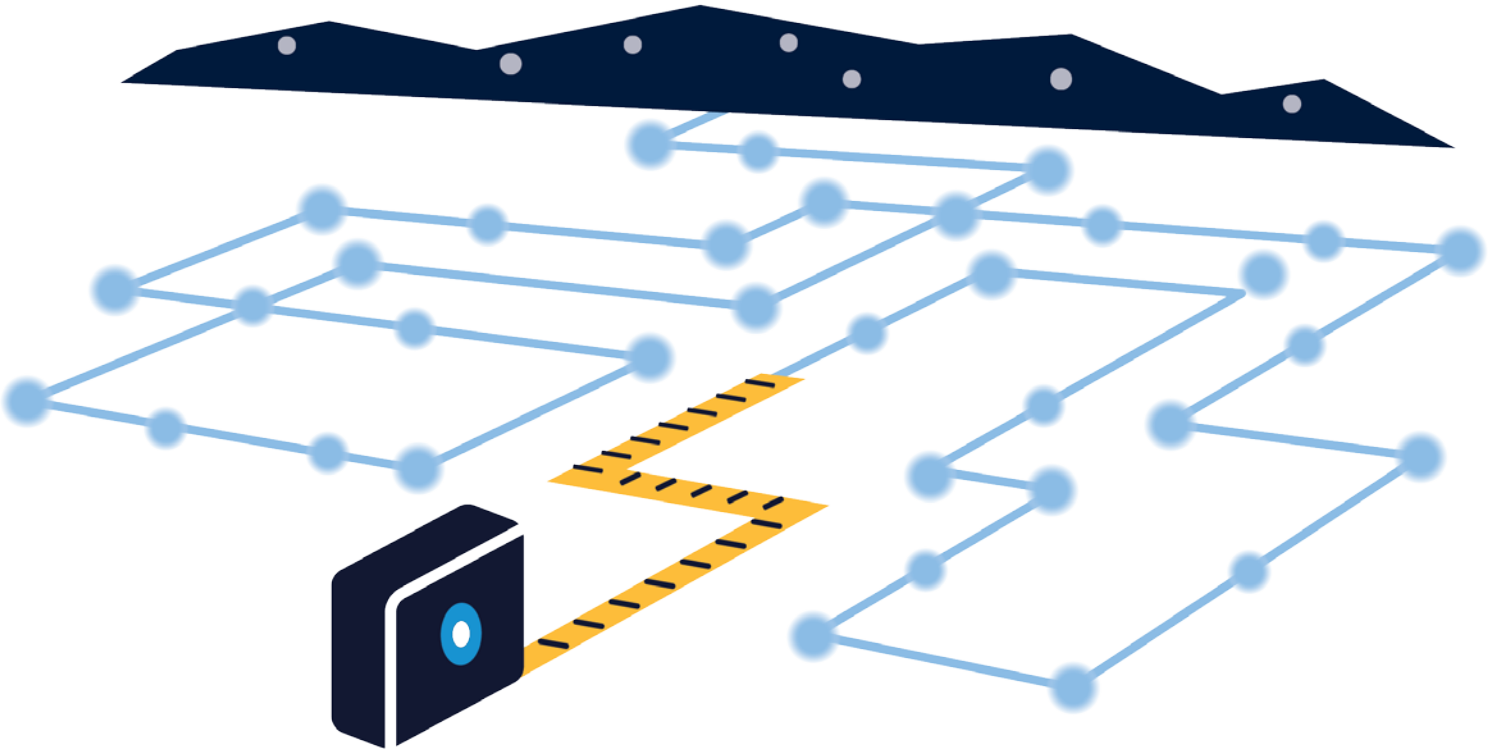
Market Logics

# PY 2016-2018 BUILDING CODES ADVOCACY PROGRAM EVALUATION

## VOLUME II – FINAL REPORT



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This project was a collaborative effort under contract to the CPUC. We would like to thank the Commission Staff for guidance and input throughout project planning and execution. In addition, we want to thank the building permit departments throughout CA that contributed time and effort into retrieving building plans and reports. Frequently these reports were not digitized and needed to be pulled from archives. The full list of building departments is provided in Section 3.2.1, Table 11. Finally, we would like to thank the Codes and Standards advocacy staff and consultants of the investor-owned utilities, the CPUC DEER support team, California Energy Commission staff, and CPUC energy division staff who took the time to support this study by participating in panels, responding to surveys, reviewing report sections, providing ancillary data, and providing insight into the world of building code standard development and implementation.

## Legal Notice

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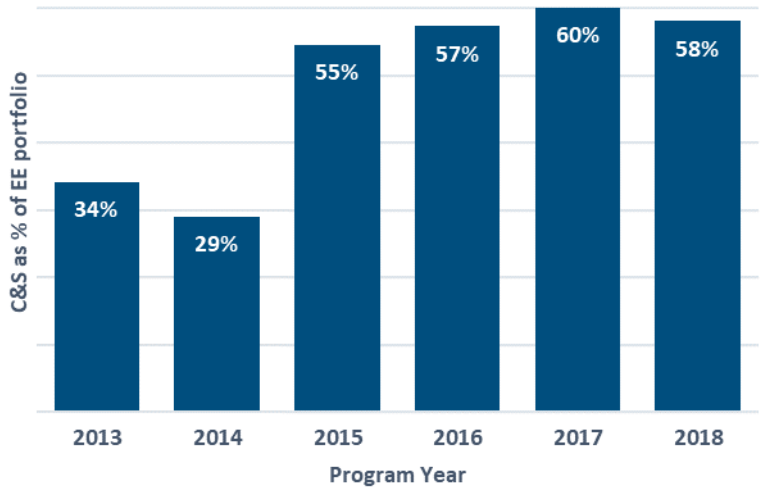
# 1. Executive Summary

This report describes the evaluation of the electric and gas savings reported by the Investor-Owned Utility (IOU) statewide Codes and Standards (C&S) Building Code Advocacy Program for program years 2016, 2017, and 2018. It is volume two of a two-volume report. Volume one focuses on California state and Federal appliance and equipment (product) minimum energy efficiency levels (standards). This volume (Volume two) focuses on California minimum energy efficiency levels for building performance (state building codes). The statewide program administrator for this program is Pacific Gas and Electric (PG&E). The four California IOUs jointly implement the overall program. In addition to PG&E, the other IOUs include Southern California Edison (SCE), Southern California Gas (SCG)[1], and San Diego Gas and Electric (SDG&E).

The two codes and standards advocacy programs (building codes advocacy and appliance standards) have been contributing to an increasing percentage of the overall IOU energy efficiency portfolio savings. The electric savings percentage contribution of reported C&S to the entire energy efficiency portfolio over the last few years is illustrated in Figure 1.

Figure 1: C&S Contribution of IOU Claim Portfolio kWh Savings



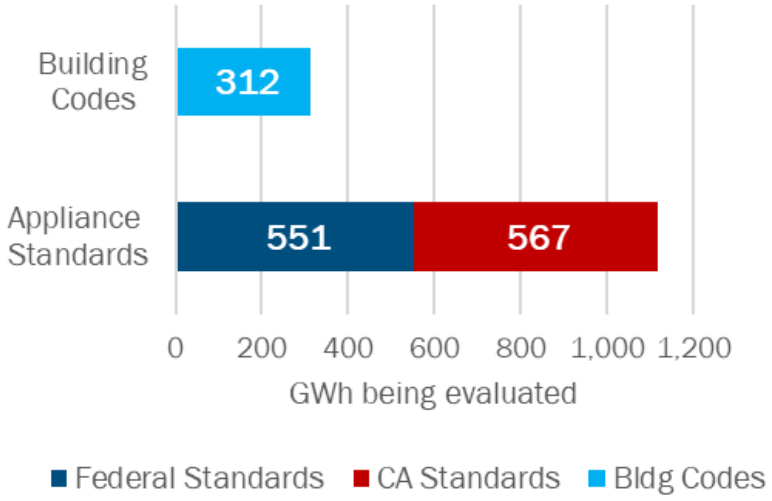

*Source data*: CEDARS summary_report_ by "Program Category" (a.k.a., claimed net savings)

For all new codes and standards savings, the IOUs claimed during the three-year period 2016–2018, new product standards accounted for 78% of electric savings (551+567=1,118 GWh). New building codes contributed 312 GWh (less than a quarter of the total at 22%). These savings are illustrated in Figure 2. The codes were approved in 2016 but did not become effective until January 1, 2017. As a result, in 2016, no

[1] SCG is no longer involved in advocacy activities. Pursuant to Decision (D.) 22-03-010, Southern California Gas is prohibited from engaging in building code and appliance standard advocacy until the Commission. According to Order 10 of the Decision, The prohibition ordered in this decision shall remain in effect until the Commission lifts such prohibition, or until the Commission finds that Southern California Gas Company has sufficient and appropriate policies, practices, and procedures to ensure adherence to Commission intent for codes and standards advocacy. February 3, 2022, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M469/K615/469615267.PDF

savings were claimed from new codes. In 2017, the IOUs claimed 103 GWh savings from new codes and in 2018 they claimed 209 GWh savings.

Figure 2: IOU Claim Savings for New Codes and Standards Savings (2016–2018)




*Source*: CEDARS

The total savings from building codes advocacy is primarily driven by two components: (1) the stringency of code changes and (2) the level of building activity. For example, even with more stringent codes, lower building activity will produce lower total savings.

## 1.1 Study Purpose

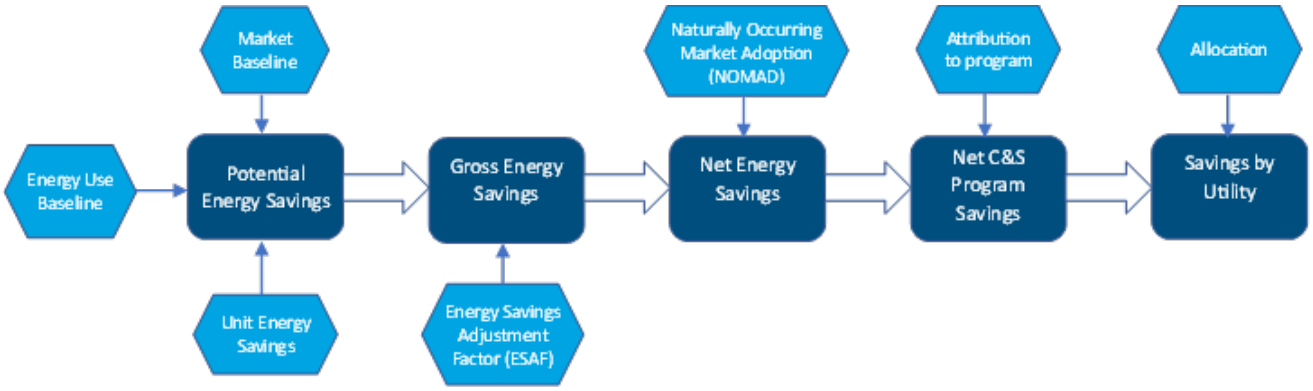
The purpose of this evaluation is to validate the electric and gas savings claim by the California IOUs for their code advocacy subprogram for the years 2016, 2017, and 2018. These savings are used to calculate program cost-effectiveness and as inputs for future planning and goal setting at the statewide level. The evaluation includes the 2016 codes with effective dates of January 1, 2017. The emphasis is on single-family residential new construction and alterations and nonresidential new construction and lighting alterations.

## 1.2 Method

The C&S evaluation protocols differ from the evaluation protocols for resource programs.[2] To develop the savings estimates for C&S we used a mixed methods approach. Specifically, we conducted interviews and surveys with subject matter experts, on-site visits to a sample of residential and nonresidential buildings, and engineering simulation modeling. Findings from these activities were then combined in the Integrated Standards Savings Model (ISSM). The ISSM is the database and calculation engine that calculates results for each step of the evaluation. The steps and associated inputs and outputs are illustrated in Figure 4.

[2] Hall, Nick, John Roth, and Carmen Best. 2006. "California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals."

Figure 3: Codes and Standards Evaluation Components and Steps (ISSM)




Potential energy savings are estimated by comparing the annual energy use of various building prototypes under two building codes. The baseline is energy use under the 2013 Title 24 code. The difference between the baseline and energy use under the 2016 Title 24 code represents savings per unit.

Estimating compliance is the most involved step because it requires identifying, recruiting, and conducting site visits to a sample of buildings where no program database exists. Residential site visits focused on single family homes. The nonresidential focus was on office, retail, restaurant, and education buildings, but included other building types as available. The site visit verified the presence of mandatory equipment such as lighting controls and matched equipment types and quantities to the building plans and/or Building Energy Analysis Reports.[3] These energy reports assess the building design relative to the current energy code (2016 Title 24 for this evaluation). The site-visits are not comprehensive compliance audits and are referred to throughout this report as Energy Savings Adjustment Factors (ESAF). For example, we verify that the equipment specified in the Title 24 Certificate of Compliance (form PRF-01-E[4]) is installed. For example, the evaluation is not on-site during construction and does not disassemble walls or floors to verify the level of insulation. We check only to verify that insulation was installed.

We also estimated the naturally occurring market adoption (NOMAD) of energy savings (via common design practices and equipment types used) by iteratively surveying recognized experts (Delphi approach). Simultaneously we estimated the level of IOU influence on the code setting process through an in-person panel of experts familiar with the California state building code development process. This is referred to as an attribution score.

The ISSM outputs from these input parameters are the savings results reported in the next section of this summary and in Section 3 of this evaluation report.

## 1.3 Findings

In 2018, the IOUs filed claims in California Energy Data and Reporting System (CEDARS) for 119 individual building codes. This evaluation is limited to the eleven new codes that resulted from the 2016 Title 24

[3] A "Building Energy Analysis Report" (also known as "Certificate of Compliance") is a set of calculations that replicates the requirements of the California Energy Commission's Building Energy Efficiency Standards (Title 24, Parts 6 and 11). This is performed with simulation software approved by the Commission.
[4] https://energycodeace.com/ResidentialForms/2016 and https://energycodeace.com/NonresidentialForms/2016

changes.[5] Of these eleven codes, four accounted for 86% of the new code savings and the remaining seven accounted for 14%.

- Potential savings (the theoretical maximum) accounted for the biggest difference from evaluation to claim. For 2018 residential single-family new construction, we verified estimated savings per unit (kWh, kW, and therms), but we found a much lower level of construction activity than the IOUs' forecast. These reductions were 50% for residential new construction and 46% for nonresidential new construction.
- The 2018 nonresidential new construction evaluation found only 54% of the IOU-claimed kWh savings and 39% of the gas savings claimed. Any summary statistics for gas savings should be considered with caution. A minor change for gas can represent a significant percentage change because the MMTherm values are typically smaller numbers overall.
- We found ESAF to be at or near 100% for both sectors (residential and nonresidential) and both types of construction (alterations and new building). We discuss these in more detail in Section 4.3.

We provide a summary of the annual savings for these eleven building code claims in Table 1. We show the savings for the combined program years in Table 2.

Table 1: Savings (IOU Claim vs. Evaluated for 11 codes)

| IOU after allocation of evaluated savings | GWh | | | MW | | | MMTherm | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 |
| PG&E | - | 47.8 | 50.5 | - | 21.0 | 22.9 | - | 1.6 | 1.7 |
| SCE | - | 47.9 | 51.2 | - | 21.1 | 23.2 | - | - | - |
| SCG | - | - | - | - | - | - | - | 2.5 | 2.6 |
| SDG&E | - | 9.8 | 10.4 | - | 4.3 | 4.7 | - | 0.2 | 0.2 |
| **Evaluated savings** | **-** | **105.4** | **112.1** | **-** | **46.4** | **50.7** | **-** | **4.3** | **4.5** |
| IOU Claim savings | - | 103.0 | 208.5 | - | 42.7 | 97.6 | - | 5.8 | 11.6 |
| Difference # Evaluated vs. Claim | - | 2.4 | (96.4) | - | 3.7 | (46.9) | - | (1.5) | (7.1) |
| Difference % Evaluated vs. Claim | - | 2.3% | -46.2% | - | 8.7% | -48.0% | - | -26.5% | -61.4% |

Table 2: Cumulative Savings for 11 Codes (2016 + 2017 + 2018)

| Cumulative | GWh | MW | MMTherm |
|---|---|---|---|
| Claim by IOUs | 311.5 | 140.3 | 17.4 |
| Evaluated | 217.5 | 97.2 | 8.8 |
| Savings Difference | (94.0) | (43.2) | (8.7) |
| Eval as % of Claim | -30% | -31% | -50% |

A waterfall chart illustrates the adjustments at each step in the ISSM. Starting with Potential and ending with Evaluated Net Savings, the chart shows the reductions from each ISSM step. The bars in Figure 5 illustrate the adjustments to electricity in millions of Watt hours (GWh) for the combined 2017 and 2018 Program Years. The following chart (Figure 6) presents the same information for gas in millions of therms (MMTherm) for the same Program Years.

[5] Codes from prior program years were the subject of earlier evaluations.

Figure 4: Waterfall Chart 11 Codes (2017 2018 GWh)

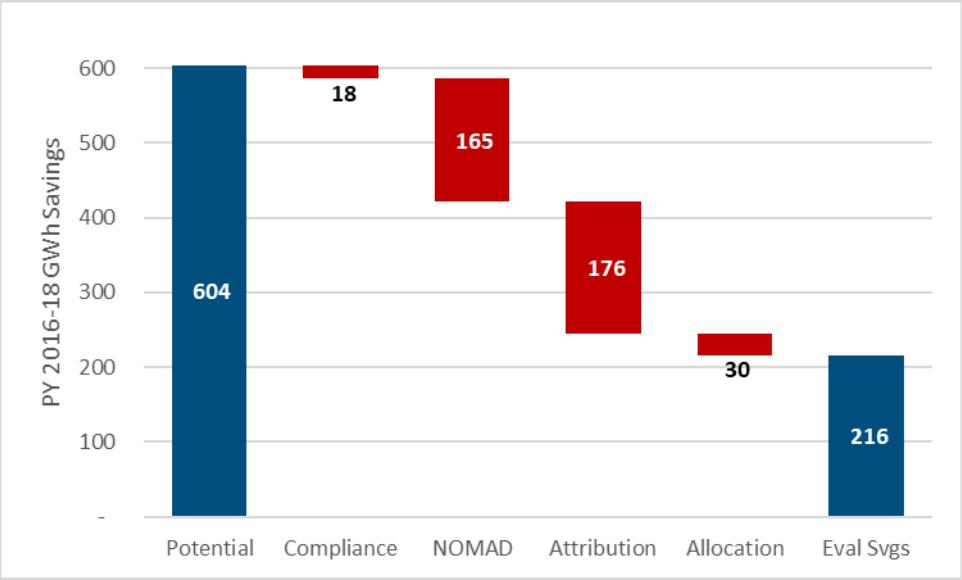
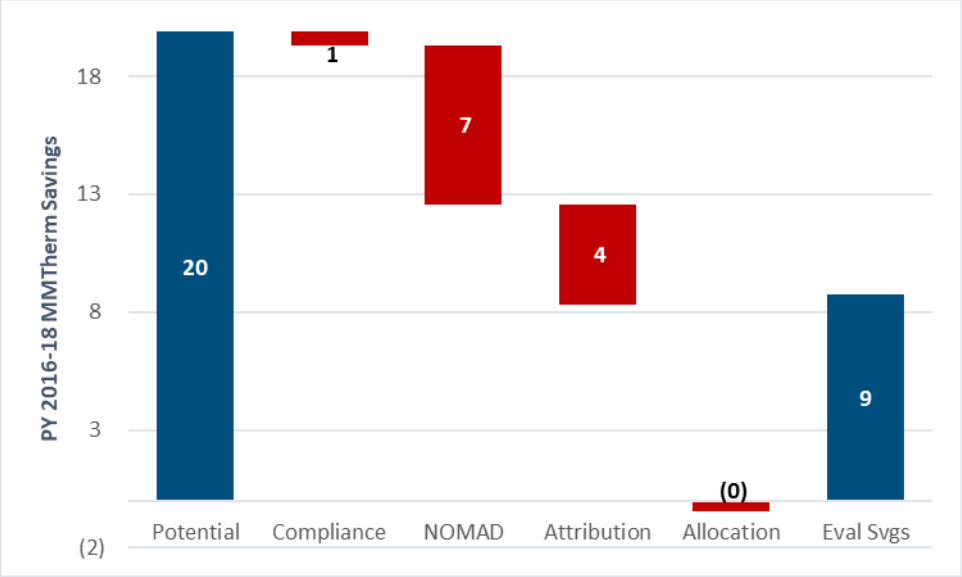



Figure 5: Waterfall Chart 11 Codes (2017-2018 MMTherm)




As shown in Figure 5 and Figure 6, the reduction due to NOMAD was a key driver between potential and evaluated net savings for both fuels. This and other key drivers of the difference between potential and evaluated net savings are discussed in the next section.

## 1.4 Conclusions and Recommendations

The conclusions and recommendations in this report reflect our experiences with the IOU CEDARS savings claims and supporting documents, publicly available data, interactions with building permit jurisdictions, and physical visits to residential and nonresidential sites across the state. In addition, we provide recommendations based on our involvement with the C&S evaluation process in general.

### 1.4.1 For the IOUs

We have provided three recommendations for the IOU C&S team, but the biggest recommendation we have is for the teams putting together the documentation for the Codes Advocacy program.

- **Conclusion1:** Documentation for ISSM parameters can be inconsistent from CASE reports to CEDARS claims.
  - **Recommendation1: Provide all ISSM parameter data with claims.** This recommendation was proposed (and agreed to) during the standards advocacy evaluation (Volume I). It is included here as a reminder that transparency of these data and their underlying assumptions supports continuous improvement for evaluation and forecasting.
- **Conclusion 2:** We found documentation, especially for nonresidential whole building savings, to be convoluted and in some instances contradictory with other IOU-produced documentation.
  - **Recommendation 2: Provide a step-by-step analysis** to present a clearer mapping of whole building assumptions and savings. Typically, there is confusion among evaluators, regulators, and other data users about how whole building savings are derived. To address this, we recommend including interim steps with savings per square foot by climate zone and building type in documentation. This will streamline the evaluation process and provide value to other data users.
- **Conclusion 3: Economic conditions seem to be changing more frequently than in the past**. Forecasts of housing units or commercial square feet are produced and updated frequently as well. There are two main options for source data on housing units in California depending on the use case:
  - **Recommendation 3a:** For consistency across programs and studies, we recommend the **continued use of California Energy Commission Demand Analysis Office forecasts** on building stock and additions for residential housing units and additional square footage for nonresidential buildings. As each dataset has pros and cons; however, we recommend the data set used should be explicitly stated, along with an explanation of why it reflects the most expected outcome.
  - **Recommendation 3b:** Consider using **number of dwelling units when forecasting multifamily** savings rather than total square feet. Using number of dwelling units is more relatable than square feet and aids in understanding of housing trends for policy makers and other stakeholders.

### 1.4.2 For the CPUC

Given the level of effort and time needed to develop a sample and collect data, we have three recommendations.

- **Conclusion 1: Codes cycles are not equal** in terms of new codes (or standards) approved, impact on industry, and energy savings generated. Some cycles include aggressive changes, other cycles may only be comprised of minor updates due to focus on other related issues or to allow the industry to

"catch-up." Consequently, each evaluation will not produce the same value in terms of supporting the State's goal of reducing greenhouse gas emissions.

- **Recommendation 1a: Review the changes** to codes or standards before initiating an evaluation of the C&S advocacy programs. Do the potential savings warrant a full impact evaluation?
- **Recommendation 1b:** Consider **individual studies for individual sectors or building types**. For example, a study can focus on a certain sector and building type. Going forward we recommend a focus on multifamily dwellings. Multifamily dwellings are becoming the more common type of residential new construction structure in California. Highrise and larger low- to mid-rise developments promise to become even more common as available land decreases and urban infill becomes more necessary to stay coordinated with the State's climate goals.

- **Conclusion 2:** The C&S advocacy evaluation is really **four separate studies** that each require different skill sets and a broad set of third-party participants (experts from various industries and property owners/operators). These four studies include macro-economic research and engineering simulation modeling (Potential savings), plan review and field studies (ESAF), market research (NOMAD) and process evaluation (Attribution).
  - **Recommendation 2**: After reviewing IOU savings and assumptions for a given Title 24 code cycle, we recommend deciding which study or studies to commission. The IOUs are scheduled to provide all ISSM parameters along with their annual claim filings. These parameters, along with an analysis of the new building code, can be the basis for determining the study or studies to commission.
- **Conclusion 3:** The most time-consuming and costly task for this C&S evaluation was identifying and recruiting participant buildings, particularly residential homes. The COVID-19 pandemic restrictions and Building owners, facility managers, and homeowners working remotely, in some instances outside the city or even state, were two of the highest hurdles we encountered to access buildings. Even with a $100 incentive, homeowners were understandably reluctant to let anyone into their home. Additionally, building departments were closed or working at minimal staffing levels for nearly two years. We found, in most cases, that digitized plans were rare before 2018. Due to this, many jurisdictions stored plans offsite, and these older plans could only be accessed physically. Even then, legal issues of confidentiality and State agency access had to be dealt with on an individual basis, jurisdiction by jurisdiction.
  - **Recommendation 3**: Going forward, consider an alternate evaluation approach that does not rely heavily on access to homes and businesses. For example, the results from single-family residential evaluations have been consistent over time. ESAF rates for residential properties hover at or near 100%. Residential savings also account for less than a quarter (21%) of C&S portfolio savings from new codes. As a result, under most code cycles, visiting homes is unlikely to be worth the time and monetary investment. Where plans with Title 24 compliance documents can be accessed, they could be reviewed for energy budgets and types of equipment. In addition, homes could be accessed virtually to review basic equipment (e.g., lighting and cooking) by using real estate websites or other public data websites.

# 2. Introduction and Overview

This report describes the impact evaluation of the statewide C&S Programs jointly implemented by the four California IOUs. The statewide program administrator is PG&E, in addition to administrators SCE, SCG[6], and SDG&E. The overall C&S portfolio is made up of five subprograms: Building Codes Advocacy, Appliance Standards Advocacy, Compliance Improvement, Reach Codes, and Planning and Coordination.

This report (Volume 2) focuses specifically on Building Codes Advocacy. This subprogram focuses on supporting and influencing California Building Energy Efficiency Standards – Title 24. An earlier report (Volume 1) evaluated California Appliance Efficiency Regulations (Title 20) and Federal appliance standards.

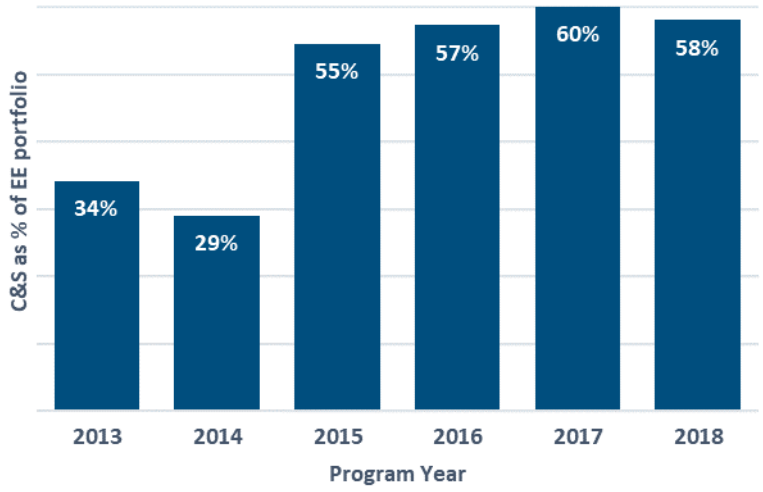
The specific program codes in the California Energy Data and Reporting System (CEDARS) for the evaluated programs are listed in Table 3.

Table 3: IOU Programs Evaluated

| Subprogram Name | PG&E | SCE | SCG | SDG&E |
|---|---|---|---|---|
| Building Codes Advocacy – Title 24 | PGE21051 | SCE-13-SW-008A | SCG3724 | SDGE3249 |

During the evaluation period, the two C&S subprograms (building and appliance standards) accounted for more than 50% of claimed portfolio gross kWh savings (Figure 7).

Figure 6: Advocacy Subprogram Contribution to IOU C&S Portfolio Savings Claim




[6] SCG is no longer involved in advocacy activities. Pursuant to Decision (D.) 22-03-010, Southern California Gas is prohibited from engaging in building code and appliance standard advocacy until the Commission. According to Order 10 of the Decision, The prohibition ordered in this decision shall remain in effect until the Commission lifts such prohibition, or until the Commission finds that Southern California Gas Company has sufficient and appropriate policies, practices, and procedures to ensure adherence to Commission intent for codes and standards advocacy. February 3, 2022, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M469/K615/469615267.PDF

For the new C&S GWh savings claimed for the 2016–2018 period, new construction and alteration codes accounted for 24%. State and Federal appliance standards combined contributed just over three-fourths of savings at 76%. The percentage of savings contribution from each claim category is provided in Table 4.

Table 4: Savings Contribution by Claim Category

| Category | 2016–2018 | | |
|---|---|---|---|
| | GWh | MW | MMTherm |
| Title 24 Nonresidential Alterations | 7% | 7% | −1% |
| Title 24 Nonresidential New Construction | 5% | 13% | 0% |
| Title 24 Residential Single-Family Alterations | 6% | 12% | 21% |
| Title 24 Residential Single-Family New Construction | 3% | 6% | 10% |
| Title 24 Residential Multifamily New Construction | 1% | 1% | 4% |
| Title 24 Residential Multifamily Alterations | 1% | 0% | 2% |
| Title 24 Other Codes | 2% | 5% | 1% |
| Title 20 Appliance | 42% | 27% | 63% |
| Federal Appliance | 34% | 30% | 1% |
| **Total** | **100%** | **100%** | **100%** |

## 2.1 Study Purpose

The purpose of this evaluation (Group B, Deliverable 13) is to confirm the electric and gas savings claimed by the IOUs for the resulting 2016 Title 24 building code. Even though the 2016 code became effective January 1, 2017,[7] the IOUs claimed savings for program years 2016, 2017, and 2018. The savings in 2016 are a continuation of savings from earlier code claims.

In this report, we have prioritized activities based on the size of savings associated with each code and the uncertainty of the values used to compute savings. In short, we evaluated all of the codes but prioritized activities such as savings, ESAF, NOMAD, and attribution for the codes that contributed the most to total savings for new codes.

## 2.2 Background

In 1974, the State of California established the California Energy Commission. One of its main roles is to, "…promote all feasible means of energy and water conservation and all feasible uses of alternative energy and water supply sources…"[8] One way the Commission achieves its mission is through the adoption of building and appliance efficiency standards. The standards for buildings and appliances are in the California Administrative Code.[9] These standards are often referenced using their location in the code: Title 24 for building energy standards and Title 20 for appliance standards.

The California Building Code requires a permit for "Any owner or authorized agent who intends to construct, enlarge, alter, repair, move, demolish or change the occupancy of a building or structure, or to erect, install, enlarge, alter, repair, remove, convert or replace any electrical, gas, mechanical or plumbing system, the

[7] Building Codes were approved in June 2016 but did not become effective until January 1, 2017.
[8] California Energy Commission Strategic Plan, June 2014, p 2
[9] In general, we refer to standards that are adopted to regulate building energy efficiency as "codes" and standards that apply to appliances and equipment as "standards."

installation of which is regulated by this code, or to cause any such work to be done, shall first make application to the building official and obtain the required permit."

Starting in the late 1990s, California utilities became more involved in researching, proposing, and promoting efficiency standards through what has become the statewide utility C&S program. The IOUs are currently involved in the State's building codes and appliance standards setting in several ways, including:

- Advocating for codes and standards that position California to meet its ambitious energy savings and greenhouse gas emissions reductions goals.
- Providing technical research to the California Energy Commission as inputs into state-level decisions on code adoption.
- Supporting compliance improvement efforts at the municipal level through workforce education and code-readiness activities such as supporting local "reach" codes.

According to the Statewide Codes and Standards Program Implementation Plan,[10] the mission of the program is as follows:

"The Codes and Standards (C&S) program saves energy on behalf of ratepayers by influencing continuous improvements in energy efficiency regulations, improving compliance with existing codes and standards, and working with local governments to develop ordinances that exceed statewide minimum requirements. Both the C&S program advocacy and compliance improvement activities extend to all buildings and potentially any appliance in California." According to the programs, this includes influencing continuous improvements in energy efficiency regulations, improving compliance with existing codes and standards, and working with local governments to develop ordinances that exceed statewide minimum requirements."

The principal audience for these services is the California Energy Commission, which conducts new code rulemaking – typically every three years. C&S also seeks to influence the United States Department of Energy (DOE) in setting national energy policy that affects California.

The IOUs claim energy and gas savings for these services along with reductions in electric peak demand and greenhouse gas emissions. These savings, and the IOU level of influence in the standard-setting process, are the primary focus of this evaluation.

For example, in 2018 the IOUs claimed gross savings of 1,940 GWh from 167 codes and standards. Of these, only 45 codes and standards became effective during the evaluation period between 2016 and 2018 (11 building codes, 21 State appliance standards, and 13 Federal appliance standards). The IOU savings claims for codes and standards groups are shown in Table 5. The 11 codes and 34 standards account for 51% (993 GWh) of the claimed 2018 savings, but only the 11 codes are the focus of this evaluation.

[10] The Program Implementation Plan (PIP) for the statewide program can be found on the following webpage: http://eestats.cpuc.ca.gov/Views/Documents.aspx?ReportType=PIP

Table 5: Statewide Total Gross Electric Energy Savings Claim by the IOUs

| Category | 2016 | | | 2017 | | | 2018 | | |
|---|---|---|---|---|---|---|---|---|---|
| | GWh | MW | MMTherm | GWh | MW | MMTherm | GWh | MW | MMTherm |
| Title 24 NRA | 0 | 0 | 0 | 51 | 17 | 0 | 68 | 22 | 0 |
| Title 24 NRNC | 0 | 0 | 0 | 9 | 6 | 0 | 62 | 38 | 0 |
| Title 24 RA | 0 | 0 | 0 | 17 | 8 | 2 | 28 | 13 | 4 |
| Title 24 RNC | 0 | 0 | 0 | 26 | 12 | 3 | 64 | 30 | 8 |
| Title 20 Appliance | 29 | 3 | 14 | 95 | 6 | 24 | 534 | 84 | 19 |
| Federal Appliance | 107 | 22 | 0 | 222 | 42 | 0 | 236 | 58 | 1 |
| **Total** | **136** | **25** | **13** | **419** | **91** | **30** | **993** | **246** | **32** |

*Note*: 2016 is the year new building codes were approved. January 2017 is when they became effective; NRA = nonresidential alterations, NRNC = nonresidential new construction, RA = residential alterations, RNC = residential new construction.

A listing of these codes included in this evaluation is provided in Appendix A.

# 3. Evaluation Approach

This section presents an overview of key issues and details in the work plan for the building codes and compliance impact evaluation. The evaluation estimates **gross and net electricity and gas savings for buildings built under the 2016 Title 24 building codes**. The emphasis is on single-family residential new construction and alterations and nonresidential new construction and lighting alterations. The residential multifamily segment is not included in this evaluation.

Since building codes affect the entire state by default, the first step is understanding the market size. This is **market potential savings**. These savings are estimated by multiplying the savings per unit times the number of units built. A unit may be a dwelling, as is the case for residential, or square footage in the case of nonresidential. All units built may not meet the new code. Therefore, to develop gross savings, potential savings is adjusted by the estimated ESAF when comparing the "as planned" and "as built" buildings.

Since the codes cover nearly all new construction and alterations, everyone is technically a participant. As such, the traditional approach of moving from gross savings to net savings by identifying free riders does not apply. To compensate for this, the C&S evaluation substitutes two other measures: **Naturally Occurring Market Adoption (NOMAD)** and **Attribution**.

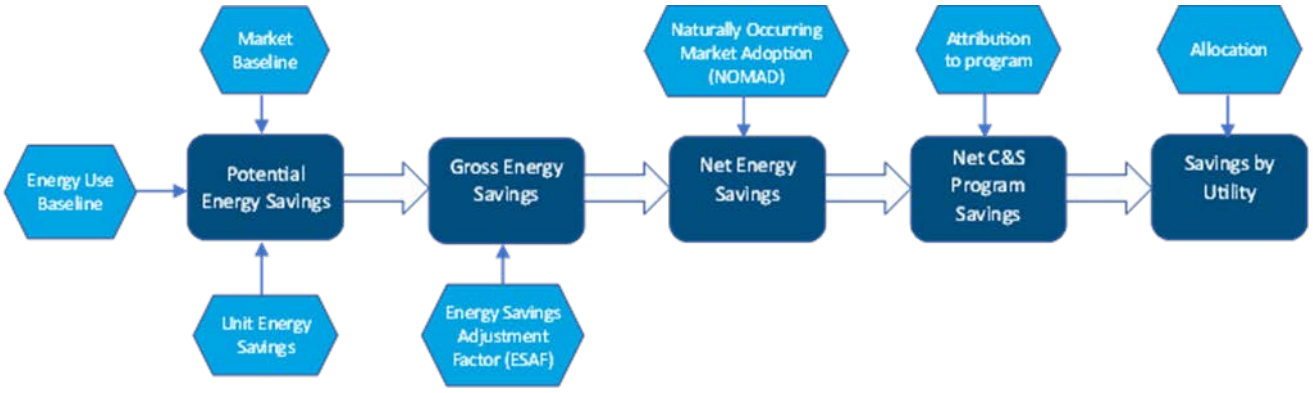
NOMAD is an estimate of what the market was doing without any IOU interventions in code development. It considers questions such as, What was the trend for building code development? How was building technology developing and being applied? What were consumers demanding and builders delivering?

Attribution is the level of IOU influence on the final adopted code. Were IOUs proactive in pressing stricter codes or were they only providing technical support in the process? If they lobbied regulators or industry, how did they lobby for their position and how broad was their effort? Did regulators listen to them and adopt their recommendations?

**Net program savings** are derived from adjusting gross savings by NOMAD and attribution. Once net program savings are calculated, the last step in the evaluation is **allocating net savings to each IOU service territory**. The IOUs account for about 80% of all electric sales and 99% of all gas sales statewide. Savings credit is distributed by applying IOU service territory–specific electric and gas sales ratios to total statewide sales.[11] The **Savings by Utility** (or allocated) savings are the evaluated savings value that is compared to the savings claimed by the IOUs. The steps involved in this calculation are depicted in Figure 8.

[11] Electric and gas sales have been used historically. In the next evaluation cycle, program budget will be used to allocate savings per D.16-08-019.

Figure 7. Codes and Standards Evaluation Components and Steps (ISSM)

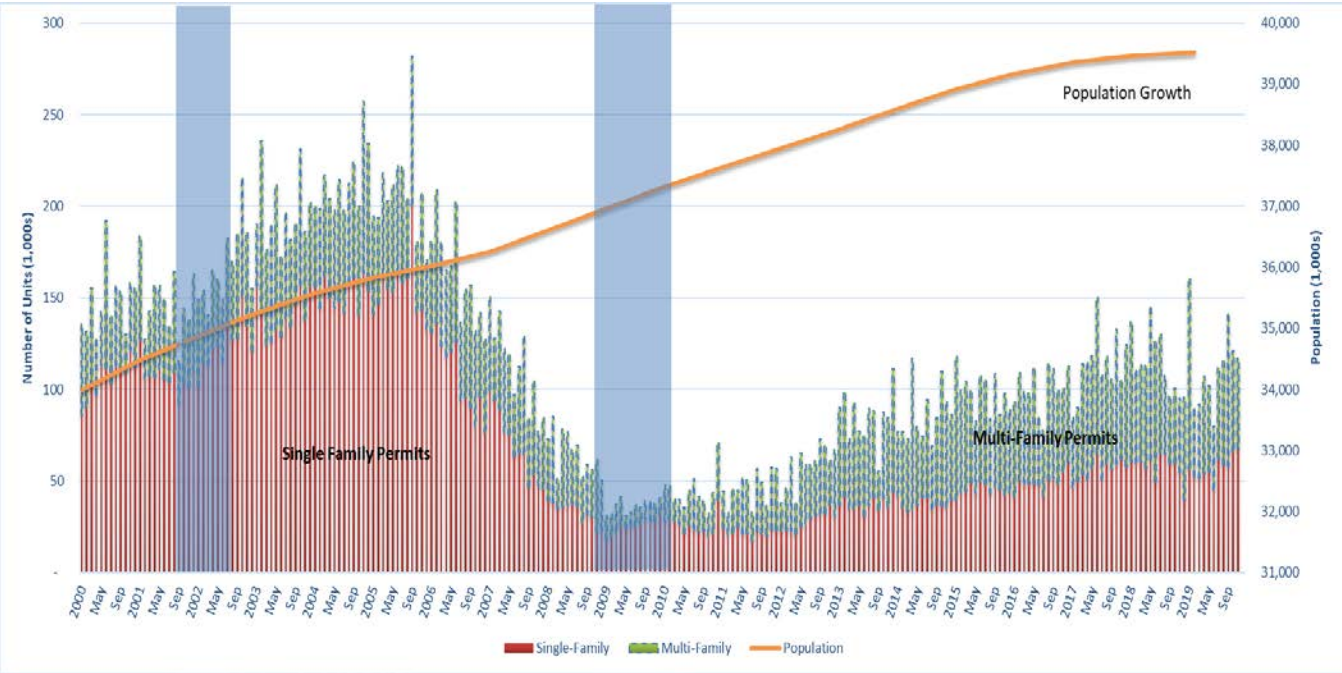



## 3.1 Potential Energy Savings

The evaluated savings from building codes are driven by two components: (1) the stringency of code changes and (2) the level of building activity. For example, even with more stringent codes, lower building activity will produce lower total savings. One example of how building activity is determined outside the code advocacy program is with residential homes in California. According to the Public Policy Institute[12], new home construction in California is highly cyclical. In 2005, 209,000 new housing permits were issued. In 2008 that number was below 50,000. In addition, since the "Great Recession" of 2008–2009, new home construction has not kept pace with population growth. This is illustrated in Figure 9. After 2011, homebuilding began increasing again but not to prior levels and has not kept pace with the growth in population since 2007.

[12] Public Policy Institute of California, https://www.ppic.org/publication/californias-housing-market/

Figure 8: Residential Building Permits Issued vs. Population




*Source*: California Department of Finance and Federal Reserve Economic Data (https://fred.stlouisfed.org/)
*Note*: The shaded rectangles highlight technical recessions

In general, the potential savings are the maximum theoretical savings for the first full year the new code is in effect, assuming every affected square foot built meets the new code's requirements. The evaluation team calculated these savings by multiplying annual new construction square feet in California by unit energy or demand savings.

For the evaluation, potential energy savings were estimated by comparing the annual energy use per square foot of various building prototypes under two building codes.[13] We modeled buildings using the 2013 Title 24 code and the 2016 Title 24 code. The difference in energy use between the 2013 code and the 2016 code represents the maximum energy savings per unit attributable to the code.

We then compare our savings estimates with the IOU unit savings estimates for the Title 24 2016 building codes. The IOU claim values are in CEDARS and the submitted ISSM and documentation files. For each selected code, we reviewed the Unit Energy Savings (UES) and assessed the underlying assumptions for the savings calculation. We then applied more current and appropriate information when available.

We used multiple data sources to support the savings verification. The most common sources are enumerated below:

- Appropriate Code and Standard Enhancement (CASE) studies
- Associated Code Change Theory Report (CCTR)[14]
- Database for Energy Efficient Resources (DEER) and IOU workpapers

[13] Prototypes as defined by the California Energy Commission, https://www.energycodes.gov/prototype-building-models#Residential
[14] More recently referred to as Code Change Savings Reports (CCSR)

- Data from the Construction Industry Research Board (CIRB)
- Data gathered from other CPUC evaluation activities.

The most important considerations in potential energy savings verification are unit energy savings and unit quantities. These values are used to calculate the potential energy savings for the first year for each measure using Equation 1.

Equation 1. Code Savings Potential Equation

*Potential savings in year 1 = Energy savings per unit * number of units*

Section 2.1 provides and overview of the approach used to create the sample frame.

## 3.1 Sample Design and Data Collection Plan

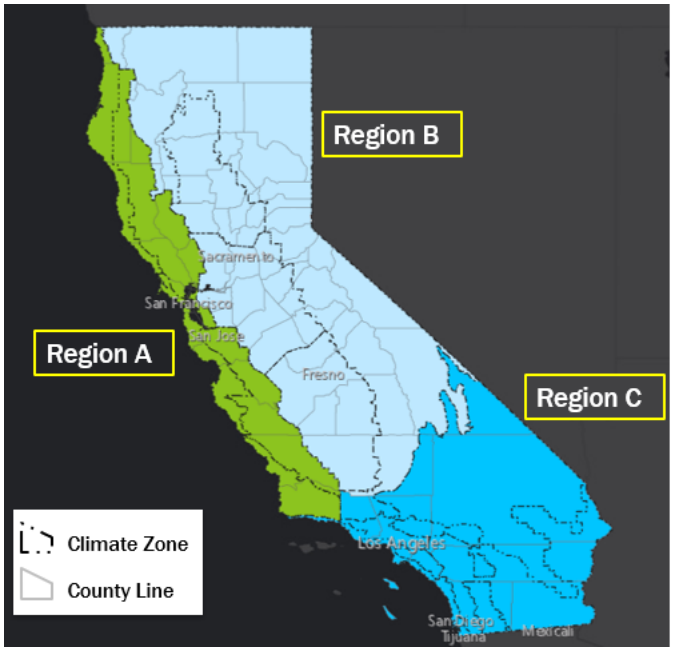
We started sample design by assessing the distribution of nonresidential building types and location of residential construction using data from Dodge Data and Analytics[15] (Dodge) and compared that with state and national data trends for validation. Differences between Dodge and the validation sources are explained through nuanced data comparability issues, such as geographic boundaries and data granularity. In response, the evaluation team adjusted data sources to create comparable datasets for assessment of Dodge's representativeness.

### 3.1.1 Regional Sampling Boundaries

The evaluation team initially looked at a sampling design based on IOU territory but determined such an approach excludes statewide construction trends. The evaluation team elected to define customized regions by integrating California's climate zones, as defined by the California Energy Commission and International Energy Conservation Code (IECC), with the major metropolitan regions where most of the construction occurred 2016–2018 to create three geographic regions inclusive of statewide construction trends. The resulting regions, illustrated in Figure 10, include Region A (marine coastal), Region B (central valley), and Region C (arid/desert). Region A and Region C intentionally separate the San Francisco/Bay Area and Los Angeles metropolitan regions because these regions account for most of the state's construction and would bias the sample towards their respective regional construction practices.

[15] https://www.construction.com/company/about

Figure 9. Map of the Three Geographic Regions Used in Sampling with California's Climate Zone Boundaries and Major Cities Overlay




### 3.1.2 Sample Design

The evaluation team constructed the following sample, summarized in Table 6, based on Dodge reported project type (nonresidential and residential construction) and construction type (alteration and new construction). For evaluations of codes and standards programs energy savings, the California Evaluation Protocols set a gross impact precision level of 90% confidence with 30% precision for Basic Rigor.[16] For net savings, the protocols specify a minimum sample size of 300.[17] Due to this, we set a target sample size of 300 buildings. The sample target consisted of 100 homes from the residential sector and 200 buildings from the nonresidential sector.

Table 6. Sample Design for Residential and Nonresidential

| | Region A | | Region B | | Region C | | All Regions | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sector | ALT | NC | ALT | NC | ALT | NC | ALT | NC | Total Sample | Sector Share of Total |
| Residential | 20 | 12 | 7 | 7 | 23 | 31 | N/A | N/A | 100 | 33.6% |
| Nonresidential – Office | 5 | 6 | 4 | 4 | 13 | 12 | N/A | N/A | 44 | 14.6% |
| Nonresidential – Education | 5 | 6 | 4 | 4 | 13 | 12 | N/A | N/A | 44 | 14.6% |
| Nonresidential – Retail | 4 | 6 | 4 | 4 | 13 | 12 | N/A | N/A | 44 | 14.6% |

[16] Hall, Nick, John Roth, and Carmen Best. 2006. "California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.", P 165
[17] Ibid P 166

| | Region A | | Region B | | Region C | | All Regions | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Nonresidential – Food Service | 5 | 5 | 4 | 4 | 13 | 12 | N/A | N/A | 44 | 14.6% |
| Nonresidential – All Others | -- | -- | -- | -- | -- | -- | 12 | 12 | 24 | 8.0% |
| **Total Sample** | **40** | **47** | **23** | **23** | **75** | **79** | **12** | **12** | **300** | **100%** |
| **Region Share of Total** | **25%** | | **15%** | | **51%** | | **8%** | | | |

*Note*: ALT is Alterations, NC is New Construction.

The resulting sample design shows sample regions and the distribution of samples across the regions. This is a product of California's unique climate zones and the construction trends observed in Dodge data. Region A encompasses the Bay Area and the marine coastal climate zones. Region B is the Central Valley. Region C encompasses the Los Angeles metropolitan region which experienced higher residential new construction than the other regions resulting in the larger sample relative to the other regions. The primary sample group was selected for not participating in an IOU new construction program and not affected by local reach codes. The specific sites in the final sample; however, were determined by cooperation rates of building departments and building owners. The preliminary sample designs for residential and nonresidential buildings are illustrated in Figure 11 and Figure 12.

Figure 10: Residential Sample

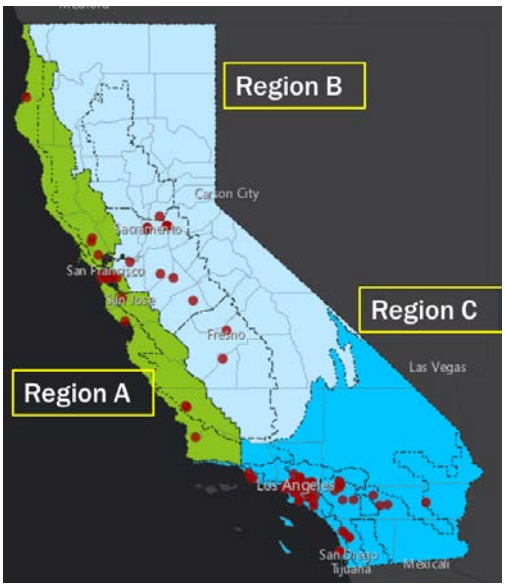
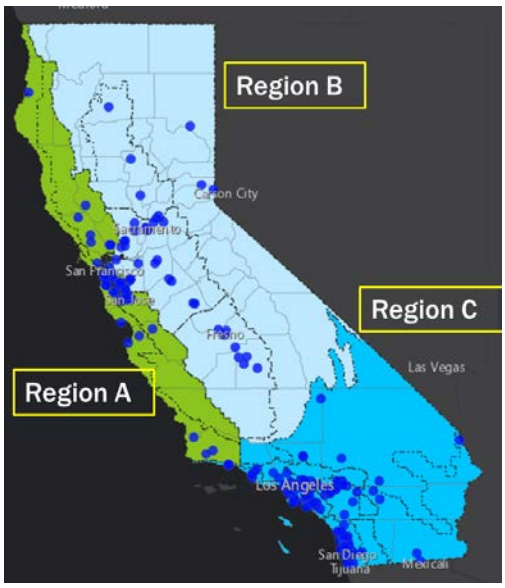



Figure 11: Nonresidential Sample




The final sample composition was determined by willingness of building jurisdictions to provide projects and the availability of potential participants. Final project counts are shared in Section 3.2.1.

### 3.1.3 Field Data Collection

We conducted site visits as the core data collection activity for measuring ESAF. The objectives of our field data collection included:

- Performing data collection based on the specification of the measures covered under the 2016 Title 24 building codes (e.g., HVAC equipment and controls, and lighting and controls).
- Collecting data on any building characteristics and operational parameters that affect the savings calculations used in the savings algorithms.
- Identifying the current ESAF levels and assessing the key reasons why a building may not conform to plan.

To collect data on residential dwellings, we recruited sites via letter. In total we mailed 397 letters. For nonresidential sites we called ahead when contact data existed. Where contact with building owners was not feasible, we visited sites directly.[18]

1. **Site Recruitment:** As part of the recruitment process, we requested building permit data from local building offices for projects approved under the 2016 Title 24 building codes. Building permit records typically include the following:
   - Permit type (building, electrical, plumbing, and mechanical)
   - Permit number
   - Permit date
   - Permit description
   - Building location and address
   - Building owner's name and contact information
   - Building plan submittal
   - Building, architectural, mechanical, and electric as-built plans
   - Copy of the building permit
   - Title 24 Certificate of Compliance documentation

   Our team reviewed the permit data, performed an eligibility check to determine whether permits were for an alteration to an existing structure or whole building new construction, and whether the projects were permitted through the 2016 Title 24 code or another Title 24 code such as 2013 or 2019.

   To recruit nonresidential sites for data collection, we first attempted to contact the sites via telephone if phone numbers were available to us. If we were unable to contact the building owner via telephone, we visited the site directly. After we completed the eligibility checks, we reviewed the building plans to identify equipment and locations. Once a site visit data collection form was generated, we visited the site.

2. **On-site visits:** We conducted in-person site visits for all sample sites to verify the installation of the measures and ensure they were operating as planned. During the site visit, we collected building characteristics data, and equipment specifications per the data collection guide. See Appendix G for an

[18] In many cases for nonresidential buildings, perhaps as a result of the pandemic, owners/investors or building owners and facility managers were not on-site. Often, they were not even in-state.

example form. Table 7 shows a sample of the information collected during each site visit and the specific data sources used for verification.

Table 7. Site Visit Data Collection Plan

| Building Characteristics | Description | Data Sources |
|---|---|---|
| Overall Building | Building configuration, square footage, number of floors, orientation | On-site interview, as-built plans, physical verification |
| Envelope | Number and area of doors and windows on each orientation, number and area of skylight, glass layer and coating, glass center u-factor and Solar Heat Gain Coefficient (SHGC), window frame type, door type and insulation, exterior wall, constructions and insulation of exterior wall, foundation, and roof | On-site interview, as-built building architecture drawings, on-site observation and measurement, glass specifications |
| Lighting | Lamp types, model and serial numbers, ballast factors, number of fixtures, controls, sensors, etc. | Lighting plans, site survey, cut sheets |
| HVAC – Air System | Number and model of air handling units, rated airflow, coil size, fan airflow, and motor power draw, control strategies of air supply temperature and supply fan speed, economizer control, terminal box types, turn-down ratio, minimum heating flow ratio, heat recovery system | On-site interview, on-site survey, Energy management systems (EMS), historical trend data, mechanical drawings |
| HVAC – Water System | Number and type of chillers, rated sizes and efficiencies, chiller sequencing and control strategies, temperature and flow set points, number of primary and secondary CHW pumps, pump model, motor efficiency, pump speed control strategies | On-site interview, on-site survey, EMS, historical trend data, piping, and instrumentation diagram (P&ID), mechanical drawings |
| Heating Hot Water | Number and type of boilers, efficiencies, sizes, temperature control set points, sequencing and control strategies, circulation pump sizes, models, motor efficiencies | On-site interview, on-site survey, mechanical drawings, boiler specifications |
| Domestic Hot Water (DHW) | DHW heater type, fuel, efficiency, operating strategies, control, typical fixtures, and use | As-built plans, on-site interview, on-site survey, DHW specifications |
| Schedule | Operating schedules of occupancy, lighting, space thermostat, air handling units, plug load, and some major internal loads for individual areas | On-site interview, EMS, historical trending data of power sub-metering system |

3. **Interview with building operators:** As part of the site visit to collect building characteristic data, we conducted interviews with the site owner or building operator, where possible, to collect information about the building and the equipment.

### 3.1.4 Evaluate Use of New Compliance Techniques

Although energy codes are the critical tools for enhancing energy efficiency in buildings, assessing code compliance can be complex and challenging. As part of this evaluation, we explored some new techniques to assess aspects of code compliance. For example, verifying building envelope parameters (U value) can be challenging on-site since insulation is behind walls or above ceilings. Traditionally, inspectors make separate visits during construction to capture these values. One method to overcome this hurdle is using infrared thermography to measure surface temperatures. Thermal imaging cameras record the measured temperatures along with the heat loss and can be used to estimate the presence of insulation. One drawback to this method is that a thermal image only shows the temperature recorded at a specific moment in time. Due to changing environmental conditions in the building, the rate of heat flow is constantly changing. In addition, there is no reliable translation method from color or temperature to U or R values. Thus, thermal imaging cameras cannot be used to calculate these values.

For this evaluation, we gathered standard and thermal images from a sample of residential buildings during site visits. While we cannot determine savings directly from these surface temperatures, they provide additional insights into construction practices, such as consistency for infiltration and insulation across sites. We provide examples in Section 3.2.

## 3.2 Gross Energy Savings (ESAF)

In this report, we define compliance as how well the building's main energy end uses conform to the building plans "as approved" by the local jurisdiction. California allows two methods to achieving "compliance."[19] These methods are:

- **Prescriptive**: This the more straightforward method, but also the least flexible from a design perspective. To be in "compliance" under this method, specific items must be present. For example, attic insulation must have an R-value of at least 30.
- **Performance:** This method is more involved but provides the most design flexibility and is the preferred choice for most residential and nonresidential new construction projects. The performance method allows trade-offs for equipment and building specifications. To allow trade-offs the method requires a "Building Energy Analysis Report."[20] This report calculates the "to code" energy budget for a particular building type and compares that to the building "as planned." If the "as planned" energy budget is less than or equal to the "to code" energy budget, the building complies with the building code.

A building that includes all mandatory equipment, such as lighting controls, and complies with the energy budget in the building code based on simulation modeling is considered in compliance under the performance method. A building that does not comply should not be approved by the jurisdiction.

The energy savings due to the building code are the maximum savings attributable to that code. A building with operating energy use less than or equal to the energy budget allowed by code is 100% compliant. A building may save more energy than the overall building code requires, but the additional savings must be attributed to the building design or other factors outside the specific code.[21]

[19] Title 24 Express, Title 24 Compliance, https://www.title24express.com/what-is-title-24/title-24-compliance/
[20] A "Building Energy Analysis Report" is a set of calculations that replicates the requirements of the California Energy Commission's Building Energy Efficiency Standards (Title 24, Parts 6 and 11). This is performed with simulation software approved by the Commission.
[21] Letter from CPUC attached to 2013-2015 building code advocacy evaluation

For this study, our concern was with the degree to which physical buildings matched architectural building plans, but may not have actually been built "to plan." This can happen in one of two ways:

1. **Design changes during construction.** Typically, this involves changes in lighting or windows, but can also include ventilation fans or other HVAC related equipment.

2. **Mandatory equipment can be omitted or inadequate**. This is less common. Examples include installed lighting controls that do not control intended wattages outlined in the building plans.

We estimated the ESAF of each building by two methods. For buildings built "as planned," we used the original Title 24 Certificate of Compliance forms when available to identify major building components. The initial plan was to re-estimate buildings not built "as planned" if needed. IN that case we would have adjusted the appropriate prototype model supported by information and data collected during the on-site visits to reflect any differences between planned and installed equipment. Inputs to the models included building characteristics information such as area of conditioned space, building envelope construction, exterior wall U value, glazing U value, window-to-all ratio, roof reflectance, HVAC, lighting, and the energy efficiency measure characteristics (such as capacity, efficiency, and number of equipment units). As it turned out, our findings for newly constructed buildings did not require this level of building analysis.

### 3.2.1 Baselines

This evaluation covers residential and nonresidential new construction and alteration projects approved under the 2016 Title 24 standards. These became effective as of January 1, 2017.

To develop baselines, we modeled the California Energy Commission building prototypes under 2013 and 2016 Title 24 requirements and compared energy usage. The difference between the energy usage of the two models became the baseline savings values. We then multiplied these savings by the estimated number of units to calculate potential savings. We discuss these results in Section 3.1 Potential Savings.

Savings resulting from the standard have a maximum potential of 100%. Where building compliance documents showed savings beyond the standard, we assigned a value of 100%. The added savings were attributed to some factor outside the specific building code, for example, more nuanced building design or equipment changeouts (heat pumps instead of packaged air conditioning units).

### 3.2.2 Avoiding Double Counting

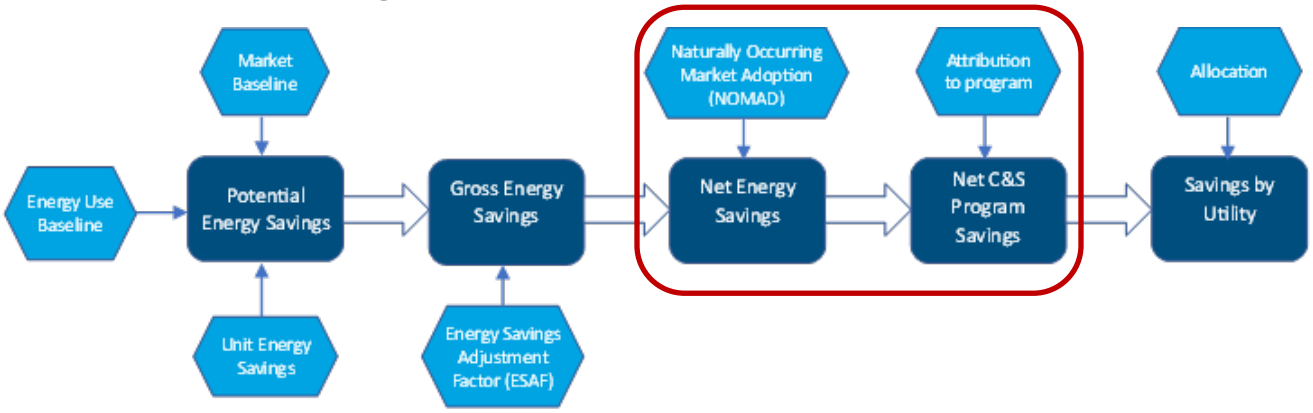
The original sample design considered areas where the IOUs' new construction programs were in effect to avoid double counting. We also reviewed sampled jurisdictions for reach codes, which are local codes that can have distinctive design or construction requirements or that are more stringent than the statewide code. For example, in 2016 a jurisdiction could have requirements for disposal of building materials, rooftop solar, electric vehicle charger readiness, or all electric appliances, which were not included in the 2016 Title 24 building code. We targeted jurisdictions without reach codes but verified that if a reach code did exist during the 2016–2018 period, it did not coincide with the attributes we were evaluating.

## 3.3 Net Energy Savings

C&S advocacy programs do not have "participants' and "non-participants," every new building is directly affected by the program outcome (i.e., a new code or standard). This is because C&S affects the entire new construction market but has no "participant" data set. As a result, there is no "net-to-gross" ratio to determine free riders.

For C&S, the equivalent of a net-to-gross ratio is calculated in multiple steps: **NOMAD** and **Attribution**, as shown in Figure 13. This is a key distinction from other resource programs because CEDARS provides only a net-to-gross input field for reporting.

Figure 12: ISSM Evaluation Steps (NOMAD + Attribution)




The next two sub sections discuss the development of NOMAD and Attribution in more detail.

### 3.3.1 NOMAD

This section summarizes the methodology and findings of our NOMAD analysis. As shown in Figure 13, the NOMAD values are applied to the gross standards energy savings to yield the net standards energy savings.

NOMAD is estimated as an adoption curve over time. In the evaluation, however, the NOMAD value represents a point in time (i.e., the program year). Historically, IOUs and evaluators have used a BASS diffusion model[22] to estimate the rate at which a technology or building practice is adopted and its eventual saturation of the market.[23] The BASS method requires the estimation of four coefficients for each code estimate.

1. t – the year a product enters the market
2. M – the potential market (the ultimate number of adopters),
3. p – coefficient of innovation (leading)
4. q – coefficient of imitation (following)

The IOUs have commented that the BASS diffusion model may not be the best method for estimating values for all code or standards. In some cases, a Markov decision process may be a better estimator.[24] The pros and cons of the Markov method as an estimator and its implementation should be explored in more detail to understand the data requirements, method of data collection, and results for evaluation (i.e., defined start and end states, objective function, and actions).

The evaluation estimated NOMAD curves directly using a pool of experts who provided their insights through an iterative process known as the Delphi method. The difference between the Delphi panel estimated curves

[22] Developed in 1963 by Frank Bass, the BASS diffusion model describes the process of how new products get adopted as an interaction between users and potential users. http://www.bassbasement.org/BassModel/
[23] Market saturation under a BASS framework can be, and often is, defined as less than 100%.
[24] The process refers to the actions that happen to move from the current period state to the next period state. For C&S advocacy this would be the IOU actions during the development steps of a code or standard.

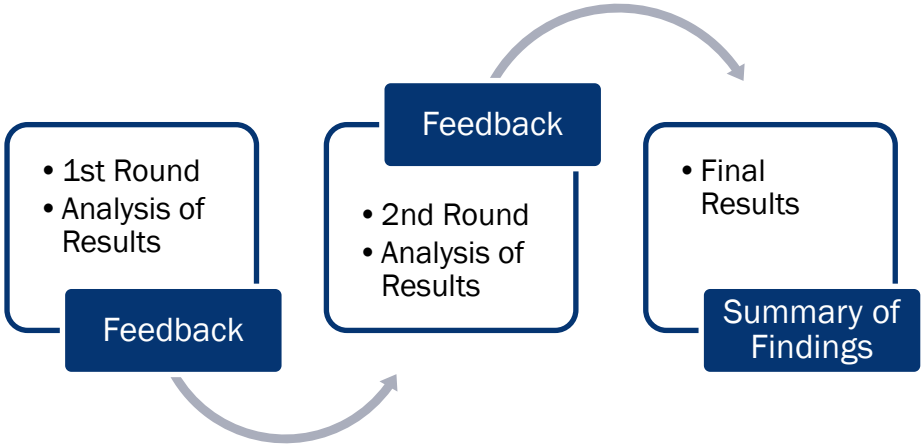
and the IOU estimated curves reflects the difference in perceptions of market activity. It is understood that accounting for the influence of natural market adoption is separate from attributing the code change to IOU advocacy efforts.

## NOMAD Surveying Process

The evaluation team used the Delphi method to determine the NOMAD curve for each standard in the evaluation scope. The Delphi method is a structured communication technique that gathers feedback from a group of geographically dispersed experts to converge into one aggregated response. The Delphi process is commonly used in technology forecasting and policy making.

In the Delphi process, the facilitator asked a group of experts to anonymously predict the naturally occurring adoption rate of code changes in the absence of a standard and explain their reasoning. To assist the participants, the IOUs' determined forecast adoption curve was included as a baseline. After the respondents made their initial predictions, the facilitator calculated the average of the results and summarized the respondents' rationale, as shown in Figure 14. The facilitator distributed these findings to the same group of experts and encouraged them to consider modifying their responses in light of the latest information.

Figure 13: Delphi Surveying Process




Some respondents decided to not to modify their first-round responses after reviewing the group averages. Others modified their responses slightly to match that of the group and provided reasoning accordingly. Respondents commented on the group's summary rationale and added insights on whether they believed it to be accurate.

## Expert Selection Process Description

The evaluation team examined a wide range of sources while recruiting experts to provide input into the Delphi process, including:

- Individuals nominated for the panel by the IOU Program Coordinating Group (PCG)
- Interested parties who participated in the state and Federal rulemaking process for the relevant standards, and whose contact information could be found in public rulemaking documents.
- Members of industry and professional associations

- Employees or associates of energy-related nonprofit organizations
- Employees of national laboratories
- Other individuals nominated by anyone belonging to the above categories

The Delphi panel facilitator reached out to the identified individuals and followed up with those who did not respond to the initial contact. In all, the facilitator contacted approximately 500 potential panelists. Panelist knowledge of appliance technologies can cross over to buildings. Of these 500 candidates however, 138 were associated specifically with code development. Individuals who expressed interest in participating were asked to provide a brief statement noting any relevant academic or professional experience, publications, and/or credentials (e.g., P.E., CEM, etc.). The facilitator selected panelists based on demonstrated expertise related to the technology and attempted to create a balance of affiliations on the panels. Panelists were grouped by the code group in which they had expertise; not every person on each group's panel provided estimates for every product in the group.

Table 8 shows the number of participants in each code or standard group.

Table 8. Summary of Panel Participation

| Code or Standard Group | # Panelists | # Responded to First Survey | # Responded to Second Survey |
|---|---|---|---|
| T24 Building Codes (Residential) | 11 | 7 | 7 |
| T24 Building Codes (Nonresidential) | 11 | 7 | 7 |

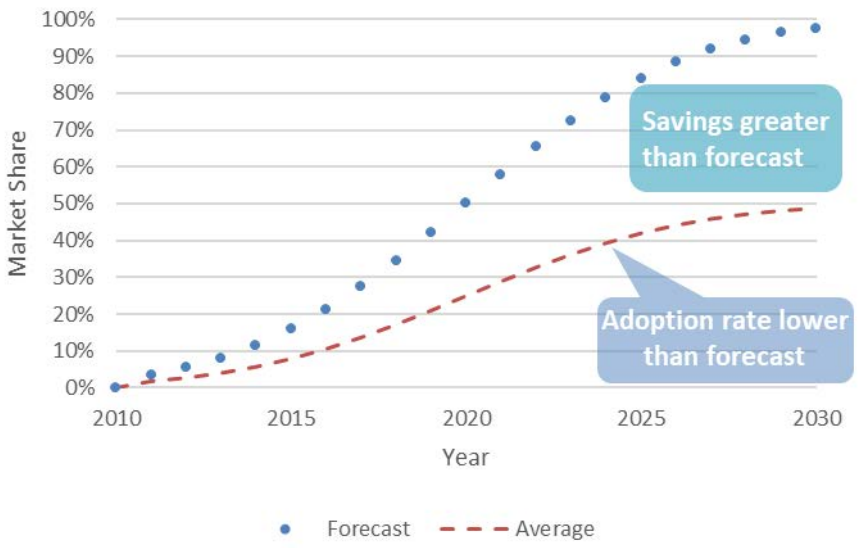
## Interpreting the Results

The estimated NOMAD rates indicate the percentage of the market for each product that **would have achieved** efficiency levels equivalent to the standard level **even if the code was not adopted**.

- Lower NOMAD rates mean that only a small percentage of the market would have reached the standard level without the standard being in place. Correspondingly, net savings associated with the standard are higher.
- Higher NOMAD rates mean that a larger percentage of the market would have reached the standard level without the standard being in place, indicating that the standard had less of an impact on the market than other, natural market factors. Consequently, the net savings associated with the standard are lower.

Lower NOMAD rates correspond to higher net savings and conversely higher NOMAD rates correspond to lower net savings. This concept is illustrated in Figure 15. When the evaluated average rate of market adoption is lower than the IOU forecast rate of market adoption, the standard either accelerated savings, increased savings, or affected both simultaneously compared to the IOU forecast. It does not, however, tell us directly how much the IOU advocacy efforts influenced development or adoption of the standard. Findings for attribution scores are presented in Section 3.5.1 of this report.

Figure 14: Example NOMAD Graph




### 3.3.2 Attribution

This section summarizes the methodology and findings of our attribution analysis. The attribution factors are applied to the net standards savings to yield the net codes & standards (C&S) program savings. (See Figure 13).

Attribution is the estimate for the level of influence the IOU advocacy activities had on the final standard outcome through a regulatory body (state or federal). The evidence for this influence is provided in Code and Standard Enhancement (CASE) reports and by the IOUs in a Code Change Savings Report (CCSR). This evidence is categorized, weighted, and reviewed by the evaluators and a panel of independent industry experts. The weights and scores are used to develop an attribution value between 0% and 100%. A zero percent attribution value means no influence and 100% means the standard would not have happened without the intervention of the IOU advocacy program. The attribution value is then multiplied against the net C&S savings resulting in the net IOU C&S program savings.

Current factors to determine IOU influence for each new code or standard are as follows:

- Compliance Determination and Other Special Analytic Methods
- Technical Information and Standard Language
- Feasibility of Meeting the Standard

These factors were weighted by the evaluation team, then discussed and scored by independent experts. Three key steps were involved in evaluating attribution scores:

1. The evaluation team collected information on IOU and stakeholder activities from a variety of sources, including CASE reports, state, and federal rulemaking dockets, and CCSRs provided by the IOUs.
2. The team convened a panel of independent codes and standards experts to assess the C&S Program's contributions to the development and adoption of each standard based on a systematic review of the

evidence gathered in step 1. The expert panel scored the program's contributions in the three factor areas (compliance determination, technical information, and feasibility), which are described in Section 2.3.3.

3. The evaluation team developed weights for each of the three factor areas based on the team's assessment of the relative effort required for each factor. The team then applied these weights to calculate a summary attribution score for each code or standard as a weighted average of the scores assessed by the expert panel in step 2.

## The Attribution Model

The attribution model used in this analysis applies to both state and federal rulemaking. The model sets forth specific criteria for evaluating the C&S Program's contributions to the development and adoption of codes and standards.

The model focuses on three areas of activity, which represent the fundamental requirements that must be met for the Energy Commission (for state standards and building codes) to adopt a code:

- Development of compliance determination methods and other special analytic techniques.
- Development of code language and technical, scientific, and economic information in support of the standard.
- Demonstrating the feasibility or market acceptance of standard adoption.

The following sections of this report discuss these factors in further detail.

### Development of Compliance Determination Methods and Other Special Analytic Techniques

For a code or standard to be implemented effectively, manufacturers and enforcement bodies must have tools and methods to determine which buildings and products comply with the code or standard. For product standards, the compliance determination method is typically a test procedure that may be performed to assess the product's energy and/or water consumption. Test procedures may be developed by industry groups, governmental agencies, or independent organizations. There are several ways the C&S Program may contribute to the development or revision of test methods. For example, the program may conduct product testing, participate in standards-making committees, or develop analytical tools to assess product compliance.

### Development of Code Language and Technical, Scientific, and Economic Information in Support of the Standard

Codes and standards must be defined using careful language that describes which products are covered by the standard, the efficiency requirements of the standard, and the effective date of the standard. The development of regulatory language depends on extensive engineering and economic research. This research estimates the energy and peak demand savings and the economic impacts of the standard.

At the state level, much of this research is conducted by the C&S Program and its contractors, and findings are summarized in CASE reports. At the federal level, the DOE's contractors prepare market assessments, engineering analyses, and economic analyses to determine whether particular standard levels are technically feasible and economically justified.

There are several ways the C&S Program may contribute to the development or revision of code language and supporting information. For example, the program may draft and present recommended standard language or use studies and calculations to estimate the energy and demand savings and the cost-effectiveness of a standard.

### Demonstrating the Feasibility or Market Acceptance of Standard Adoption

An implicit requirement for adopting a new standard is that compliance with the standard must be practical and feasible. Supporters of the standard must address stakeholder concerns and demonstrate through market research that stakeholders can comply with the standard. The C&S Program may demonstrate the feasibility of a standard by documenting the market readiness of compliant products, the costs to end users, and any health and environmental externalities.

## Data Collection Activities

The evaluation team conducted a systematic and thorough review of available evidence regarding the C&S Program's activities in support of code and standard development. The team collected information from a variety of sources, including CCSR and CASE reports provided by the IOUs, public documents (including rulemaking notices, stakeholder comments submitted to rulemaking dockets, and transcripts of public meetings), and interviews with C&S experts who participated in rulemaking proceedings.

Based on this review, the team documented the following information for each code and standard:

- Whether a prior standard existed
- Any changes to standard's scope of coverage, the compliance determination method, and the minimum efficiency levels introduced by the new standard
- The influence of current and prior California standards on standards developed at the federal level
- The timeline of the various stages of standards development
- The C&S Program's participation in the standards making process, as evidenced by the program's participation in public meetings, publication of reports, filing of comments, and organization of other efficiency advocates

## Estimation of Factor Scores

The following principles guided the evaluation team's assessment of attribution scores:

- Attribution should be determined by disinterested third-party technical experts who do not have a stake in the amount of credit that is awarded.
- Attribution credit should be awarded based on evidence concerning the C&S Program's influence on the development and adoption of standards.
- The scoring process should be transparent, documented, and repeatable.

To adhere to these principles, the evaluation team convened a panel of independent C&S experts to assess attribution scores. The panel consisted of five experts: one representing the Northwest Energy Efficiency Alliance (NEEA); one representing the Midwest Energy Efficiency Alliance (MEEA); one representing the Pacific Northwest National Laboratory (PNNL); one who served as a reviewer for prior CPUC standards impact evaluations; and one independent consultant serving on the boards of several energy efficiency organizations. Two of the five panel members participated in at least one attribution panel for a prior evaluation cycle.

In October 2019, the panel convened for a two-day session at NEEA offices in Portland, Oregon. At the meeting, the evaluation team explained the attribution model and the method used to develop attribution scores. The team asked panelists to judge the C&S Program's contributions to each attribution factor relative to the contributions of other stakeholders such as industry representatives, energy efficiency advocates, the

California Energy Commission, and the DOE. The team informed panelists that they should not score attribution factors based on the amount of effort required for each factor, since the amount of effort would be considered separately in the evaluation team's development of factor weights (described in the following section, Estimation of Factor Weights).

For each code the panel considered, the evaluation team delivered a presentation on the code's history (i.e., whether a prior code existed, and whether the code was initially promulgated in California), the positions of various stakeholders, and the process involved in developing the new standard. The team presented evidence describing the C&S Program's contributions related to each of the three factors in the attribution model. Several panelists were active participants in the proceedings for some of the codes considered by the panel, and they offered first-hand knowledge from their experience. The panelists discussed their impressions of the C&S Program's contributions relative to the contributions of other stakeholders. During their discussion, the panelists asked the evaluation team questions about the rulemaking activities. For some codes, the panelists referenced regulatory notices and comments that were submitted during the development process. After discussing their individual opinions regarding factor scores, the panel attempted to reach agreement on scores for each of the three attribution factors. In cases where the panel could not reach agreement on factor scores, the evaluation team calculated the final score for each factor as an average of the scores assigned to the factor by individual panelists.

To ensure the panel had adequate time to consider each code presented, the panel session only assessed scores for 9 building codes in scope for this analysis. Since there are no "whole building" codes, these savings claims were considered (by the panelists) to be too broad and too vague for the panel to consider directly. The whole building codes were derived from averages of component codes weighted by first year (2017) kWh savings.

### Estimation of Factor Weights

The evaluation team developed factor weights internally for each code evaluated in this attribution analysis. The team based the factor weights on an assessment of the resources expended for each factor area for each code. This assessment drew upon evidence provided in CCSRs and on data collected through the team's review of rulemaking documents and stakeholder interviews.

To validate these internally developed factor weights, the evaluation team asked the IOUs to provide estimates of the factor weights for each standard. We submitted a data request to the IOUs similar to the surveys used in previous evaluations. For each code, we asked, "What was the percentage allocation of total stakeholder resources across the factor areas in the development of the standard, where resources are defined in terms of budgets?" We also asked the IOUs to provide a brief explanation as to the reasoning behind their weights.

The team compared our internal weights to those provided by the IOUs. If the weights proved close, the team used the weights developed internally. If large discrepancies arose between the team's estimates and those provided by the IOUs (discrepancies equal to 10% or more), the team reviewed the justification provided by the IOUs, conducted additional research, and adjusted the weights, as necessary.

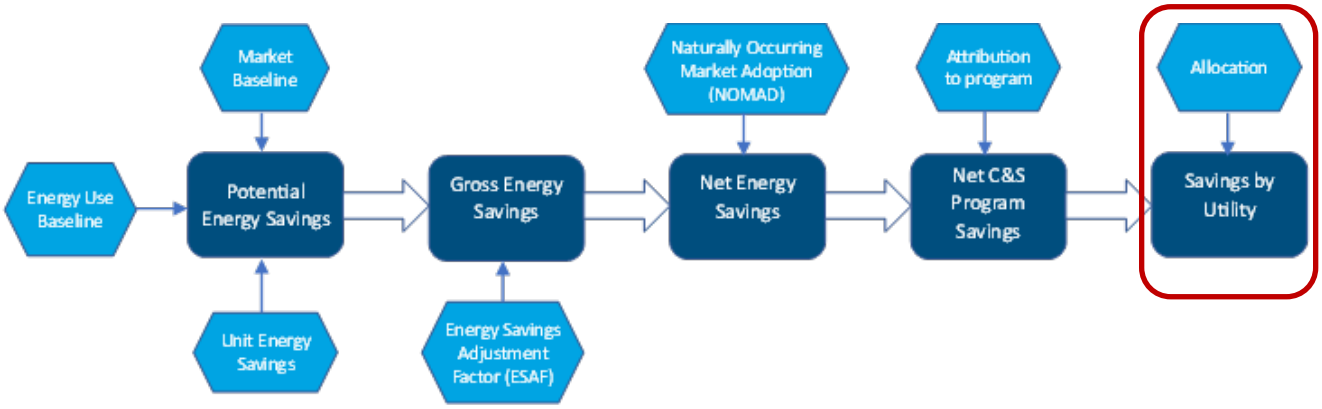
### Calculation of Attribution Scores

The evaluation team calculated the summary attribution score for each code by multiplying the factor score and factor weight for each factor, and then summing the weighted scores. This summary attribution score measures the C&S Program's contribution to the development and adoption of a code. In our overall evaluation process, these attribution scores are applied to the net standards savings to yield the net codes & standards program savings.

## 3.4 Net Savings by Utility

In addition to savings calculated at the statewide level, each IOU is allocated a portion of these statewide savings as credit to their energy efficiency portfolio goals. The last step in the evaluation is allocating these savings to each IOU. In this and prior evaluations the allocation factor is based on electric and gas sales [25] These factors are provided in 4.6.2.

Figure 15: ISSM Evaluation Step (Allocation)




Through the business planning process, policy decisions for Statewide programs directly affect C&S advocacy. According to Decision 16-08-019, Section 4.3 page 55, "The lead statewide administrator for each area will not be assigned credit for all of the results of the program; rather, the energy savings will be apportioned to all contributing administrators based on actual customer participation."[26] On page 103 of the same Decision, under Conclusions of Law, it states,

> *47. Program administrators from whose customers funds are collected for the statewide programs should have both program costs and savings reflected in their cost-effectiveness showings, savings credit, and ESPI awards based on their proportional contribution to the statewide programs.*

Later in Decision 18-05-041, on page 82, for business planning that covered 2018–2025, it states,

> *D.16-08-019 addressed the issue of allocation of savings credit for statewide programs based on budget contributed by each IOU PA. "We clarify that this means that credit for energy savings generated will be based on funding contributed only, and not in relation to the geographic region in which the energy efficiency measure was sold or installed."*[27]

After PY 2018, the program electric and gas benefits and costs allocated to each utility will be based on their monetary contribution to the statewide program budget.

[25] From 2020 forward, the weighting factor will be IOU budget expenditures. See Cost Effectiveness report for more details.
[26] D.16-08-019 DECISION PROVIDING GUIDANCE FOR INITIAL ENERGY EFFICIENCY ROLLING PORTFOLIO BUSINESS PLAN FILINGS, 08/25/2016
[27] D.18-05-041 DECISION ADDRESSING ENERGY EFFICIENCY BUSINESS PLANS, 05/31/2018

The values in Table 9 are derived from California Energy Commission Energy Reports.[28] The values are used to allocate the evaluated statewide benefits and costs, by fuel type, to each utility for the cost effectiveness calculations.

Table 9. Electric and Gas Savings by Planning Area

| IOU | Electric | | | Gas | | |
|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 |
| PG&E | 36.4% | 35.8% | 36.2% | 36.6% | 37.5% | 37.9% |
| SCE | 35.9% | 35.8% | 36.7% | 0% | 0% | 0% |
| SCG | 0% | 0% | 0% | 41.1% | 40.9% | 40.7% |
| SDG&E | 7.4% | 7.3% | 7.5% | 3.8% | 3.8% | 3.8% |
| Other | 20.3% | 21.1% | 19.6 | 18.4% | 17.8% | 17.6% |
| **Total** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

The "Other" category for electric includes publicly owned load-serving entities, rural electric cooperatives, community choice aggregators and non-IOU electric service providers. For gas, the "Other" category includes publicly owned utilities, and the western area power administration.

[28] California Energy Commission, https://ecdms.energy.ca.gov/gasbyutil.aspx and https://ecdms.energy.ca.gov/elecbyutil.aspx

# 4. Evaluation Findings for Building Codes

This section presents the findings from the evaluation steps as explained in the prior sections.

## 4.1 Potential Savings

Table 10 provides the potential first-year electricity, peak demand, and natural gas savings for each of the program elements in the scope of this evaluation. The values in these tables represent savings for the 12-month period following the effective date of the 2016 Title 24 code. Electric and natural gas interactive effects are included in these savings values. In section 4.6 of this code impact evaluation we compare the evaluated net code savings to utilities' savings claims in CEDARS.

The California IOUs report savings resulting from energy efficiency standards in CEDARS. The CEDARS database contains gross savings claims, net savings claims, and other data; but CEDARS does not report the potential savings values calculated prior to the application of ESAF rates. The IOUs provided estimates of potential savings to the evaluation team in the form of CCSRs with supporting spreadsheet calculations.

Details for each sector are included in Section 4.3 (Residential) and Section 4.4 (Nonresidential). Each code has its own section. At a minimum, each section contains an assessment of the California market size and the unit energy savings for the code in question. In instances where our evaluation results differ from the estimates supporting the IOUs' claimed savings, we identify and describe the cause of the discrepancy.

**Residential:** We estimated savings potential for residential single-family new construction (B130) to be about 50% lower than IOU estimates for electricity and gas savings. Residential single-family alterations (B132) savings are derived from project value ratios applied to new construction estimates and therefore show a similar lower savings relationship. In both cases, we found similar savings per unit as the IOU estimates, but we estimated a lower number of units built or remodeled using more recent data from the California Energy Commission Demand Forecast Office.

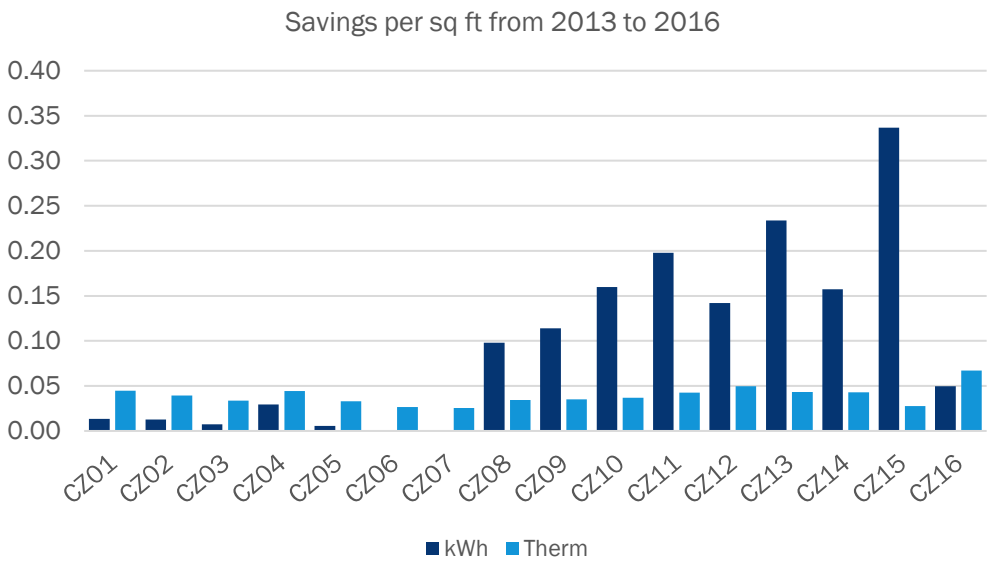
Key changes for 2016 included high performance attics (extra insulation) and walls (design), efficient lighting and controls, and tankless—or high efficiency tank—water heaters.[29] Extra roof deck insulation works in conjunction with radiant barriers (zones 2–15) and affects how the radiant barrier is installed. A radiant barrier is a reflective layer (perforated or non-perforated) located in an attic beneath the roof deck to reduce heat transfer caused by solar heat gain in the roof.[30] Figure 16 provides one example of an insulated attic from a Northern California home alteration.

[29] Energy Code Ace, Residential Fact Sheet: What's New with 2016 Code? https://energycodeace.com/download/8866/file_path/fieldList/Fact%20Sheet%20-%20Whats%20New%202016%20Residential
[30] Title 24 Express, https://www.title24express.com/what-is-title-24/title-24-radiant-barrier/

Figure 16: Attic with Insulation and Radiant Barrier (Non-perforated)

Savings per square foot estimates for residential new construction by climate zone are shown in Figure 17. As expected, the estimates imply that savings are more prominent in warmer climate zones (CZ08 - CZ16).

Figure 17: RES New Construction Savings per Square Foot by Climate Zone




For the multifamily sector (B131-P, B133-P) we updated units only. We estimated a higher number of units than the IOUs and as a result, higher overall savings than the IOUs estimated when using the same savings per unit. Part of this difference may be due to accounting. In some sources, high-rise multifamily buildings are counted as residential dwellings. In others, they are included with nonresidential square footage. These classification differences are typically due to the differences in wall structural requirements for high-rise vs. low-rise buildings. This is another example of why including details and explicitly citing sources in forecasts is important. A summary of residential single-family and multifamily findings is presented in Table 10.

**Nonresidential:** This sector includes new construction and lighting alterations. For whole-building new construction (B121) our estimate was approximately 41% lower than the IOU estimate for kWh and kW, but

only 36% lower for therm savings. For lighting alterations (B101) our estimate was about 6.0% lower than the IOU estimate. Once again, the primary driver of the lower savings was a lower estimate of square footage, rather than a significant difference in savings per unit. These estimates also are provided in Table 10.

Table 10. Summary of California Potential Energy, Demand, and Gas Savings, by Code (2017)

| Building Code ID | Building Code Name | First-Year Potential Savings, California | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Electric Savings (GWh/year) | | | Demand Savings (MW/year) | | | Natural Gas Savings (MMTherm/year) | | |
| | | IOU Estimate | Evaluated | Difference | IOU Estimate | Evaluated | Difference | IOU Estimate | Evaluated | Difference |
| **Residential** | | | | | | | | | | |
| B130 | RNC – Single Family | 93.01 | 46.21 | -50% | 48.88 | 31.08 | -36% | 9.19 | 4.41 | -52% |
| B132 | RA – Single Family | 39.99 | 19.27 | -52% | 21.02 | 12.96 | -38% | 3.95 | 1.84 | -53% |
| B131 | RNC – Multifamily | 18.55 | 38.48 | 107% | 3.97 | 8.24 | 107% | 1.59 | 3.30 | 107% |
| B133 | RA – Multifamily | 7.98 | 25.17 | 215% | 1.71 | 5.39 | 216% | 0.68 | 2.16 | 216% |
| | ***Residential Total*** | ***159.53*** | ***129.13*** | **-19%** | **75.58** | ***57.66*** | **-24%** | **15.42** | ***11.71*** | ***-24*** |
| **Nonresidential** | | | | | | | | | | |
| B101 | NRA – Lighting Alterations | 100.08 | 93.83 | -6% | 19.34 | 18.13 | -6% | -0.18 | -0.17 | -6% |
| B102-P | NRA – Lighting-Outdoor Lighting Controls | 2.51 | 2.51 | 0% | 0.00 | 0.00 | 0% | 0.00 | 0.00 | 0% |
| B103-P | NRA – Lighting-ASHRAE Elevator Lighting and Ventilation | 3.65 | 3.65 | 0% | 0.13 | 0.13 | 0% | 0.00 | 0.00 | 0% |
| B105-P | NRA – HVAC-ASHRAE Measure-DDC | 4.20 | 4.20 | 0% | 0.93 | 0.93 | 0% | 0.53 | 0.53 | 0% |
| B106-P | NRA – HVAC-ASHRAE Equipment Efficiency | 14.50 | 14.50 | 0% | 19.40 | 19.40 | 0% | 0.00 | 0.00 | 0% |
| B107-P | NRA – Process-ASHRAE Measure Escalator Speed Control | 0.68 | 0.68 | 0% | 0.00 | 0.00 | 0% | 0.00 | 0.00 | 0% |
| B121 | NRNC – Whole Building | 129.80 | 76.75 | -41% | 79.70 | 47.12 | -41% | -0.33 | -0.20 | -39% |
| | ***Nonresidential Total*** | ***255.42*** | **196.12** | ***-23%*** | ***119.50*** | ***85.71*** | ***-28%*** | ***0.02*** | ***0.16*** | ***700%*** |
| | **Codes Total** | **414.95** | **325.25** | **-22%** | **195.08** | **143.37** | **-27%** | **15.43** | **11.87** | **-23%** |

*Notes*: For B131, the difference is due entirely to the evaluation team updating the number of units; Building Code IDs ending with "-P" indicate that final net evaluation results are "passed through" from CEDARS claim data; NRA = nonresidential alterations, NRNC = nonresidential new construction, RA = residential alterations, RNC = residential new construction.

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## 4.2 Gross Energy Savings (ESAF)

In this section, we discuss the results of our analysis of the Energy Savings Adjustment Factor (ESAF). As mentioned in Section 3.2, a building that includes all mandatory equipment, such as lighting controls, and complies with the energy budget in the building code based on simulation modeling is considered to have an ESAF or 1.0. A building that is not built "as planned" may be deemed to have an ESAF of zero (0.0) if the features are found to be less efficient than specified (e.g., incandescent vs. LED), or more equipment is installed than specified (e.g., lamps have the specified wattage, but twice as many were installed). For new construction, the features we examined were building envelope (windows and roof), purpose (office, education, etc.), dimensions and orientation and equipment, primarily HVAC, hot water, and lighting.

### 4.2.1 Finding the Sites to Visit

California does not have a uniform or centralized method for managing building permit data. As a result, we contacted the building departments for individual jurisdictions to request code Certificate of Compliance documentation. Each building department willing and able to cooperate with the evaluation team provided information in a different format and to a varying degree of completeness. Building departments, in general, are moving toward electronic storage of permit documentation. This is a recent move however, so many jurisdictions have not digitized historical files (i.e., files prior to 2018). The usability of jurisdiction building permit data for this effort depended on the completeness of provided data, and the type of work required by the permit. For example, Americans with Disabilities Act (ADA) upgrades or exterior sign changes may not, by themselves, qualify for this study of energy code compliance.

The COVID-19 pandemic and associated office shutdowns negatively affected our recruitment effort in 202 and 2021. Related to this, many building departments experienced staff resignations during the lockdown. That resulted in either completely restarting recruitment efforts with new building department staff, or where no replacement staff existed, the building department chose to not participate. As building department staff returned to the office, a backlog of construction projects and other initiatives—such as development of climate action plans—kept staff busy. Additionally, once contacted, and stating their willingness to cooperate, several building departments were reluctant to share data due to perceived legal requirements for release of building plans. Intervention by the CPUC legal department and clarification of the relevant statute helped secure the participation of several jurisdictions. This essential information was also incorporated into the building department recruitment letter to facilitate future efforts.

While the data sources, such as Dodge Data and Analytics,[31] can help supply broader counts of projects, they often supply incomplete information for building types, number of units, and ownership contact details. Getting information to verify code year, address, Title 24 design documents and lighting or HVAC schedules requires cooperation from building departments to find valid projects. In California, this requires navigating multiple permit jurisdictions. There are 541 jurisdictions, including counties, cities, and towns, overseeing building codes in California.[32] The evaluation team contacted the jurisdictions shown in Table 11. As a side note, in addition to county and city jurisdictions there also are 4,763 "special" districts that may impose added requirements on building location or façade design.[33]

[31] https://www.construction.com/company/about
[32] These 541 jurisdictions are comprised of 58 counties and 483 cities and towns. https://census.ca.gov/resource/counties/
[33] Georgetown Law Library, California Resources, https://guides.ll.georgetown.edu/c.php?g=275786&p=1838520

Table 11: Contacted Jurisdictions by Sample Region

| Region A | Region B | Region C | |
|---|---|---|---|
| City of Berkeley | ~~City of Bakersfield~~ | ~~City of Carlsbad~~ | ~~City of San Bernardino~~ |
| ~~City of Mountain View~~ | ~~City of Davis~~ | City of Costa Mesa | City of San Diego |
| ~~City of Napa~~ | ~~City of Hanford~~ | ~~City of Fontana~~ | ~~City of San Marcos~~ |
| City of Oakland | ~~City of Lodi~~ | City of Irvine | ~~City of Santa Ana~~ |
| City of Redwood City | ~~City of Shafter~~ | ~~City of Long Beach~~ | City of Santa Barbara |
| ~~City of San Jose~~ | City of Tracy | ~~City of Los Angeles~~ | City of Santa Monica |
| City of San Luis Obispo | | City of Montclair | City of Vista |
| City of Santa Clara | | City of Newport Beach | ~~City of Westminster~~ |
| City of Santa Rosa | | City of Oxnard | ~~County of Los Angeles~~ |
| City of South San Francisco | | ~~City of Redlands~~ | County of San Diego |
| City of Sunnyvale | | City of Riverside | ~~County of Santa Barbara~~ |

*Note*: Jurisdictions marked with a strikethrough did not provide any building plans to the evaluation team.

The residential project plans obtained consisted of both single-family attached and detached homes. The sample included tract homes in subdivisions, custom homes, townhomes, and even accessory dwelling units (ADUs).[34] To recruit participants, we mailed out 379 recruitment letters[35] offering a $100 VISA gift card and flexible (day and time) scheduling over a two-week period. We conducted on-site visits of 109 homes (See Table 13). Prior to the on-site visits we reviewed the building plans and Title 24 documentation, which enabled us to compare the equipment in the documentation to the physical building during the visit.

The evaluation of nonresidential buildings focused on five categories (Office, Retail, Restaurant, Education, and Other). The "Other" building type included any building not included in one of the four explicit categories that otherwise met the evaluation criteria. Building departments provided 160 permitted projects. After review, we were able to include 115 projects in this evaluation (See Table 18 and Table 19). Projects were excluded if they were under the wrong Title 24 code year, an alteration project was not a lighting project, the documents sent were not building plans, critical plans were missing (i.e., lighting or HVAC schedule), or the project was never built.

### 4.2.2 Final Sample Composition

The disposition of the sample projects is listed in Table 12. We excluded projects with incomplete plans, alteration projects that did not include lighting, or where projects were permitted under the 2019 Title 24 code.

We received and reviewed building plans for 294 projects. Of these, 78% (238 projects) met the criteria to be included in the evaluation. We were able to conduct site visits at 153 of these 238 projects (52%). A breakout of project site visits by jurisdiction is provided in Appendix C.

Table 12: Sample Disposition

| | NR NC | NR ALT | RES NC | RES ALT | Total |
|---|---|---|---|---|---|
| **Project Sample (All)** | **44** | **126** | **100** | **24** | **294** |
| Not 2016 T24 | 0 | 2 | 11 | | 0 |
| Incomplete document set or wrong project type | 11 | 26 | 23 | 14 | 74 |

[34] ADUs have progressed from backyard garage conversions to one-, two-, or even three-bedroom "tiny" homes. This concept accelerated in 2020 with the passage of California AB 68 and SB 13.
[35] Letters were mailed, Nov 2021 and Feb, April, June, July 2022

| | | | | | |
|---|---|---|---|---|---|
| No project or empty building | 3 | 5 | 0 | 0 | 8 |
| **Viable Projects** | **30** | **95** | **89** | **24** | **238** |
| Project Site Visits | 27 | 88 | 28 | 10 | 153 |
| Visit / Sample | 61% | 70% | 28% | 42% | 52% |

*Note*: ALT is Alterations, NC is New Construction, NR is Nonresidential, RES is Residential

*An incomplete document set may not disqualify a project from a site visit.*

Wrong project type example for NR ALT: non-lighting alterations

We noted earlier acquiring project data from building departments was not as straightforward as anticipated. We attribute this to several factors. During the evaluation, building departments were closed due to the COVID-19 pandemic. When the building departments re-opened, they informed us they were short of staff and could not accommodate any request for past projects. We also learned that most of the records we were requesting (before 2019) were not digitized and/or were stored off-site, requiring extra retrieval time. In addition, legal concerns around data privacy by building departments required intervention by CPUC legal staff on several occasions. It was a slow process, but as issues resolved we were eventually able to access building plans. We show the distribution of these plans by building type and region in Table 13.

Table 13: Project Sample (ALL)

| | Region A | | Region B | | Region C | | All Regions | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sector** | **ALT** | **NC** | **ALT** | **NC** | **ALT** | **NC** | **ALT** | **NC** | **Total Sample** | **Sector Share of Total** |
| Residential | 17 | 51 | 3 | 10 | 4 | 39 | N/A | N/A | 124 | 42% |
| Nonresidential – Office | 21 | 1 | 0 | 1 | 15 | 5 | N/A | N/A | 43 | 15% |
| Nonresidential – Education | 1 | 0 | 0 | 0 | 5 | 2 | N/A | N/A | 8 | 3% |
| Nonresidential – Retail | 5 | 0 | 1 | 1 | 19 | 9 | N/A | N/A | 35 | 12% |
| Nonresidential – Food Service | 9 | 3 | 1 | 0 | 26 | 11 | N/A | N/A | 50 | 17% |
| Nonresidential – All Others | -- | -- | -- | -- | -- | -- | 23 | 11 | 34 | 11% |
| **Total Sample** | **53** | **55** | **5** | **12** | **69** | **66** | **23** | **11** | **294** | **100%** |
| **Region Share of Total** | **37%** | | **6%** | | **46%** | | **11%** | | | |

*Note*: ALT is Alterations, NC is New Construction

A note about the residential sample: The portion of multifamily versus single-family projects could not be quantified based on the Dodge population dataset due to coding and definition inconsistencies. We asked building departments (via phone and email) specifically for 2016 Title 24 residential single-family projects. The plans they provided included single-family and multifamily projects and projects under the 2019 Title 24 code.

### 4.2.3 ESAF Rates

Table 14 provides an overview of the ESAF rates we assigned to each code for this evaluation. Details are provided in the remainder of this section.

Table 14: Energy Savings Adjustment Factor Summary

| Measure ID | Measure Name | IOU ESAF % | Evaluated ESAF % | Evaluation Difference % |
|---|---|---|---|---|
| Std B101 | T-24 – NRA-Lighting-Alterations | 95 | 98 | 2 |
| Std B102 | T-24 – NRA-Lighting-Outdoor Lighting Controls | 95 | 95 | -- |
| Std B103 | T-24 – NRA-Lighting-ASHARE Elevator Lighting & Ventilation | 95 | 95 | -- |
| Std B105 | T-24 – NRA-HVAC-ASHARE Measure-DDC | 95 | 95 | -- |
| Std B106 | T-24 – NRA-HVAC-ASHRAE Equipment Efficiency | 95 | 95 | -- |
| Std B107 | T-24 – NRA-Process-ASHARE Measure-Escalator Speed Control | 95 | 95 | -- |
| Std B121 | Nonresidential New Construction (NRNC) – Whole Building[1] | 95 | 96 | 1 |
| Std B130 | Residential New Construction (RNC) – Single Family Whole Building[1] | 95 | 100 | 5 |
| Std B131 | RNC –Multifamily Whole Building[1] | 95 | 95 | -- |
| Std B132 | RA – Single-Family Whole Building[1] | 95 | 95 | -- |
| Std B133 | RA – Multifamily Whole Building[1] | 95 | 95 | -- |

*Note*: NRA = nonresidential alterations, NRNC = nonresidential new construction, RA = residential alterations, RNC = residential new construction.

The next two subsections report the findings from on-site visits to verify minimum equipment requirements and compare these to the approved building plans.

### 4.2.4 Sample Precision

Once we developed compliance estimates, we calculated the margin of error given our sample sizes. For each sector, the unit for the sample size is "number of buildings visited" (e.g., one residential building is a single-family home,1 nonresidential building is one of the building types as described by the California Energy Commission (i.e., restaurants, grocery stores, retail store, office building, school, warehouse, etc.)[36]. The condition was binary. Did the equipment in the building meet the criteria specified in the building plan and energy compliance documentation?

The CPUC's *California Energy Efficiency Evaluation Protocols* states that the target relative precision for gross savings impacts is 90% confidence with 30% precision (90/30).[37] For basic verification the target relative precision is 90/10.

Our statewide samples of compliance for the residential and nonresidential sectors, and all sites combined, exceeded this target. See Table 15 for details.

Table 15: Sample and Margin of Error

| Sector | Sample Size | Confidence Level | Margin of Error |
|---|---|---|---|
| Residential | 38 | 90% | ±8.0% |
| Nonresidential | 115 | 90% | ±4.6% |
| All Statewide | 153 | 90% | ±4.0% |

[3636] 2016 Nonresidential Compliance Manual, Chapter 1 Introduction, p 9, January 2017, https://www.energy.ca.gov/filebrowser/download/2372

[37] PUC (2006). "California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals." Table 20 - 23, pp.95, 167. https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5212

We calculated the margin of error using Equation 2:

Equation 2 Degree of Precision (aka Margin of Error)

$$Z * \sqrt{\frac{p * (1 - p)}{n}}$$

where,

**Z** = the Z-value for the selected confidence level (from look-up table)

**p** = the sample proportion

**(1 – p)** = confidence level

**n** = the sample size

## 4.3 Residential ESAF

### 4.3.1 Findings Overview

Overall, we assigned residential new construction an ESAF of 1.0. Of the eighty-nine new construction sites that qualified for our sample, we were able to fully inspect 28 homes. We found windows, doors, insulation, and lighting conformed to the details in the Title 24 Certificate of Compliance documentation.

### 4.3.2 Residential New Construction (Std B130)

As mentioned previously, for this evaluation, new construction homes were deemed compliant if,

1. Mandatory measures were present, and
2. The physical dwelling matched its Title 24 Certificate of Compliance documentation.

Region A included smaller homes and ADU construction; however, recruitment was more successful in Region A, which resulted in a higher weight. Regions B and C included larger tract homes in subdivisions, but homeowners were reluctant to participate despite the proffered $100 VISA gift card.

In our sample, we found key elements such as insulation, windows, and radiant barriers were installed as expected. We also used infrared (IR) photography to potentially show insulation leaks. Figure 19 through Figure 23 provide examples of two views of a dwelling: standard photo and IR photo. The IR photos illustrate temperature variations on surfaces. The scale is in degrees Fahrenheit. Blue color ranges denote lower temperatures while red and white denote higher temperatures. The key point to note, however, is the temperature differential between surfaces as indicated by the colors, rather than the actual temperature reading.

We did find instances of heat pump water heater installations that were consistent with building plans. In several cases, we found instantaneous water heaters had been installed and credits for these units were used to offset penalties for cooling and to a lesser degree space heating. Example instantaneous water heating units are shown in Figure 18.

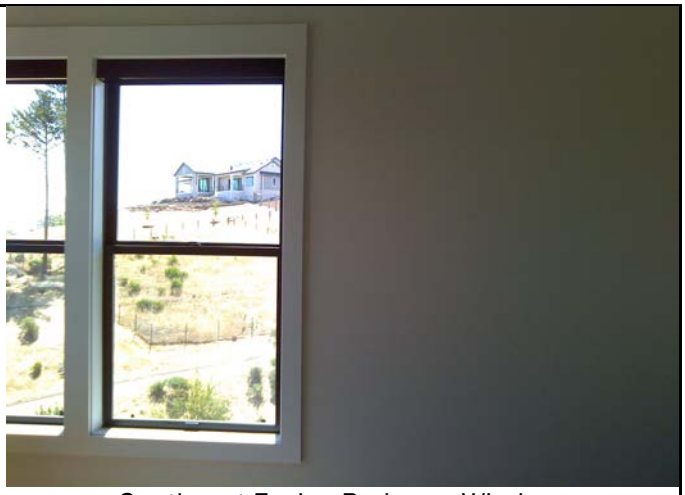
Figure 18: Instantaneous Water Heater Examples

| | |
|---|---|
|  |  |
| Region C (gas) | Region A (gas) |

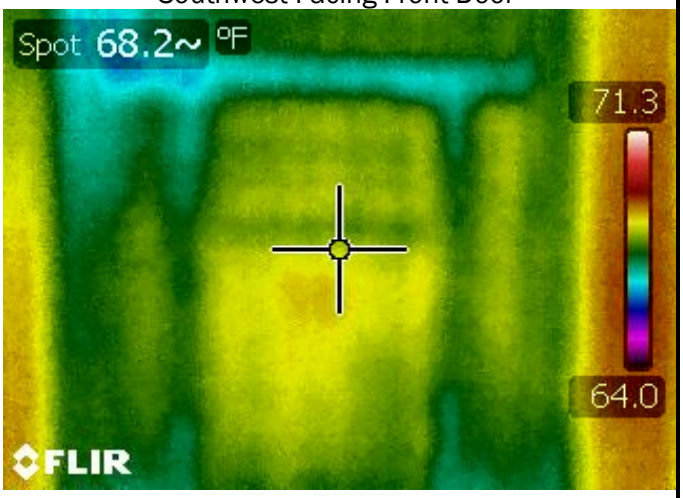
The normal and thermal images of a solid door and a bedroom wall with window, taken during the summer in Region A, are shown in Figure 19. Temperature differential in both photos indicates cooler walls and doors. The vinyl frame on the window is clearly warmer than the windowpanes themselves. This is to be expected with high-efficiency windows and wall insulation.

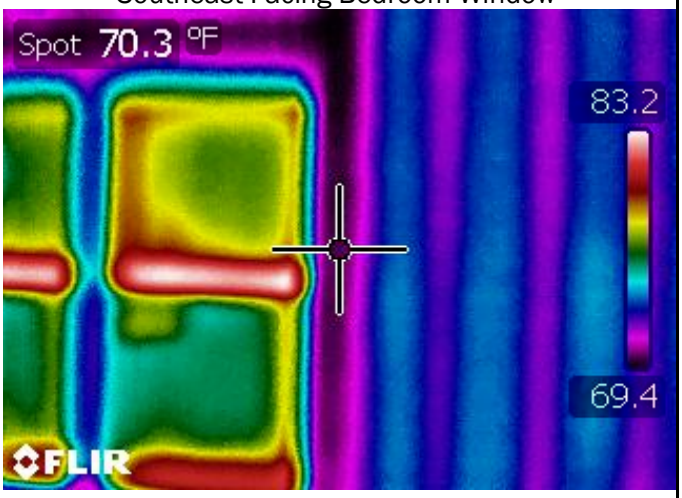
Figure 19: Standard and Thermal Photos of Region A Home (New Construction Interior)

Southwest Facing Front Door



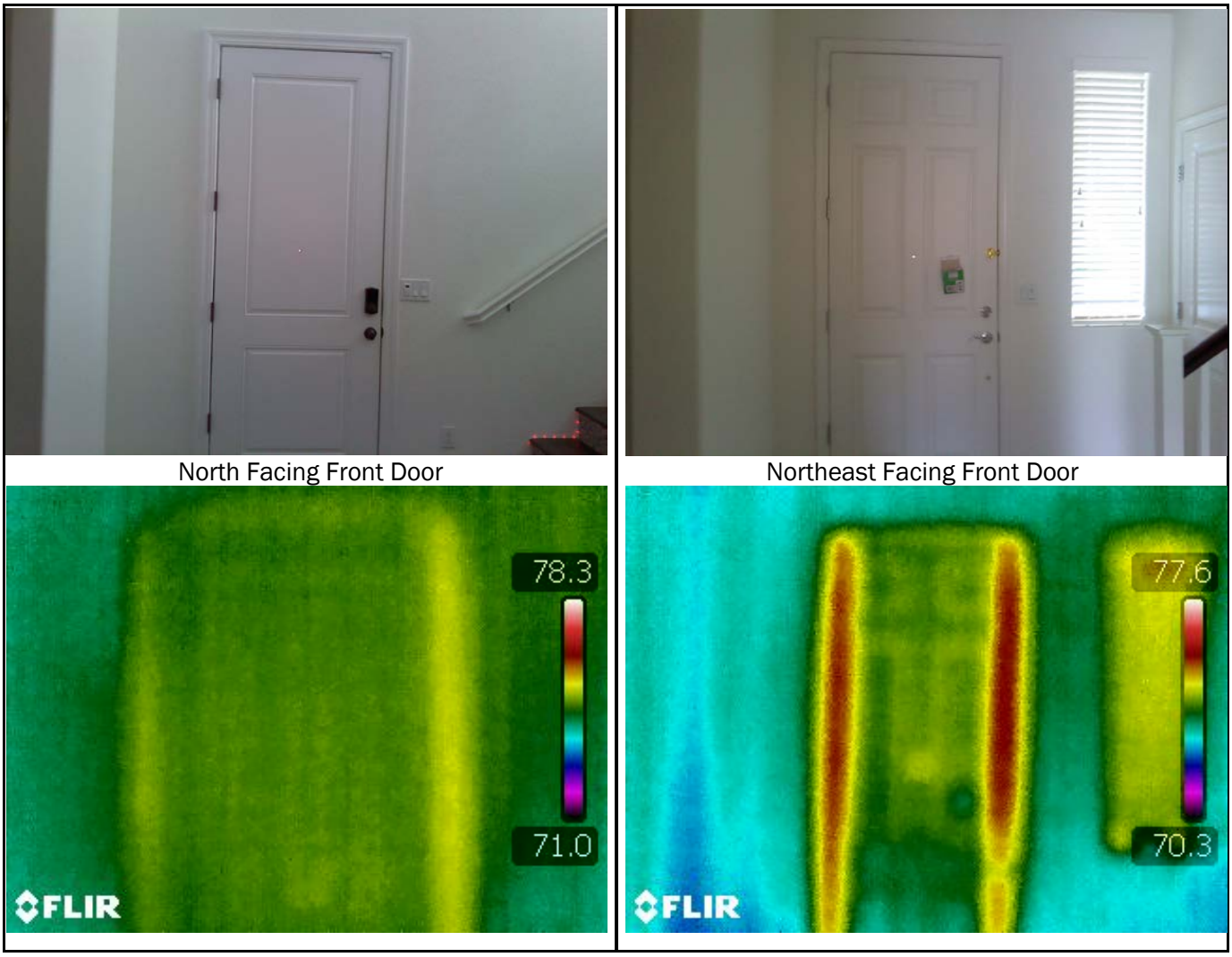
Southeast Facing Bedroom Window



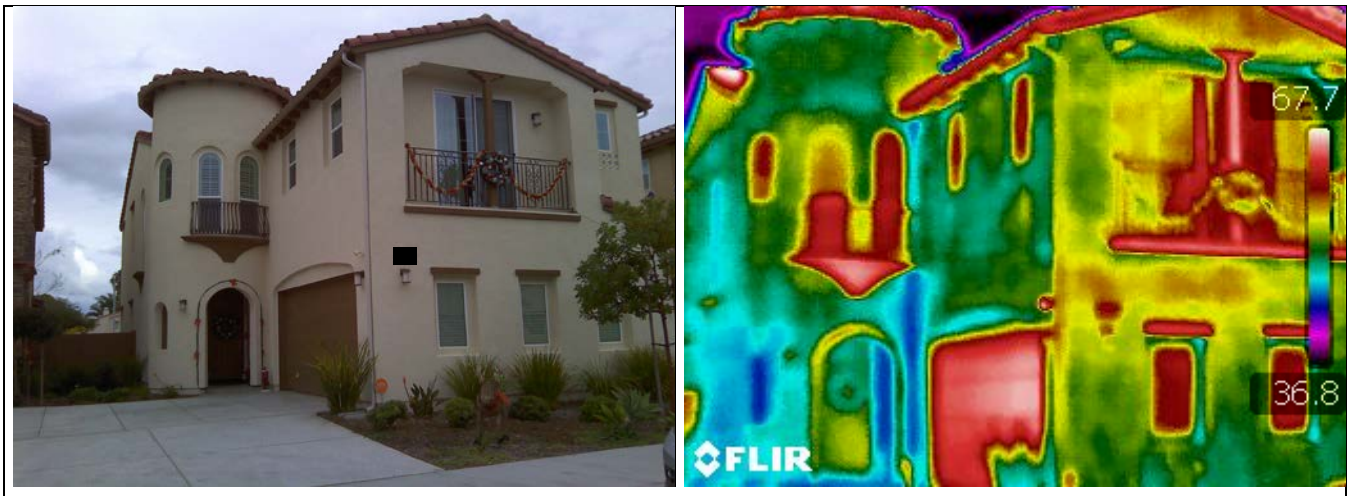

In Figure 20, we show the front doors of two homes within the same subdivision for comparison. Both doors look similar in the standard (top) photos; however, differences are clearly visible in the IR photos. The IR photo on the left displays consistent temperatures across the walls and door (indicating consistent and complete insulation and solid core doors). The IR photo on the right also displays the walls and door with consistent temperatures but shows higher temperatures on the left and right side of the door frame, which could indicate that the air seals on those sides are damaged or missing. Even though both homes include "to code" elements, quality control during construction (for different builders in this example) is not consistent. This condition was an anomaly in our sample, but the degree of this type of inconsistency may degrade overall energy savings.

Figure 20: Standard and Thermal Photos of Region B Home (New Construction Front Doors)




The photos in Figure 21 show a two-story home in Southern California with a west-facing front. The image on the left is the exterior of a home built under the 2016 Title 24 code. The image on the right is the same home viewed through an IR camera.

Figure 21: Standard and Thermal Photos of Region C Home (New Construction Exterior)

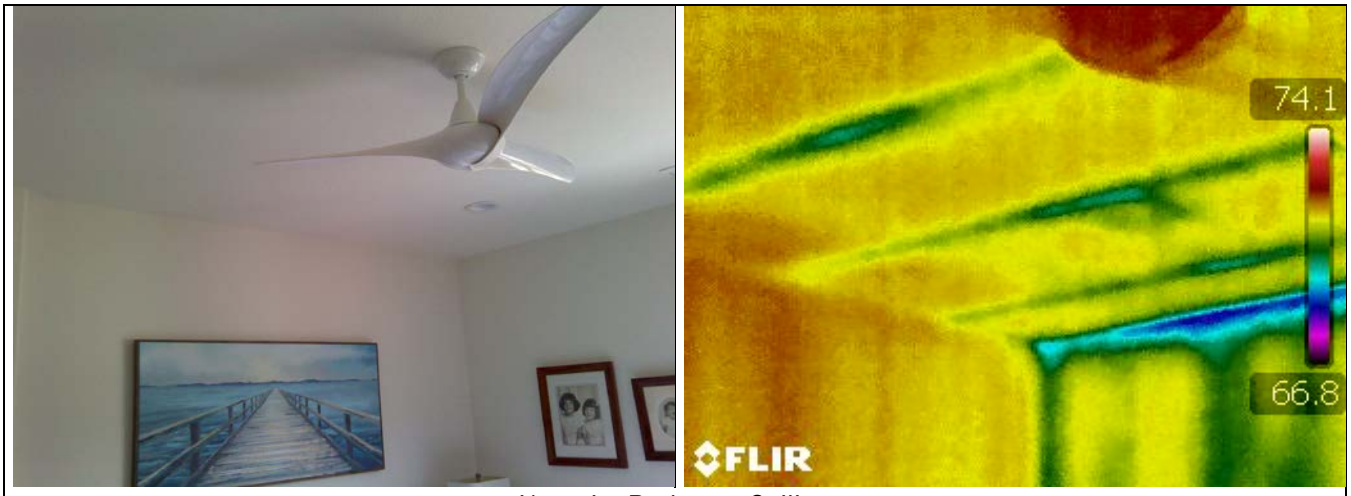



West Facing Home

In Figure 21, the temperature differential is about 31°F. In the IR photo, the surface of the metal balconies, metal garage door, metal roof trim and window surfaces are hotter relative to the rest of the structure, which indicates they are radiating heat. The colors of the home's wall surface, windows, and roof indicate these surface areas are cooler (i.e., radiating less heat).

Figure 22 shows the upstairs bedroom of a two-story home. The wall on the right is an exterior wall. The wall on the left is an interior wall. In the IR photo (right), the ceiling beams are visible and record as cooler than the surrounding walls. The band of light and dark blue shows that the ceiling line (arris) possesses a lower temperature (by a couple of degrees) than the walls. The red dome in the foreground is the ceiling fan.

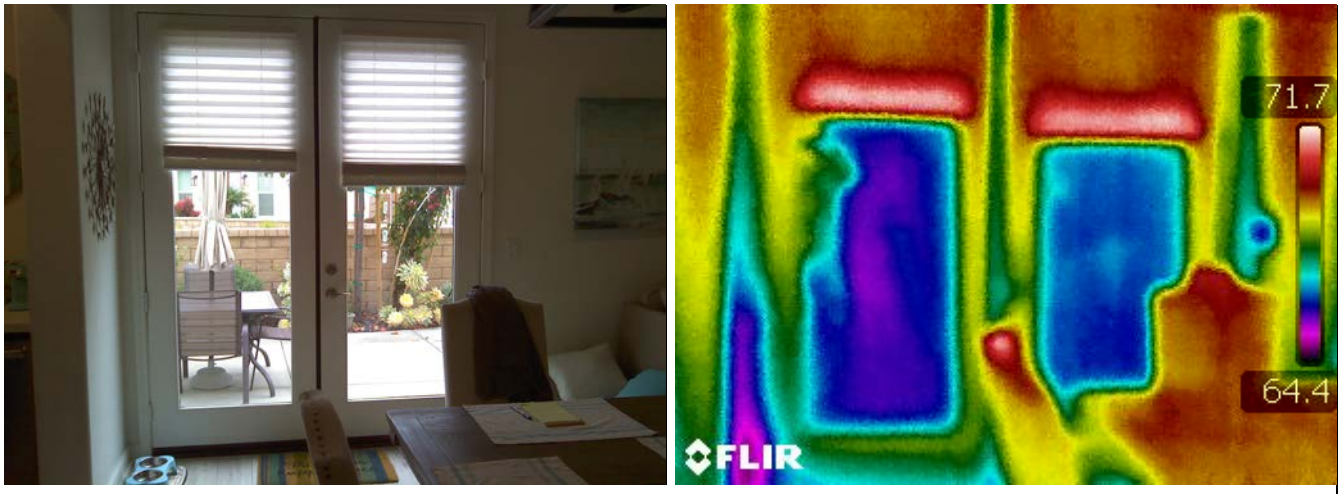
Figure 22: Standard and Thermal Photos of Region C Home (New Construction Interior)




Upstairs Bedroom Ceiling

The next figure, Figure 23, depicts patio doors from a dining room. The entire temperature differential is s7°F. Still, the IR photo (right) reveals the door glass is cooler than the shades covering them. The metal frames of the blinds are the warmest areas in the room. In the foreground, the yellow and reddish colors show the dining room chairs and table at "room temperature." The blue circle in the middle right is the light switch.

Figure 23: Standard and Thermal Photos of Region C Home (New Construction Interior)




Patio Doors Southwest facing

### 4.3.3 Forward Looking Information

In addition to reviewing major components of homes, field personnel looked for functioning solar panels and evidence of electrification. Specifically, we proactively sought out electric vehicle chargers, induction stoves, "smart" water heaters, and heat pump water heaters. In total we found no homes with solar panels. One home had a wall mounted EV charger installed and two homes (listed as alterations) had smart water heaters.

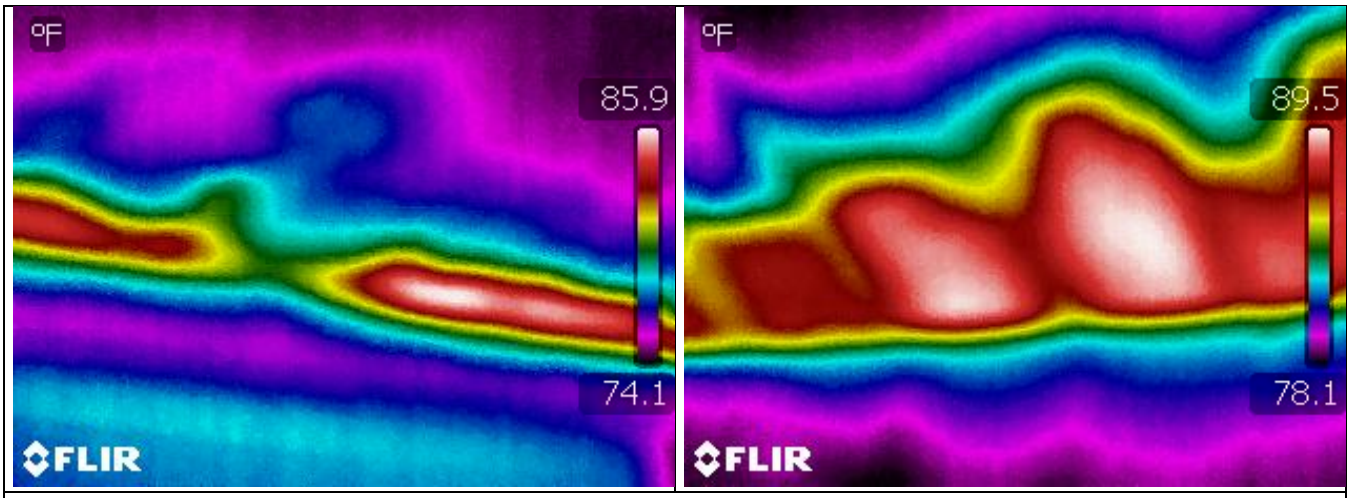
### 4.3.4 Residential Alterations (Std B132)

Residential alterations, or remodels, may add square footage, renovate a room such as a bathroom or kitchen, or both. While adding square footage or changing interior spaces usually requires a permit and inspections, anecdotal evidence suggests that not all alterations are permitted. We had 24 projects in our sample and were able to visit nine. All nine projects matched the elements of their compliance documentation. Due to this small sample size and the uncertainty that comes with it, we kept the ESAF rate for alterations consistent with the IOU claim at 95%.

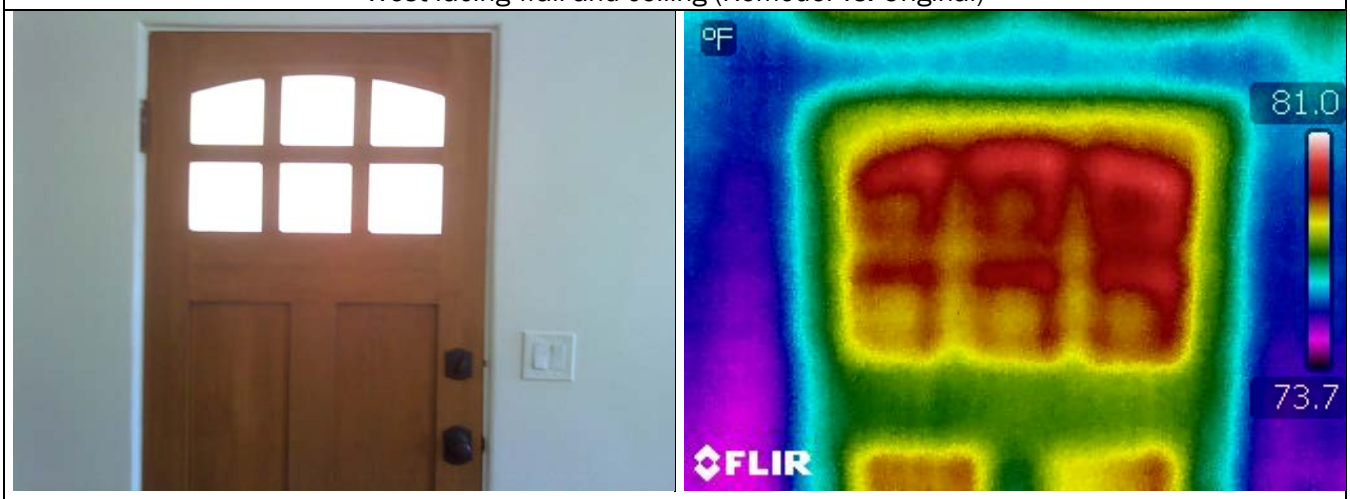
Figure 24 shows a 1,186 square foot home originally built in 1943. This is a residential alteration where only a part of the home was remodeled under 2016 Tile 24 requirements. The alteration includes a 40-gallon storage electric water heater and a heat pump. All photos were taken during a summer afternoon.

The upper photos show the home's west facing wall. The image on the left (remodel) displays cooler temperatures on the ceiling and wall, while the image on the right (original) displays warmer temperatures. The lower photos show the front door. The IR photo shows that the thinner areas of the door (windows and panel inserts) show as warmer than the thicker sections.

Figure 24: Standard and Thermal Photos of Region A Partial Alteration




West-facing wall and ceiling (Remodel vs. Original)




West-facing wall and ceiling (Remodel vs. Original)

We verified the as-built residential alterations matched with the approved plans as described in the building plans and Certificate of Compliance documents. We were able to fully inspect ten homes (outside and inside). Energy Savings is capped at 100%, as discussed in Section 3.2. Due to the consistency of our findings, we assigned a ESAF of 1.0 to new construction (B130). For alterations (B132), projects matched plans. When looking at TDV calculations the square foot weighted average improvement beyond TDV was less than 1.0% (0.4%). To account for the wider differences in residential alteration designs and implementation however, we applied the IOU estimated value of 0.95.

Table 16: Summary of ESAF Findings, by Code

| Code | IOU Claim Name | IOU ESAF Estimate | Evaluated ESAF Estimate | Difference |
|---|---|---|---|---|
| B130 | New Construction – Single Family Whole Building | 95.0% | 100.0% | 0.0% |
| B132 | Alterations – Single Family Whole Building | 95.0% | 95.0% | 0.0% |

## 4.4 Nonresidential ESAF

The nonresidential portion of this evaluation focused on two IOU savings claims,

- Lighting alterations, and
- Whole building new construction.

We targeted four building types:

- Education
- Food service (casual dining and fast food)
- Retail
- Office

Also included was an "Other" category to capture broader building activity in each jurisdiction (e.g., medical offices, grocery stores, or cannabis warehouses). The sample covered nine Title 24 climate zones.

We used the plan reviews and on-site verifications to disposition each site into one of the following four categories:

- **A= OK** (equipment and specifications confirmed, no discrepancies)
- **B= Indeterminant** (not enough detail or some equipment inaccessible for inspection, but sufficient match with plan to presume compliance)
- **C= Discrepancies** (equipment specifications do not match plan or systems not installed)
- **D= Eliminate** (not in scope; examples include a project that was not started, unfinished, or a vacated site)

For the nonresidential sector, the evaluation team created a "pass/fail" scoring system. We treated A and B as a "pass" and C as a "failure." We did not calculate a TDV weighted average for the nonresidential sample. For lighting alterations and new construction, a majority of the sample (71% and 67%, respectively) fell into categories A or B. Category C accounted for 2% and 3% of alterations and new construction, respectively. The "fails" were driven by lighting and occurred in small restaurants and one retail store. The remaining alternations and new construction sites fell into category D (27% and 31%, respectively). A summary of ESAF estimates is shown in Table 17. Detailed observations from the on-site inspections are provided in Section 4.4.2.

Table 17: Summary of ESAF Findings, by Code

| Code | IOU Claim Name | IOU ESAF Estimate | Evaluated ESAF Estimate | Difference |
|---|---|---|---|---|
| B101 | T-24 – NRA-Lighting Alterations | 95.0% | 97.7% | 2.7% |
| B121 | Nonresidential New Construction (NRNC) – Whole Building | 95.0% | 96.0% | 1.0% |

*Note*: NRA = nonresidential alterations, NRNC = nonresidential new construction

### 4.4.1 Nonresidential Lighting Alterations (Std B101)

The evaluation team focused on interior lighting alterations for nonresidential structures since the IOU claim specified lighting alterations. To verify lighting, we compared the 2016 Title 24 lighting documentation with the physical space at 89 sites. Lighting fixture and controls counts were compared to post-alteration spaces.

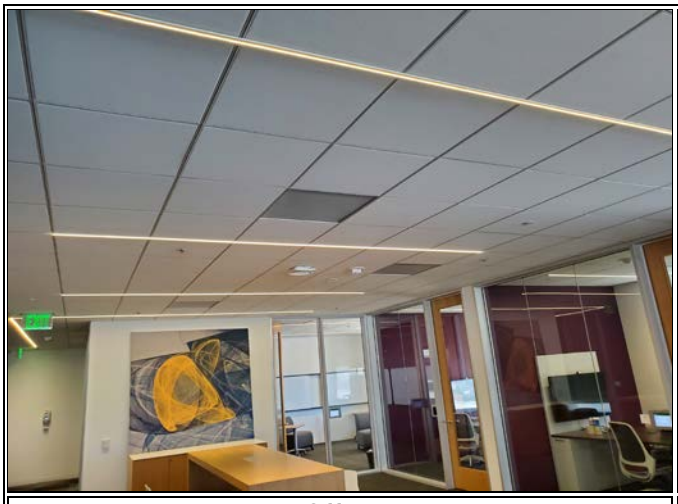
Most alterations were in Retail and Food Service buildings. For lighting alterations, we found that the "as-built" lighting configurations matched the building permit configurations in our sample. The climate zones and building types for the site visits are listed in Table 18.

Table 18: Nonresidential Site Visit Composition (Lighting Alterations)

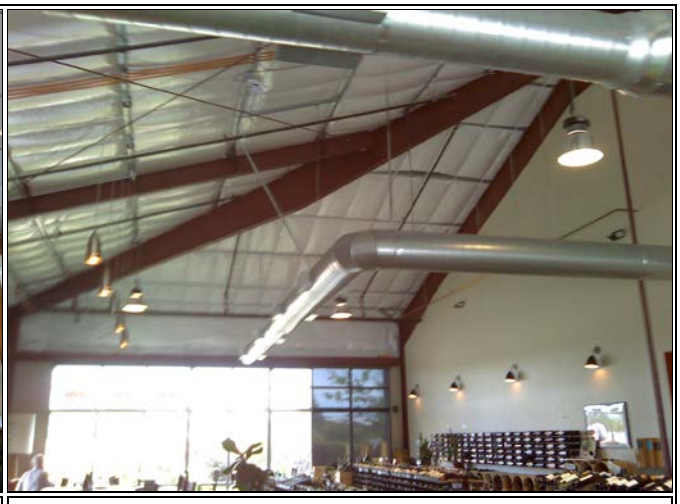
| Climate Zone | Education | Food Service | Office | Other | Retail | Total | Contribution |
|---|---|---|---|---|---|---|---|
| 1 | -- | -- | -- | -- | -- | -- | -- |
| 2 | -- | -- | 2 | 3 | -- | 5 | 6% |
| 3 | -- | 4 | 9 | 2 | -- | 15 | 17% |
| 4 | 1 | 3 | 7 | 1 | 2 | 14 | 16% |
| 5 | -- | 1 | 1 | 1 | 2 | 5 | 6% |
| 6 | -- | 11 | 4 | 1 | 5 | 22 | 25% |
| 7 | 1 | 4 | -- | 1 | 4 | 10 | 11% |
| 8 | 1 | 2 | 2 | 2 | 1 | 7 | 8% |
| 9 | -- | -- | -- | -- | -- | -- | -- |
| 10 | -- | 5 | 4 | 2 | 2 | 9 | 10% |
| 11 | -- | -- | -- | -- | -- | -- | -- |
| 12 | -- | -- | 1 | -- | -- | 1 | 1%-- |
| 13 | -- | -- | -- | -- | -- | -- | -- |
| 14 | -- | -- | -- | -- | -- | -- | -- |
| 15 | -- | -- | -- | -- | -- | -- | -- |
| 16 | -- | -- | -- | -- | -- | -- | -- |
| **Total** | **3** | **30** | **30** | **13** | **17** | **88** | **100%** |

We found a broad range of lighting configurations during the on-site inspections. Alteration lighting designs included blending LED and specialty incandescent in some instances. Four examples of lighting alteration projects are provided in Figure 25.

Figure 25: Lighting Alteration Examples



Office



Retail

Library

Cannabis warehouses

### 4.4.2 Nonresidential New Construction (Std B121)

For new construction, our evaluation was focused on equipment such as lighting, HVAC, and hot water. For alteration, the focus was solely on lighting. As a result, we did not use IR photography in the nonresidential sector to collect data on building envelopes. The climate zones and building types from the site visits are listed in Table 19.

Table 19: Nonresidential Site Visit Composition (New Construction)

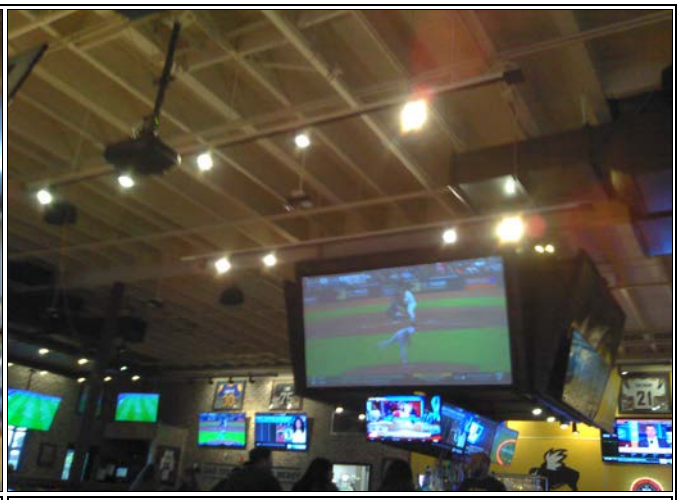
| Climate Zone | Education | Food Service | Office | Other | Retail | Total | Contribution |
|---|---|---|---|---|---|---|---|
| 1 | -- | -- | -- | -- | -- | -- | -- |
| 2 | -- | -- | -- | 1 | -- | 1 | 4% |
| 3 | -- | 1 | -- | 1 | -- | 2 | 7% |
| 4 | -- | 1 | -- | -- | -- | 1 | 4% |
| 5 | -- | -- | -- | -- | -- | -- | -- |
| 6 | -- | 1 | -- | -- | 1 | 2 | 7% |
| 7 | -- | 4 | -- | 3 | 3 | 10 | 37% |
| 8 | -- | -- | 1 | -- | -- | 1 | 4% |
| 9 | -- | -- | -- | -- | -- | -- | -- |
| 10 | -- | 3 | 3 | -- | 1 | 7 | 26% |
| 11 | -- | -- | -- | -- | -- | -- | -- |
| 12 | -- | -- | 1 | 1 | 1 | 3 | 11% |
| 13 | -- | -- | -- | -- | -- | -- | -- |
| 14 | -- | -- | -- | -- | -- | -- | -- |
| 15 | -- | -- | -- | -- | -- | -- | -- |
| 16 | -- | -- | -- | -- | -- | -- | -- |
| **Total** | **0** | **10** | **5** | **6** | **6** | **27** | **100%** |

Figure 26 shows the interiors of four new construction projects. The photo on the upper left shows a building built to plan, but the plan called mostly for incandescent lighting (75- and 60-Watt luminaires). The incandescent lighting was offset by credits for daylight and dimming controls. The photo on the upper right shows a comparable size establishment (note the high plug loads from TV monitors and signage).

The two lower photos are of a grocery store. The image on the lower left shows that lighting from the skylights is sufficient to substitute for the powered lighting (turned off in foreground). The photo on the right shows three gas-fired instantaneous water heaters in the same store.

Figure 26: New Construction Interior Examples

Food Service Dining Room



Food Service

Retail Interior Skylights

Grocery Store Water Heaters (Gas)

Figure 27 shows rooftops on four new construction projects. The photo on the upper left includes two York heat pumps. The photo on the upper right shows one bank of six Trane XR14 heat pumps and a Mitsubishi split-system heat pump. The lower left includes a Daikin heat pump, Lochinvar gas boiler, NEMA motors, and other equipment. The photo on the bottom right shows a set of Carrier "EcoBlue$^{tm}$" heat pumps, as part of a 92,893 square foot office / warehouse building.

Figure 27: New Construction Rooftop Examples

Office Heat Pumps

Hotel Packaged and Split System Heat Pump

Office Heat Pumps, etc.

Office / Warehouse Heat Pumps

## 4.5 Net Program Energy Savings

For C&S advocacy programs, everyone is a non-participant even when they are directly affected by the program outcome (i.e., a new code or standard). This is because C&S affects the entire market but has no "participant" data set. As a result, the C&S evaluation equivalent of a net-to-gross ratio is calculated by combining two components: NOMAD and Attribution. This is a key distinction from typical incentive-based resource programs because the CEDARS claim only provides only net-to-gross input field for reporting. This section walks through the findings for NOMAD and Attribution the evaluation team used to develop net savings,

### 4.5.1 NOMAD

This section summarizes the NOMAD results for each of the standards in the evaluation scope that are not "high priority" codes. In 2018, the four high priority codes made up over 84% of new code evaluated kWh savings and 13% of all evaluated C&S kWh savings.[38] NOMAD for medium and low priority codes were

[38] In 2018, the high priority standards accounted for 88% of new IOU C&S kWh savings claims and 22% of all CS& kWh claims.

reviewed for reasonableness but not subject to the NOMAD survey. Section 4.5.1 includes product-specific insights from the survey respondents, as well as the NOMAD results for each product. The charts illustrating the NOMAD results include an area showing the range of responses among the experts to provide context for the varied predictions of the NOMAD curve. The results and the range do not include the first-round responses and are only representative of the second-round Delphi responses.

The majority of the evaluated NOMAD rates were consistent with IOU claimed rates—within 15%—especially in the early years of the 30-year timeframe. Detailed graphs are provided in Appendix E.

Table 20 provides a summary of the NOMAD rate evaluated for each of the building codes. The table also compares our evaluation results to the claims presented in CCSRs and other documentation the IOUs provided to the evaluation team. The evaluation team evaluated the range of time between 2015 and 2030. The summary tables below compare evaluated results to IOU results in two example years: 2017 and 2018.

Table 20: Summary of NOMAD Findings for State Building Codes

| Standard | Building Code | Natural Market Adoption 2017 | | | Natural Market Adoption 2018 | | |
|---|---|---|---|---|---|---|---|
| | | IOU Estimate | Evaluated Estimate | Difference * | IOU Estimate | Evaluated Estimate | Difference * |
| Std B101 | Nonresidential – Lighting Alterations | 18% | 18% | 0% | 21% | 20% | (1%) |
| Std B121 | Nonresidential – New Construction of Whole Buildings | 18% | 27% | 9% | 21% | 30% | 9% |
| Std B130 | Residential New Construction – Single-Family Whole Buildings | 5% | 5% | (2%) | 8% | 5% | (3%) |
| Std B132 | Residential Alteration – Single-Family Buildings | 92% | 78% | (14%) | 92% | 79% | (14%) |

## 4.5.2 Attribution

This section summarizes the Attribution results for each of the "high priority" codes in the evaluation scope, as defined in Section 4.3. Attribution was not estimated for the pass-through claims since net savings values from CEDARS were adopted and "passes-through" to the evaluation results. Details for these scores are provided in Appendix G.

Table 21: Summary of Attribution Findings for State Building Codes

| Standard | Building Code | Attribution | | | |
|---|---|---|---|---|---|
| | | IOU Estimate | Evaluated Estimate | Difference # | Difference % |
| Std B101 | Nonresidential – Lighting Alterations | 0.750 | 0.573 | 0.177 | -24% |
| Std B121 | Nonresidential New Construction – Whole Buildings | 0.750 | 0.507 | 0.244 | -32% |
| Std B130 | Residential New Construction – Single-Family Whole Buildings | 0.750 | 0.678 | 0.072 | -10% |
| Std B132 | Residential Alterations | 0.750 | 0.678 | 0.072 | -10% |

Attribution for nonresidential whole building (B121) is the average of attribution scores for six codes (B108, B109, B111, B113, B115 and B116). Attribution for nonresidential lighting alterations (B101) was the average of three codes (B108, B109, and B111). For residential single-family whole building new construction attribution was an average of B122, B123, and B124).

### 4.5.3 Allocation of Savings by IOU

The final adjustment to statewide savings estimates is allocating savings to IOUs. Building code savings are calculated on a statewide basis because the code applies equally across the state. Most energy sales occur in the IOU service areas, but the IOUs do not supply electricity and gas across the entire state. These other areas consist of municipal providers, cooperatives, irrigation districts, and companies not regulated by the CPUC. For this evaluation, we use California Energy Commission Energy Reports by planning region sales of electric and gas volumes to allocate savings. Gas sales were adjusted by removing non-retail sales and recalculating the allocations. This view provides a fuller picture of savings for distribution system planning. For electricity, it includes some of the smaller non-IOU areas for planning purposes. The factors for each IOU are applied to statewide savings based on planning areas and presented in Table 22. Savings from outside IOU planning areas are excluded.

Table 22: Electric and Gas Sales Allocation Factors by Planning Area (IOU only)

| | 2017 | | 2018 | |
|---|---|---|---|---|
| | Electricity | Gas | Electricity | Gas |
| PG&E | 45.3% | 38.2% | 45.1% | 38.5% |
| SCE | 45.4% | 0.0% | 45.7% | 0.0% |
| SCG | 0.0% | 58.0% | 0.0% | 57.7% |
| SDG&E | 9.3% | 3.9% | 9.3% | 3.9% |
| **Total** | **100.0%** | **100.0%** | **100%** | **100%** |

## 4.6 Evaluated vs. IOU Claim Savings

The C&S protocols do not use a typical net-to-gross ratio to estimate net savings. Instead, moving from gross to net requires application of NOMAD and Attribution estimates. In this section, we outline each step of the process we used to ascertain the evaluated net savings. Specifically, we started with gross savings (developed from multiplying evaluated potential savings by evaluated ESAF. We then applied the NOMAD and Attribution estimates to derive evaluated net savings at the statewide level. To credit savings to the IOUs, we applied an allocation factor based on energy sales data provided by the California Energy Commission. Finally, we compared the resulting IOU-only evaluated net savings to the IOU savings claims filed in CEDARS.

Codes with effective dates before 2017 were included in prior evaluations. The savings from those codes are not part of this evaluation scope and are "passed through" from claim totals to evaluation totals. New codes accounted for 13% of all code savings in 2017. By program year 2018, the new codes contribution was approaching one third (27%) of the evaluated kWh savings.

### 4.6.1 Net Statewide Savings

Combining the data and parameters developed in Sections 4.1, 4.2, and 4.5 results in the evaluated net statewide savings presented in Table 24. The IOU savings reported in CEDARS are presented in Table 25 and a comparison of the two is presented in Table 26.

The savings are split into two groups. The first group, "Prior Codes," represents the residual savings from the 108 prior code savings claims. These represent new codes with first-year effective dates from 2005 through 2015. Those codes were included in prior evaluations. The other group "New Codes" represents codes resulting from the 11 new 2016 Title 24 changes and are the subject of this evaluation.

Table 23: Statewide Net Savings (Evaluated)

| Codes Only | Savings from Evaluation | | | | |
|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | Total | Contribution |
| **Savings kWh** | | | | | |
| Prior Codes | 700,612,648 | 615,368,699 | 609,971,995 | 1,925,953,342 | 90% |
| New Codes | 0 | 105,401,657 | 112,106,259 | 217,507,916 | 10% |
| **Total** | **700,612,648** | 720,770,356 | 722,078,254 | 2,143,461,258 | **100%** |
| | | | | | |
| **Savings kW** | | | | | |
| Prior Codes | 180,218 | 135,788 | 128,127 | 444,134 | 82% |
| New Codes | 0 | 46,418 | 50,733 | 97,151 | 18% |
| **Total** | **180,218** | 182,206 | 178,860 | 541,285 | **100%** |
| | | | | | |
| **Savings Therm** | | | | | |
| Prior Codes | 14,630,132 | 13,227,870 | 12,119,775 | 39,977,779 | 82% |
| New Codes | 0 | 4,282,504 | 4,480,644 | 8,763,148 | 18% |
| **Total** | **14,630,132** | 17,510,374 | 16,600,419 | 48,740,925 | **100%** |

Table 24: Statewide Net Savings (IOU Claim)

| Codes Only | Savings from Claims | | | | |
|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | Total | Contribution |
| **Savings kWh** | | | | | |
| Prior Codes | 700,612,648 | 615,368,699 | 609,971,995 | 1,925,953,342 | 86% |
| New Codes | 0 | 103,036,273 | 208,491,987 | 311,528,260 | 14% |
| **Total** | 700,612,648 | 718,404,972 | 818,463,982 | 2,237,481,602 | 100% |
| | | | | | |
| **Savings kW** | | | | | |
| Prior Codes | 180,218 | 135,788 | 128,127 | 444,133 | 76% |
| New Codes | 0 | 42,721 | 97,590 | 140,311 | 24% |
| **Total** | 180,218 | 178,509 | 225,717 | 584,444 | 100% |
| | | | | | |
| **Savings Therm** | | | | | |
| Prior Codes | 14,630,132 | 13,227,870 | 12,119,775 | 39,977,777 | 70% |
| New Codes | 0 | 5,830,325 | 11,605,370 | 17,435,695 | 30% |
| **Total** | 14,630,132 | 19,058,195 | 23,725,145 | 57,413,472 | 100% |

Table 25: Difference Between Claim and Evaluated

| Codes Only | Evaluation – Claim | | | |
|---|---|---|---|---|
| | 2016 | 2017 | 2018 | Total |
| **Savings kWh** | | | | |
| Prior Codes | 0 | 0 | 0 | 0 |
| New Codes | 0 | 2,365,384 | (96,385,728) | (94,020,344) |
| **Total** | 0 | 2,365,384 | (96,385,728) | (94,020,344) |
| | | | | |
| **Savings kW** | | | | |
| Prior Codes | 0 | 0 | 0 | 0 |
| New Codes | 0 | 3,697 | (46,857) | (43,160) |
| **Total** | 0 | 3,697 | (46,857) | (43,160) |
| | | | | |
| **Savings Therm** | | | | |
| Prior Codes | 0 | 0 | 0 | 0 |
| New Codes | 0 | (1,547,821) | (7,124,726) | (8,672,547) |
| **Total** | 0 | (1,547,821) | (7,124,726) | (8,672,547) |

Caution should be used when interpreting IOU savings data. Given that the reported savings includes savings from codes with effective dates starting in 2005, using total program savings from current year CEDAR reports can obfuscate the effects of the most recent code cycle. For example, for program years 2016 through 2018 the IOU reported 2,143 GWh of savings from code advocacy efforts. The current code cycle that includes 2017 and-2018 contributed 10% of that (217 GWh).

Figure 28 shows a comparison of savings from the individual new codes to the evaluated savings. The key differences are in nonresidential lighting alterations (B101), nonresidential new construction (B121), residential new construction (B130), and residential alterations (B132). The primary driver of these differences was not savings per unit or ESAF. As discussed in Section 4.1, we simply estimated a lower number of units for these categories.

Figure 28. New Claim vs. Evaluation Savings 2018

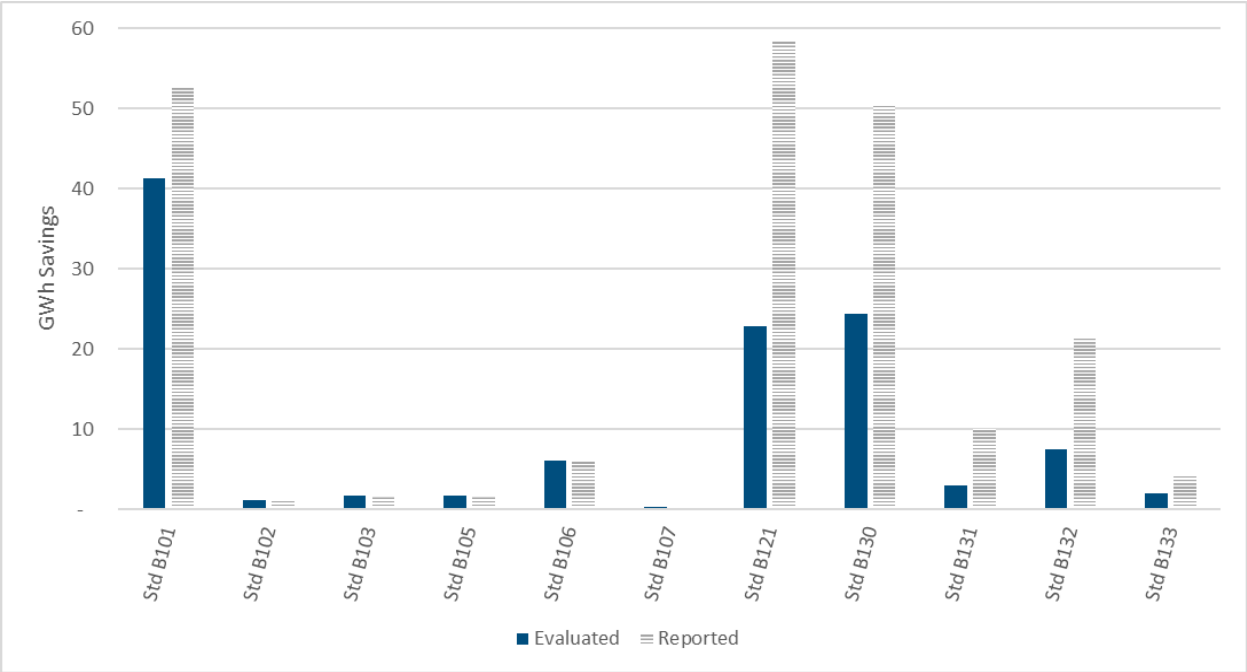
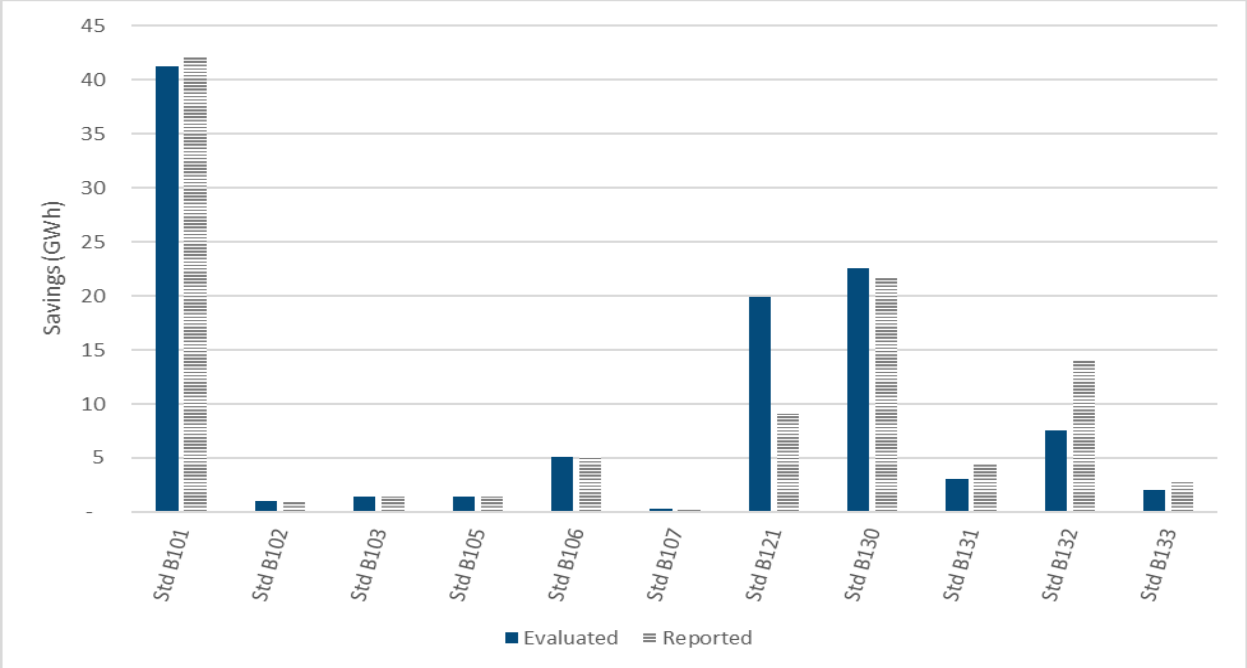



Figure 29: New Claim vs. Evaluation Savings 2017



### 4.6.2 Energy Savings by Utility

The last step in determining evaluated net savings was allocating the evaluated statewide net savings to each utility as discussed in Section 4.5.3. Applying the allocation factors to total savings resulted in the evaluated net energy savings by utility.

Table 26: Energy Savings by Utility

| IOU after allocation of evaluated savings | GWh | | | MW | | | MMTherm | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 |
| PG&E | - | 47.8 | 50.5 | - | 21.0 | 22.9 | - | 1.6 | 1.7 |
| SCE | - | 47.9 | 51.2 | - | 21.1 | 23.2 | - | - | - |
| SCG | - | - | - | - | - | - | - | 2.5 | 2.6 |
| SDG&E | - | 9.8 | 10.4 | - | 4.3 | 4.7 | - | 0.2 | 0.2 |
| **Evaluated savings** | **-** | **105.4** | **112.1** | **-** | **46.4** | **50.7** | **-** | **4.3** | **4.5** |
| IOU Claim savings | - | 103.0 | 208.5 | - | 42.7 | 97.6 | - | 5.8 | 11.6 |
| Difference # Evaluated vs. Claim | - | 2.4 | (96.4) | - | 3.7 | (46.9) | - | (1.5) | (7.1) |
| Difference % Evaluated vs. Claim | - | 2.3% | -46.2% | #DIV/0! | 8.7% | -48.0% | #DIV/0! | -26.5% | -61.4% |

Evaluated savings were close to claim savings because the bulk of savings were from claim years before the evaluation period. For example, in 2017 and 2018 prior period code savings accounted for approximately 86% of the code portfolio savings.

### 4.6.3 Summary Evaluated Electric and Gas Savings (2016–2018)

The evaluation estimated electric and gas savings for 11 IOU building code claims for the program years 2017 and 2018. Of these eleven codes, over the two years four accounted for 86% of savings and seven accounted for the remaining 14% of savings.

We reviewed the seven codes that accounted for 14% of savings for technical validity and reasonableness of assumptions. We found five of these to be reasonable and adopted the savings claim values. For the remaining two codes (multifamily codes B131 and B133) we adjusted the number of units and attribution scores and adopted the remaining parameters such as savings per unit and ESAF.

Our on-site verification focused on the four claims accounting for 86% of the total savings. These were the two whole building new construction claims (B121 and B130) and the two alterations claims (B101 and B132). Overall, we found,

- Potential savings (the theoretical maximum) accounted for the biggest difference from evaluation to claim. These reductions were 50% for residential new construction and 46% for nonresidential new construction.
- For PY 2018 residential single-family new construction, we verified estimated savings per unit (kWh, kW, and therms), but we found a much lower level of construction activity. This resulted in kWh savings that were 51% lower and therm savings that were 35% lower.

- The 2018 nonresidential new construction evaluation found only 41% of the claimed kWh savings and a much larger increase (7x) in gas usage than claimed.
- ESAF was high for both sectors (residential and nonresidential) and both types of construction (alterations and new building).

The combined savings for the new claims in the building code advocacy portfolio are presented in Table 28.

Table 27. Codes Advocacy Savings vs. Evaluation (2016–2018)

| IOU Only | 2016–2108 | | |
|---|---|---|---|
| | GWh | MW | MMTherm |
| IOU Claim | 311.5 | 140.3 | 17.4 |
| Evaluated | 217.5 | 97.2 | 8.8 |
| Evaluated Difference # | (94.0) | (43.2) | (8.7) |
| Evaluated Difference % | -30% | -31% | -50% |

*Note*: Savings in this table are for the building codes advocacy program only

Evaluated GWh savings are 30% lower than the IOU claim, MW reduction is 16% lower and MMTherm savings are 75% lower than the IOU claim.

The ISSM steps from potential savings to evaluated net savings can be illustrated in waterfall charts. These types of charts show the sequential progression of the evaluation steps to produce the final values that are compared to the IOU claims. The charts in Figure 29 though Figure 32 illustrate the adjustments to the 2017 and 2018 Program Year savings.

Figure 29 and Figure 31 show that NOMAD and attribution were the largest contributors to adjusting the final GWh savings value. In 2018 NOMAD and attribution combined accounted for 89% of the total savings GWh reduction. In 2017 NOMAD accounted for a 60% reduction while attribution contributed 39%. The implication is that the new code changes captured much of what was already happening in the new construction market rather than completely driving innovative technology and techniques.

Figure 30. Waterfall Chart (PY 2018 GWh)

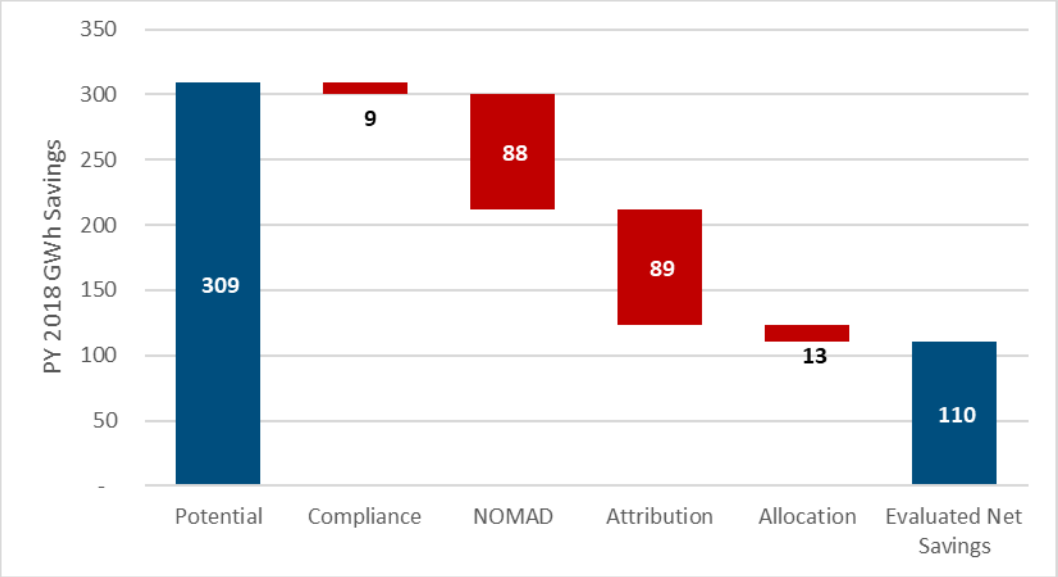



Figure 30 presents the MMTherm information for Program Year 2018. In this case, NOMAD accounted for 61% of the change. Any statistics for gas savings should be viewed with caution since a good outcome for therm savings can manifest as a positive or negative value depending on the application.

Figure 31. Waterfall Chart (PY 2018 MMTherm)

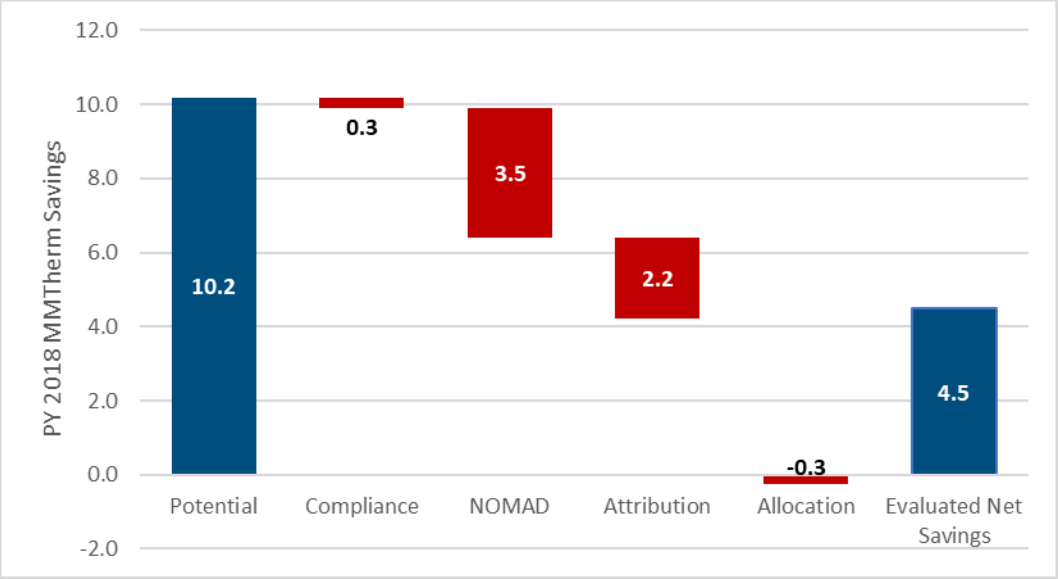


Figure 32: Waterfall Chart (PY 2017 GWh)

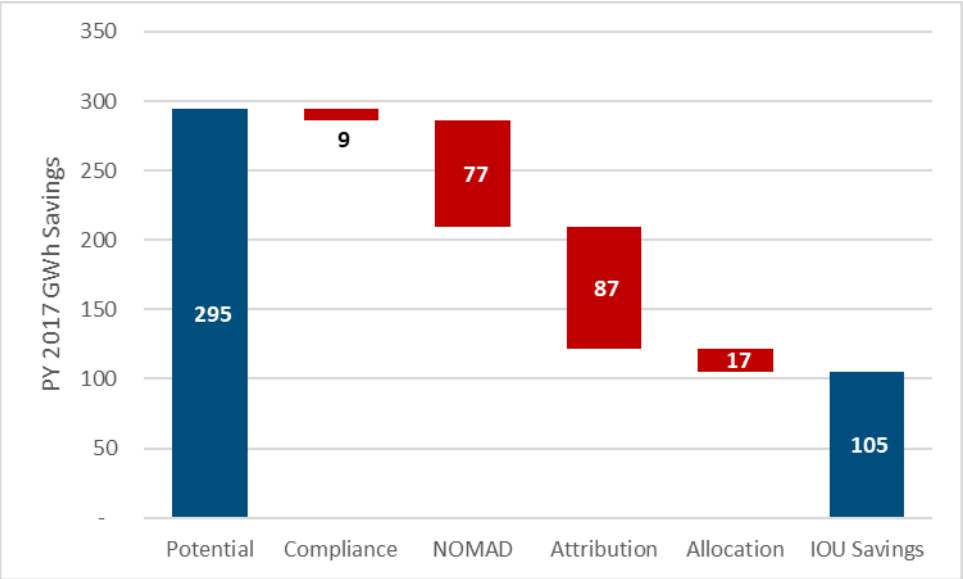
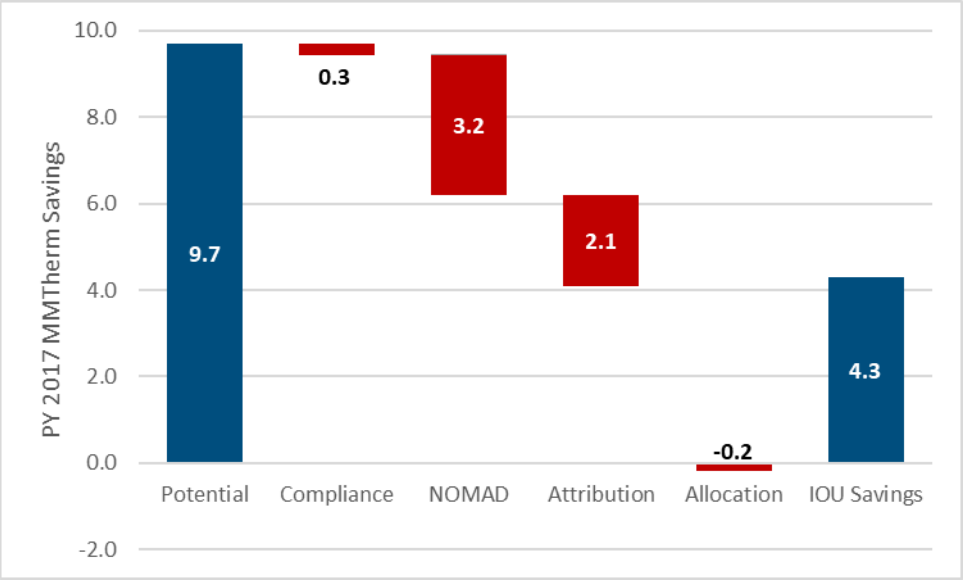



Figure 32 presents the MMTherm information for Program Year 2017. In this case, NOMAD accounted for 41% of the change and attribution 46%.

Figure 33: Waterfall Chart (PY 2017 MMTherm



### 4.6.4 Green House Gas Implications

The evaluation found that the 11 new claims in the IOU C&S portfolio for 2017 and 2018 avoided a total of 221,025 tons of CO2e over two years. This is equivalent to the annual energy use of 12,629 single-family homes or reducing gasoline consumption by 11.3 million gallons per year.[39]

### 4.6.5 Limitations of this Study

The limitations inherent in this study can be applied to all code evaluations. We list several in this section.

1. These studies are a snapshot in time. As a result, the findings can apply only to the code cycle being evaluated. While the results from this evaluation reflect the findings from the 2016 code cycle, they should not be applied – or applied with caution – to subsequent Title 24 code cycles such as 2019, 2022, and the upcoming 2025. For example, the level of IOU intervention and influence on the code development process changes across code cycles depending on
    a. the number and type of codes being considered,
    b. the number and type of participants in a given proceeding, and
    c. the types and degree of code changes being considered.
2. The IOUs participate in code development, but due to the lagged nature from code development to code implementation (several years) the IOUs play no role in determining how many buildings are built, where they are built, and what type of buildings are built. This is determined by future market conditions, technological developments, building industry practices, and political factors. As such the question raised in every evaluation remains, "Is the value of information attained from site visits worth the time and cost incurred to obtain the data?" These are the experiences of the last three evaluations.
    a. The 2006-2008 evaluation included a total of 20 "codes" and 275 (194 res + 81 nonres) analysis sites[40]
    b. The 2013-2015 evaluation included a total of 38 "codes" and a sample of 140 (87 res + 66 nonres) analysis sites[41]
    c. The 2016- 2018 evaluation included a total of 11 "codes" and 153 (38 res + 115 nonres) analysis sites.

[39] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator. The EPA values are based on US national averages. The CPUC cost-effectiveness tool reports California specific greenhouse gas reductions.
[40] Codes & Standards (C&S) Programs Impact Evaluation Volume III, April 9, 2010, pages 7 and 56, CALMAC ID: CPU0030.06
[41] California Statewide Codes and Standards Program Impact Evaluation Phase Two, Volume Two: 2013 Title 24, pages 71 and 24, CALMAC ID: CPU0170.01

# 5. Conclusions and Recommendations

The conclusions and recommendations in this report reflect our experiences with the IOU CEDARS savings claims and supporting documents, publicly available data, interactions with building permit jurisdictions, and physical visits to residential and nonresidential sites across the state. In addition, we provide recommendations based on our involvement with the C&S evaluation process in general.

### 5.1.1 For the IOUs

We have provided three recommendations for the IOU C&S team, but the biggest recommendation we have is for the teams putting together the documentation for the Codes Advocacy program.

- **Conclusion 1:** Documentation for ISSM parameters can be inconsistent from CASE report to CEDARS claims.
  - **Recommendation 1: Provide all ISSM parameter data with claims.** This recommendation was proposed (and agreed to) during the standards advocacy evaluation (Volume I). It is included here as a reminder that transparency of these data and their underlying assumptions supports continuous improvement for evaluation and forecasting.
- **Conclusion 2:** We found documentation, especially for nonresidential whole building savings, to be convoluted and in some instances contradictory with other IOU-produced documentation.
  - **Recommendation 2: Provide a step-by-step analysis** to present a clearer mapping of whole building assumptions and savings. Typically, there is confusion about how whole building savings are derived among evaluators, regulators, and other data users. We recommend including interim steps with savings per square foot by climate zone and building type to streamline the evaluation process and provide value to other data users. We've included two simplified examples of potential approaches to take that combine all code savings with a usable audit trail.
    - Example 1: Combine code savings by end use and weight the savings for each end use by energy use as reported by the California Commercial End-Use Survey available from the California Energy Commission.
    - Example 2: Generate simulations models for all building types for all climate zones under the preceding and current code cycle and develop a weighted average per square foot.
- **Conclusion 3: Economic conditions seem to be changing more frequently than in the past**. Forecasts of housing units or commercial square feet are produced and updated frequently as well. There are two main options for source data in California depending on the use case:

  1. The California Energy Commission Demand Analysis Office produces data on building stock and additions for residential housing units and stock and addition square feet for nonresidential buildings. The California Energy Commission forecast includes low-, mid-, and high-range scenario forecasts. Given the lag time between forecast and IOU filings, we do not recommend a specific scenario, but it should be identified in documentation for consistency and clarity.

  2. The California Department of Finance compiles data on building permits issued for residential single-family and multifamily new construction and the dollar value of alterations. Multifamily new construction can be further broken down by number of units by using US Bureau of Census data.

- **Recommendation 3a:** For consistency across programs and studies, we recommend the **continued use of California Energy Commission Demand Analysis Office forecasts** on building stock and additions for residential housing units and stock and additional square footage for nonresidential buildings. As each dataset has pros and cons; however, we recommend the data set used should be stated explicitly, along with an explanation of why it reflects the most expected outcome.
- **Recommendation 3a:** Consider using the **number of dwelling units when forecasting multifamily** savings rather than total square feet. Using the number of dwelling units is more relatable than square feet and aids understanding of housing trends for policy makers and other stakeholders.

### 5.1.2 For the CPUC

Given the level of effort and time needed to develop a sample and collect data we have three recommendations.

- **Conclusion 1: Codes cycles are not equal** in terms of new codes (or standards) approved, impact on industry, and energy savings generated. Some cycles include aggressive changes, other cycles may only be comprised of minor updates due to focus on other related issues or to allow industry to "catch-up." Consequently, each evaluation will not produce the same value in terms of supporting the State's goal of reducing greenhouse gas emissions.
  - **Recommendation 1a: Review the changes** to codes or standards before initiating an evaluation of an advocacy programs. Do the potential savings warrant a full impact evaluation?
  - **Recommendation 1b:** Consider **individual studies for individual sectors or building types**. For example, a study can focus on a certain sector and building type. Going forward we recommend a focus on multifamily dwellings. Multifamily dwellings are becoming a more common type of residential structure in California. Highrise and larger low- to mid-rise developments promise to become even more common as available land decreases and urban infill becomes more necessary to stay coordinated with the State's climate goals.
- **Conclusion 2:** The C&S advocacy evaluation is really **four separate studies** that each require different skill sets and a broad set of third-party participants (experts from various industries and property owners/operators). These four studies include macro-economic research and engineering simulation modeling (Potential savings), plan review and field studies (ESAF), market research (NOMAD) and process evaluation (Attribution).
  - **Recommendation 2:** After reviewing IOU savings and assumptions for a given Title 24 code cycle, we recommend the CPUC decide which study or studies to commission. The IOUs are scheduled to provide all ISSM parameters along with their annual claim filings. These parameters, along with an analysis of the new building code, can be the basis for determining the study or studies to commission.
- **Conclusion 3:** The most time-consuming and costly task for the C&S evaluation is identifying and recruiting participant buildings, particularly residential homes. The COVID-19 pandemic of 2020–2021 and unoccupied buildings, due mainly to remote working, were two of the highest hurdles we had to access buildings. Building owners and homeowners were often offsite, outside the city or even state. Even with a $100 incentive, homeowners were understandably reluctant to let anyone into their home. Additionally, building departments were closed or working at minimal staffing levels for nearly two years. We found in most cases that digitized plans were rare before 2018. Due to this, jurisdictions tended to store plans offsite, and these older plans could only be accessed physically. Even then, legal

issues of confidentiality and State agency access had to each be dealt with on an individual jurisdiction-by-jurisdiction basis.

- **Recommendation 3:** Going forward, consider an **alternate evaluation approach** that does not rely heavily on access to homes and businesses. For example, the results from single-family evaluations have been consistent over time. ESAF rates for residential codes hover at or near 100%. As a result, under most code cycles, visiting homes is not worth the time or monetary investment compared to the value of information collected. Where plans with Title 24 Certificate of Compliance documents can be accessed, those could be reviewed for energy budgets and types of equipment. In addition, homes could be accessed virtually to review basic equipment (e.g., lighting and cooking) using real estate websites or other public data websites. Alternatively, to simplify the evaluation procedure and reduce the required time to complete all data collection, the ISSM calculation "compliance"/ESAF rate could be stipulated. For example, at 70%.

# Appendix A. Specific Codes in Evaluation

In Table 29, the four code claims (rows not shaded) are the focus of the evaluation. For the remaining claims, we reviewed the appropriate CASE report and CCSR or other IOU provided documentation for reasonableness of their underlying data and assumptions. If we agreed that the underlying data and assumptions were reasonable, we accepted the parameters used in their calculations. For multifamily, we updated the number of units, but did not change other parameters. We then compared evaluation net savings with net savings reported in CEDARS for all codes listed in Table 29. .

Table 28: Evaluation Scope

| Effective Year | Measure ID | Measure Name | Potential | Compliance | NOMAD | Attribution |
|---|---|---|---|---|---|---|
| **Title 24 Building Codes** | | | | | | |
| 2017 | Std B101 | T-24 – NRA-Lighting-Alterations | Y | Y | Y | Y |
| 2017 | Std B102 | T-24 – NRA-Lighting-Outdoor Lighting Controls | Y | N | N | N |
| 2017 | Std B103 | T-24 – NRA-Lighting-ASHARE Elevator Lighting & Ventilation | Y | N | N | N |
| 2017 | Std B105 | T-24 – NRA-HVAC-ASHARE Measure-DDC | Y | N | N | N |
| 2017 | Std B106 | T-24 – NRA-HVAC-ASHRAE Equipment Efficiency | Y | N | N | N |
| 2017 | Std B107 | T-24 – NRA-Process-ASHARE Measure-Escalator Speed Control | Y | N | N | N |
| 2017 | Std B121 | Nonresidential New Construction (NRNC) – Whole Building[1] | Y | Y | Y | Y |
| 2017 | Std B130 | Res New Construction (RNC) – Single Family Whole Building[1] | Y | Y | Y | Y |
| 2017 | Std B131 | RNC – Multifamily Whole Building[1] | Y | N | N | N |
| 2017 | Std B132 | RA – Single Family Whole Building[1] | Y | Y | N | N |
| 2017 | Std B133 | RA – Multifamily Whole Building[1] | Y | N | N | N |

*Notes*: 1= Whole building includes multiple CASE/CCTR documents; Y = Yes - includes primary data collection; N = No - does not include primary data collection.

# Appendix B. Sample Construction Details

## Population of Buildings

The sampling strategy presented here is specific to Title 24 Building Energy Efficiency Standards and excludes discussion of Title 20 Appliance Standards. We discuss data sources, data quality, sampling considerations, and the statistical methods used in development of the final sample design.

This evaluation focused on buildings outside IOU energy efficiency programs. To identify these buildings, the evaluation team conducted an extensive review of construction data sources to estimate population and validation datasets. We selected Dodge construction data as the population of permitted projects in California, because of its high granularity of project detail. We elected to use a multi-point validation process to confirm Dodge's statewide representativeness (i.e., Dodge data is representative of California's actual construction data) drawing on California-specific and regional data sources. A discussion on the quality of each dataset is provided for transparency of the evaluation team's decisions. We confirmed the representativeness of the Dodge data through this validation process.

The sampling design approach incorporated the *Sampling and Uncertainty Protocols* for enhanced rigor requirements targeting a 90% confidence level with a 10% margin of error (90/10) at a total sample size of 300; 100 residential and 200 nonresidential.[42] The sample design integrated California's climate zones, as defined by the California Energy Commission and International Energy Conservation Code (IECC), with the major metropolitan areas, where the majority of construction occurred, to create three geographic regions for sampling. Further, the sampling design integrated three additional guiding factors, specifically: (1) building sector (residential or nonresidential), (2) project type (alteration or new construction), and (3) nonresidential building type (e.g., office, retail, education, food service, and all others), with the three geographic regions forming a matrix of sample sizes under each scenario (e.g., Region 1 – Nonresidential – Office – New Construction). We applied weights using Dodge project counts across the residential and nonresidential new construction and alteration populations for each of the three geographic regions for allocation of sample sizes.

## Data Sources

The evaluation team used a mixed strategy for data collection and analysis. This approach considered new construction and alterations covered by Title 24 in existing buildings. We excluded new construction buildings that were part of IOU new construction programs. Buildings included in the population had permits that required compliance with 2016 Title 24 standards. The primary data sources fall into one of two categories: (1) **Population Data** (i.e., data used to develop a statewide population of building construction with project-specific information), and (2) **Validation Data** (i.e., data used to validate that the population data is representative of California construction trends.) The following sections discuss the data sources in terms of data quality and the statewide representativeness of the population data. The data sources are summarized in Table 30.

Table 29. Summary of Data Sources and their Advantages and Disadvantages

| Data Source | Data | Data Use | Building Sector | Advantages | Disadvantages |
|---|---|---|---|---|---|
| Dodge Data & Analytics | Project-Level Construction Data | Population | Residential and Nonresidential | ▪ Project-level data<br>▪ Contact information<br>▪ Project address | ▪ Incomplete data fields<br>▪ Overlapping data, i.e., a project label is |

[42] California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.

| Data Source | Data | Data Use | Building Sector | Advantages | Disadvantages |
|---|---|---|---|---|---|
| | | | | ▪ High granularity of project characteristics | alteration and new construction |
| California Department of Finance | CA Permit Data | Validation | Residential and Nonresidential | ▪ California specific<br>▪ Disaggregated by building type | ▪ Low granularity compared with population data<br>▪ Nonresidential data is in terms of permit value ($) and not permits issued |
| US Energy Information Administration | 2012 Commercial Building Energy Consumption Survey | Validation | Nonresidential | ▪ High granularity of building types and characteristics<br>▪ Aligned with Dodge building type taxonomy | ▪ Existing building stock<br>▪ Regional data rather than CA-specific<br>▪ Statistical estimate |
| US Census Bureau | Building Permits Survey | Validation | Residential | ▪ California specific | ▪ Statistical estimate |
| California Energy Commission | CA Permit Data | Validation | Residential and Nonresidential | ▪ California specific | ▪ Non-traditional reporting units ($ft^2$) |

## Population Data

Dodge Data & Analytics,[43] a software and analytics firm that provides detailed information on construction projects across the globe, is a commonly accepted and used source of building construction information. Dodge Data & Analytics, referred to hereafter as Dodge, provides access to historical and current construction projects through their Global Network service. In theory, the primary advantage attributed to Dodge data is the granularity of data collected for each project, including but not limited to information on the building sector, type of project (e.g., alteration, new construction), building type (e.g., office, education, retail), project size ($ft^2$), number of buildings, project valuation, and project dates (e.g., bid date, target start date, target completion date).

The evaluation team observed two prominent disadvantages with Dodge data, specifically, the presence of **overlapping** and **incomplete** data. Overlapping data had assignments of contradictory labels, such as assigning a project as being both an alteration and new construction. Incomplete data lacked project information, typically the number of buildings or critical dates. The evaluation team contacted Dodge to discuss the source of data and their methods for reporting but learned Dodge employs a proprietary method. Dodge did share that project information is self-reported by contractors before processing, which partially explains incomplete and overlapping data.

The evaluation team performed a data cleaning process to remove projects exempt from 2016 Title 24 codes, such as hospital construction, interior painting projects, or projects permitted prior to 2016 Title 24 code effective date. Prior to cleaning, the data from Dodge contained approximately 63,000 California projects that met this evaluation's criteria. After removing permit-exempt projects (i.e., projects not permitted as of December 31, 2018) and projects flagged as "canceled," the final count of projects in the dataset was 44,904.

[43] The evaluation team extracted construction data from the Global Network service offered by Dodge Data & Analytics at https://www.construction.com/

# Validation Data

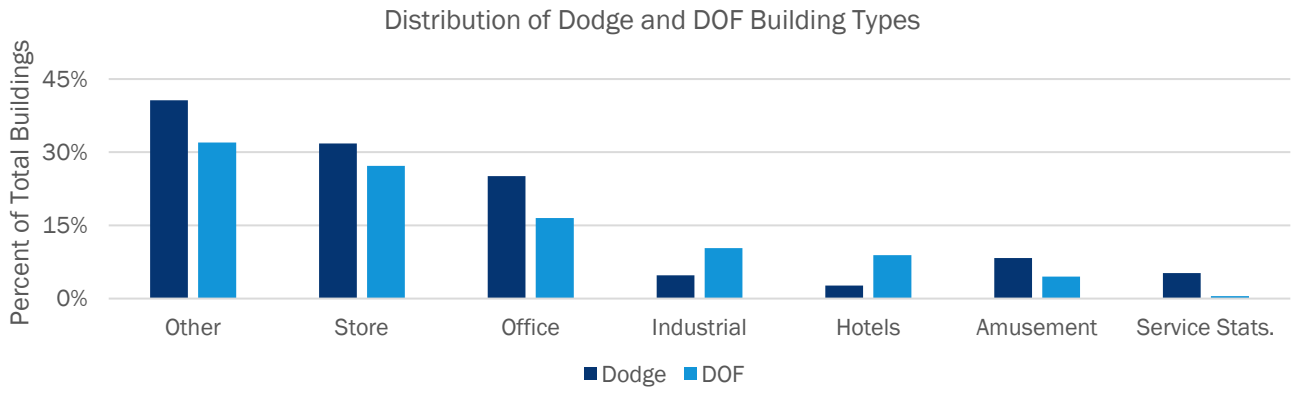
Validation data sources included the sources used to assess the statewide representativeness of the population data collected from Dodge. The methods employed by the evaluation team consisted of comparison of permit counts and building characteristics from California and regional data with the population data. Because building data is imprecise (refer to Table 30 for a summary of the validation sources), the evaluation team opted for a multi-point validation approach of utilizing multiple data sources to compare against the population data. This section discusses the validation sources individually before summarizing the statewide representativeness of the population data.

## California Department of Finance and California Homebuilding Foundation

The California Department of Finance (DOF), in collaboration with the California Homebuilding Foundation (CHF)/Construction Industry Research Board (CIRB), monitors California-specific residential and nonresidential construction permits as an indicator of economic health. For residential construction, the DOF reports the number of authorized housing permits for single- and multifamily units in monthly increments. For nonresidential, the DOF reports authorized construction permits, in terms of dollar value, for select nonresidential building types. Specifically, the building types of interest to the evaluation team were office, store, hotel, amusement, service stations, industrial and other. The DOF also reports on nonresidential alteration permits but does not break these figures down by building type.

The construction statistics provided by the DOF offer a comparative sample of California-specific construction permits and has enough granularity to assess the statewide representativeness of Dodge data, illustrated in Figure 33. The data suggest a similar distribution of building types in the Dodge population data as exhibited in the DOF data.

**Figure 34. Distribution of Nonresidential Construction Permits by Building Type Comparing Dodge and California DOF Data**

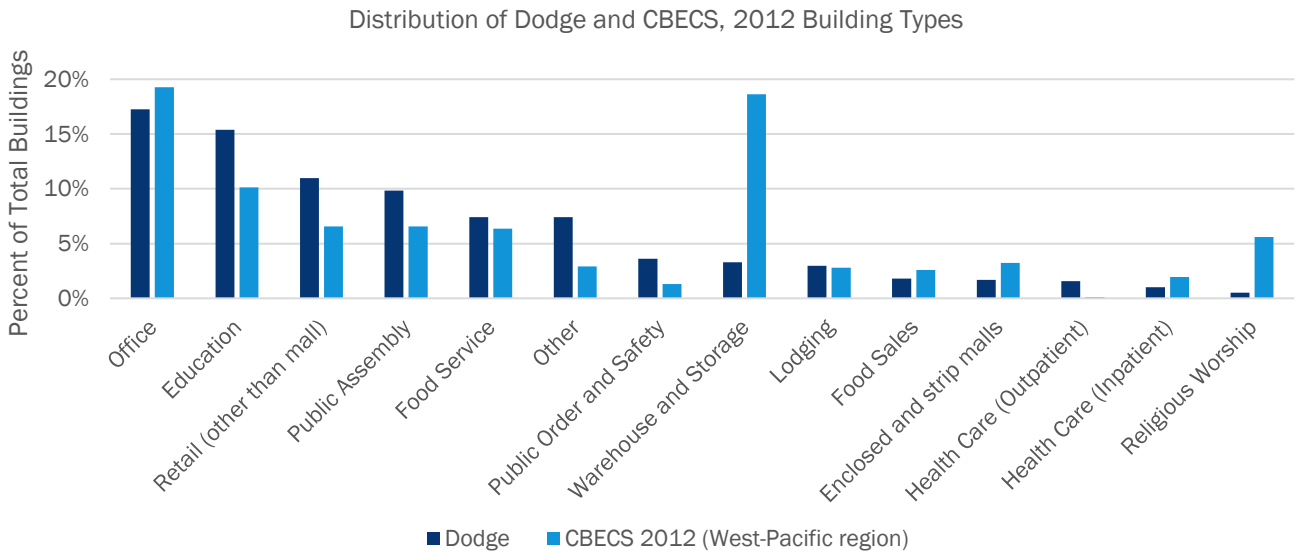



The DOF data, assembled through the CHF/CIRB, is informative but has disadvantages as a validation dataset. Notably, the DOF data are at a lower granularity than Dodge population data, leading to broader defined building types, and the DOF nonresidential data are reported in terms of permit value, which is more difficult to compare against the Dodge population data, because (1) Dodge's project value fields are incomplete, and (2) construction costs vary within and across building types (i.e., a high-rise office building will cost more to construct than a low-rise office building or retail store). To account for this, the evaluation team aligned the Dodge data building taxonomy to the DOF's and normalized permit values against the total value between 2016–2018, resulting in the similar nonresidential building type distributions illustrated in Figure 33.

## Commercial Building Energy Consumption Survey

The US Energy Information Administration (EIA) conducts the Commercial Building Energy Consumption Survey (CBECS), which reports on energy consumption and building characteristic statistics, on a rotating schedule with the other residential and manufacturing surveys. Data are collected from a statistically representative sample of buildings across the country, and then reported at a regional level; California fits within the West-Pacific region, which also includes Washington and Oregon. The evaluation team compared the population data with the mix of building types reported in the 2012 CBECS report,[44] illustrated in Figure 34. One building type, Health Care (Inpatient), was included for comparison of the representativeness of Dodge data only and removed from the final sampling design because it is exempt from Title 24.

Figure 35. Distribution of Nonresidential Building Types Comparing Dodge and EIA CBECS 2012 Data




Comparison of Dodge and CBECS building type distributions supports the statewide representativeness of the Dodge data as a statistically representative mix of nonresidential building types. While CBECS data include California, Washington and Oregon, the general trend remains consistent in Dodge; office, education, retail (other than mall), and public assembly comprise the largest categories.

The exception, warehouse and storage, represents 19% of commercial buildings for the West-Pacific region, but at an energy use intensity of 25.5 kBtu/ft$^2$, it is only marginally more energy intensive than vacant buildings (16.4 kBtu/ft$^2$)[45]. In comparison, food service (i.e., restaurants) and office building types of average 270.4 kBtu/ft$^2$ and 69.0 kBtu/ft$^2$, respectively, making warehouse and storage buildings less critical to codes and standards overall energy savings than other building types.

## Building Permits Survey

The US Census Bureau (USCB) monitors and reports on the number of monthly housing starts through the *Building Permits Survey*.[46] This survey is conducted monthly on 9,000 permit-issuing places nationwide. USCB

[44] US EIA Commercial Building Energy Consumption Survey, *Table B4. Census region and division, number of buildings* can be retrieved at https://www.eia.gov/consumption/commercial/
[45] US EIA Commercial Building Energy Consumption Survey, *Table C9. Consumption and gross energy intensity by Census division (part 3) for sum of major fuels, 2012* can be retrieved at https://www.eia.gov/consumption/commercial/
[46] US Census Bureau, *Building Permits Survey* can be retrieved at https://www.census.gov/construction/bps/

data are reported at the county-level and are directly comparable to Dodge data, which include project addresses and the number of buildings at each project. The evaluation team used USCB permit counts and Dodge project building totals to compare general trends in the data, specifically focusing on metropolitan regions. Any county touching a metropolitan statistical area was assigned to that metropolitan statistical area, all others were assigned to a non-metro category (e.g., Humboldt). The results presented in Table 31 exhibit a key commonality between the data, most permits (~85%) were issued in metropolitan regions.

Table 30. Distribution of Residential Construction Counts by Metropolitan Region

| Metropolitan Region | Dodge (% of Buildings) | US Census Bureau (% of Permits) |
|---|---|---|
| Los Angeles | 59% | 40% |
| San Francisco | 15% | 18% |
| San Diego | 8% | 7% |
| Sacramento | 4% | 14% |
| Fresno | 0% | 5% |
| Non-Metro | 14% | 16% |
| **Total** | **100%** | **100%** |

A deeper analysis of the data was improbable given inconsistencies in the Dodge data. Dodge partially relies on self-reporting for construction project characteristics, such as the number of buildings constructed at each project. But this database field was not completed for all projects. Moreover, the evaluation team found multiple site development projects reported a building total of one, while the project descriptions suggested multiple buildings at each of the sites. The evaluation team assigned all projects a building total of one when the field was empty and otherwise relied on the self-reported totals.

## California Energy Commission Construction Starts Data

The Energy Commission reports on the annual number of residential new construction starts for single-family, multifamily, and mobile homes organized by IOU territory, and nonresidential added floor area ($ft^2$) for a selection of building types. The evaluation team constructed comparable data from the Dodge population data as a last step in validating Dodge's representativeness. First, the evaluation team codified project zip codes to IOU territories. Second, the evaluation team calculated the average building sizes for the Energy Commission-specified building types using CBECS 2012 data.[47, 48]

Results, illustrated in Figure 35 and Figure 36, corroborate previous findings that Dodge data are a representative population of California's actual building stock. Similar to CBECS data, office, education, and retail building types were among the most commonly constructed. Additionally, while warehouses were underrepresented in Dodge data, their low energy use intensity did not make them as high a priority as other building types. We included the Hospital building type solely for comparison of the representativeness of Dodge data and removed it from the final sampling design.

[47] U.S. EIA Commercial Building Energy Consumption Survey, *Table B4. Census region and division, number of buildings* can be retrieved at https://www.eia.gov/consumption/commercial/

[48] U.S. EIA Commercial Building Energy Consumption Survey, *Table B5. Census region and division, floorspace* can be retrieved at https://www.eia.gov/consumption/commercial/

Figure 36. Distribution of nonresidential building types comparing Dodge and Energy Commission data.

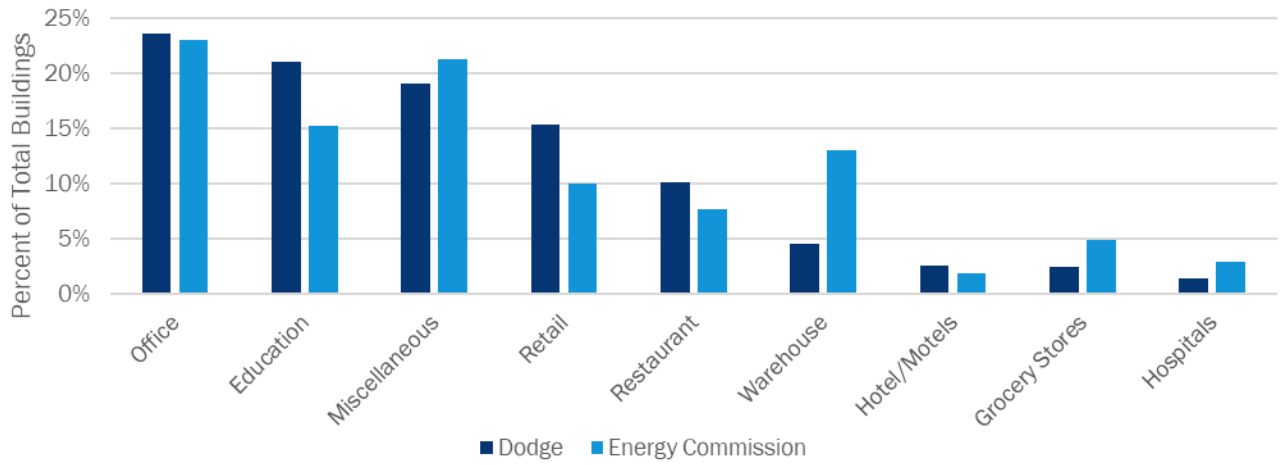
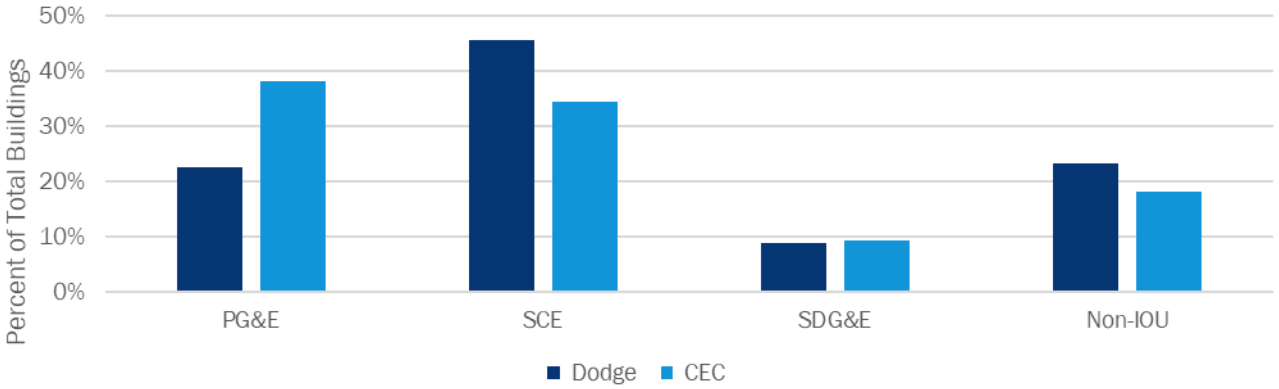



Figure 37. Distribution of residential construction by electric IOU territory comparing Dodge and Energy Commission data




## Sample Considerations

The evaluation team considered multiple criteria for sampling, including using building size, population density (e.g., metropolitan vs. rural) and California's climate zones as underlying factors of code compliance. Limitations of the Dodge data prevented the evaluation team from employing a sampling strategy that considered building size or housing unit type (single-family or multifamily), while sample size constraints prevented use of population density and climate zones as a singular criterion. The evaluation team decided to use the three geographic territories, created from integrating California's climate zones with the major geographic centers of building construction, as the sample's geographic boundaries, and key nonresidential building types (e.g., office, retail, education, and food service) to construct the samples for alteration and new construction projects separately. The following sections discuss nonresidential and residential sampling considerations in detail.

## Nonresidential Considerations

The evaluation team reviewed the Dodge data and validation sources, and identified office, education, and retail for targeted sampling, because of their building characteristics and estimated energy use in comparison

to the other nonresidential sectors. Office, retail education, and food service building construction represents approximately 60% of all Dodge-reported nonresidential construction. Moreover, these buildings represent an estimated 45% of commercial floorspace and 53% of commercial energy consumption for the Pacific region. Lastly, construction of office, retail, education, and food service buildings falls within Title 24 codes, which afforded the evaluation team the strongest evidence of ESAF rates within all facets of the Title 24 codes.

Additionally, the evaluation included all other nonresidential building types. These became a fifth sample category for holistic representation of nonresidential code compliance. The "all other" category includes a breadth of building types (e.g., public assembly and warehouse), which individually represent the remaining 40%, on average, of total construction population. Assembling these individual building types into a large category enabled sampling of these building types without increasing the overall sample size of 300.

## Residential Considerations

The residential sector is homogeneous in comparison to the nonresidential sector. As a result, the evaluation team selected a sampling approach that separated residential construction into alteration and new construction projects but did not distinguish between single-family and multifamily properties. Separation of single-family and multifamily homes into separate sample groups would result in sample sizes too small within each group to draw any meaningful conclusions.

## Competing Incentive Programs

The evaluation team identified competing energy efficiency programs offered by the IOUs, summarized in Table 32. We removed participants of the compiled list of programs, including the pilot Residential Energy Efficiency Loan program, from the final population to avoid double counting savings. In the initial sample we also cross-referenced with IOU-provided program tracking data for the listed programs prior to reaching out to jurisdictions to ensure evaluated projects did not fall under a competing energy efficiency incentive program.

Table 31. Competing Incentive Programs

| PA | Year | Program Name |
|---|---|---|
| PG&E | 2016-18 | Residential New Construction |
| PG&E | 2016-18 | Savings by Design (SBD) |
| SCE | 2016-18 | Residential New Construction Program |
| SCE | 2016-18 | Savings By Design |
| SCG | 2016-18 | RES-SW-RNC |
| SCG | 2016-18 | Ag, Com, Ind, New Construction [a] |
| SDG&E | 2016-18 | SW-CALS - CAHP/ESMH-CA Advanced Homes |
| SDG&E | 2016-18 | SW-COM-Calculated Incentives-Savings by Design |
| All | 2018 | Finance Residential Energy Efficiency Loan (REEL) Pilot |

Note: In CEDARS nonresidential new construction projects are listed under "Calculated Incentives"

## Non-IOU Territories and Reach Codes Jurisdictions

California's electricity market structure is complex. Outside of the four IOUs of interest to this study (i.e., PG&E, SCE, SCG, and SDG&E) California also includes additional small IOUs, Publicly Owned Utilities, such as the Sacramento Municipal Utility District, and Rural Electric Cooperatives. These non-IOUs commonly operate in small islands within the larger IOU's territories and are difficult to identify by zip code alone. Community Choice Aggregators (CCA) operate alongside the IOUs and are included for the purposes of this evaluation.

The Reach Codes program supports local governments with technical guidance in achieving statewide energy reductions, in part, by meeting or exceeding Title 24 building energy codes. The evaluation team identified Reach Codes program participants and will evaluate including these regions on a case-by-case basis.

# Appendix C. Site Visits by Jurisdiction

These tables (Table 33 and Table 34) list the building permit jurisdictions and the sample size of the sites visited and used for the ESAF calculations. These tables are provided in the companion .ZIP file.

Table 32: Nonresidential sample sites

| NR-Lighting Alterations (B101) | | |
|---|---|---|
| City | County | Count |
| Costa Mesa | Orange | 9 |
| Irvine | Orange | 5 |
| Norwalk | Los Angeles | 1 |
| Oxnard | Ventura | 3 |
| Redwood City | San Mateo | 11 |
| Riverside | Riverside | 8 |
| San Diego | San Diego | 1 |
| San Luis Obispo | San Luis Obispo | 5 |
| Santa Barbara | Santa Barbara | 4 |
| Santa Clara | Santa Clara | 6 |
| Santa Monica | Los Angeles | 8 |
| Santa Rosa | Sonoma | 5 |
| South San Francisco | San Mateo | 4 |
| Sunnyvale | Santa Clara | 8 |
| Tracy | San Joaquin | 1 |
| Vista | San Diego | 9 |
| | **Total** | **88** |

| NRNC-Whole Building (B121) | | |
|---|---|---|
| City | County | Count |
| Irvine | Orange | 1 |
| Montclair | San Bernardino | 6 |
| Riverside | Riverside | 1 |
| San Diego | San Diego | 5 |
| Santa Monica | Los Angeles | 2 |
| Santa Rosa | Sonoma | 1 |
| South San Francisco | San Mateo | 2 |
| Sunnyvale | Santa Clara | 1 |
| Tracy | San Joaquin | 3 |
| Vista | San Diego | 5 |
| | **Total** | **27** |

Table 33: Residential sample sites

| Res-New Construction single family whole building (B130) | | |
|---|---|---|
| City | County | Count |
| Berkeley | Alameda | 7 |
| Bonsall | San Diego | 3 |
| Oxnard | Ventura | 3 |
| Redwood City | San Mateo | 3 |
| San Luis Obispo | San Luis Obispo | 1 |
| Santa Rosa | Sonoma | 2 |
| South San Francisco | San Mateo | 3 |
| Sunnyvale | Santa Clara | 1 |
| | **Total** | **28** |

| Res Alterations (B132) | | |
|---|---|---|
| City | County | Count |
| Redwood City | San Mateo | 2 |
| Santa Barbara | Santa Barbara | 2 |
| South San Francisco | San Mateo | 3 |
| Tracy | San Joaquin | 3 |
| | **Total** | **10** |

# Appendix D. Potential Savings: Nonresidential

This section provides and overview of the assumptions and calculations used to develop savings potential for the nonresidential sector.

## Code B101: T-24 – Nonresidential Alterations-Lighting Alterations

This section presents the results of the evaluation for Code B101, the Title 24 code for Nonresidential Lighting Alterations. This code accounted for 20.0% of the total claimed building code kWh savings and −5.1% of the therm savings. It is treated as "pass-through."

### Savings

We reviewed the savings calculations presented in the Revised Impact Analysis report and found the assumptions and calculations to be reasonable. The square footage uses an assumption that lighting system replacement occurs every 15 years, on average. This assumption implies that 1/15 of the existing square feet is available for a retrofit each year. For example, 7,177 million square feet times 1/15 equates to 475.545 million square feet available for a potential retrofit. Table 33 summarizes the evaluation results for Code B101.

Table 34. Savings Potential of Code B101

| | Evaluation Results |
|---|---|
| Description | Existing building stock |
| Effective Date | 1/1/2017 |
| California Square Feet 2017 / 2018 | 478,496,573 / 482,592,487 |
| Unit Energy Savings (kWh) | 0.21 |
| Unit Demand Reduction (kW) | 0.00004 |
| Unit Natural Gas Savings (Therms) | -0.00038 |
| First Year Potential Energy Savings (GWh) | 113.16 |
| First Year Potential Demand Reduction (MW) | 25.26 |
| First Year Potential Natural Gas Savings (MMTherm) | -0.61 |

### Market Size

Updated estimates of market size are now available. Our estimates using these data were slightly lower (5.0%) than the reported square feet. For consistency, and to simplify the discussion of energy savings the evaluation adopted the values for 2017 existing square feet from IOU workpapers. The IOU Revised Impact Analysis document (Table 34)[49] was the basis for the IOU claimed alterations savings.

[49] **Revised Impact Analysis**: 2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings, September 13, 2016, Table 15, Page 16

Table 35: Existing Building Floor Area in 2017 by Building Types and Climate Zone from the Nonresidential Construction Forecast (million square feet)

| | California Climate Zone | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | TOTAL |
| Small Office | 9 | 16 | 36 | 47 | 30 | 25 | 8 | 61 | 18 | 40 | 19 | 15 | 54 | 3 | 7 | 1 | 389 |
| Large Office | 6 | 24 | 34 | 169 | 209 | 61 | 5 | 263 | 135 | 58 | 110 | 105 | 118 | 22 | 4 | 12 | 1,335 |
| Restaurant | 3 | 4 | 11 | 17 | 15 | 6 | 2 | 40 | 16 | 32 | 12 | 13 | 16 | 2 | 1 | 1 | 191 |
| Retail | 14 | 39 | 78 | 149 | 120 | 52 | 17 | 242 | 95 | 145 | 60 | 64 | 106 | 12 | 11 | 6 | 1,210 |
| Food | 5 | 13 | 26 | 39 | 28 | 10 | 6 | 61 | 23 | 39 | 15 | 16 | 32 | 3 | 4 | 1 | 321 |
| Warehouse | 7 | 56 | 76 | 100 | 109 | 39 | 9 | 227 | 79 | 170 | 62 | 62 | 72 | 6 | 14 | 3 | 1,091 |
| Ref. Warehouse | 0 | 5 | 11 | 9 | 8 | 1 | 3 | 10 | 3 | 4 | 2 | 2 | 1 | 0 | 0 | 0 | 59 |
| School | 12 | 22 | 54 | 76 | 61 | 20 | 12 | 108 | 37 | 65 | 29 | 24 | 49 | 3 | 5 | 1 | 578 |
| College | 5 | 9 | 23 | 42 | 36 | 8 | 3 | 55 | 17 | 26 | 26 | 18 | 27 | 4 | 1 | 2 | 302 |
| Hospital | 6 | 13 | 34 | 54 | 41 | 16 | 4 | 59 | 33 | 31 | 21 | 24 | 37 | 4 | 2 | 2 | 381 |
| Hotel | 5 | 7 | 18 | 51 | 50 | 12 | 3 | 67 | 26 | 26 | 19 | 19 | 47 | 2 | 4 | 1 | 357 |
| Miscellaneous | 18 | 39 | 91 | 181 | 164 | 43 | 23 | 287 | 125 | 172 | 64 | 68 | 108 | 15 | 11 | 7 | 1,416 |
| Hi-Rise Res. | 3 | 33 | 194 | 74 | 14 | 118 | 111 | 194 | 296 | 102 | 21 | 135 | 44 | 23 | 13 | 22 | 1,396 |
| TOTAL | 93 | 280 | 686 | 1,008 | 885 | 411 | 206 | 1,674 | 903 | 910 | 460 | 565 | 711 | 99 | 77 | 59 | 9,026 |

One caveat is that certain building types from the California Energy Commission forecast were not included in the IOU savings analysis. Removing these building types from the analysis left 6,547M square feet available. Specifically, the report lists the excluded building types and reasons for exclusion.[50]

- **Hospitals** (381M sq.ft.) were excluded as they are not covered by the Title 24 Code.
- **College** (302M sq.ft.) and **Miscellaneous** (1,416M sq.ft.) were excluded due to uncertainty about building characteristics.
- **Refrigerated Warehouse** (59M sq.ft.) was excluded because the energy consumption is dominated by refrigeration equipment for which a well-defined baseline is not available.
- **Food** (321M sq.ft.) was also excluded because of the significance of refrigeration equipment in building energy consumption, although refrigeration is not as dominant as in refrigerated warehouses.

To determine applicable square feet, the analysis applied a 15-year life to lighting systems. This translates to alterations occurring in 1/15 of the existing floor space each year.

## Code B102: T-24 – Nonresidential Alterations-Lighting-Outdoor Lighting Controls

This code accounted for 0.5% of the total IOU claim building code kWh savings and 0.0% of the therm savings. Savings was not evaluated and is "passed-through" unchanged to the total.

[50] Ibid, Page 16

### Savings

We reviewed the savings calculations presented in the Revised Impact Analysis report and found the assumptions and calculations to be reasonable. It is treated as "pass-through." The result is provided in Table 35.

Table 36: Savings Potential of Code B102

| | Evaluation Results |
|---|---|
| Description | Existing building stock |
| Effective Date | 1/1/2017 |
| California Units 2017 / 2018 | 455 / 455 |
| Unit Energy Savings (kWh) | 5,516.53 |
| Unit Demand Reduction (kW) | -- |
| Unit Natural Gas Savings (Therms) | -- |
| First Year Potential Energy Savings (GWh) | 2.51 |
| First Year Potential Demand Reduction (MW) | -- |
| First Year Potential Natural Gas Savings (MMTherm) | -- |

## Code B103: T-24 – Nonresidential Alterations-Lighting-ASHRAE Elevator Lighting and Ventilation

This code accounted for 0.7% of the total IOU claim building code kWh savings and –0.1% of the therm savings. This is a "pass-through" code. We reviewed the IOU calculations for reasonableness by the evaluators. Once we validated the calculations and the assumption documentation, the savings were accepted. These savings were then "passed-through" to the evaluation results.

### Savings

We reviewed the savings calculations presented in the Revised Impact Analysis report and found the assumptions and calculations to be reasonable. The result is provided in Table 36.

Table 37: Savings Potential of Code B103

| | Evaluation Results |
|---|---|
| Description | Existing building stock |
| Effective Date | 1/1/2017 |
| California Units 2017 / 2018 | 4,344 / 4,344 |
| Unit Energy Savings (kWh) | 840.00 |
| Unit Demand Reduction (kW) | 0.03 |
| Unit Natural Gas Savings (Therms) | -- |
| First Year Potential Energy Savings (GWh) | 3.65 |
| First Year Potential Demand Reduction (MW) | 0.13 |
| First Year Potential Natural Gas Savings (MMTherm) | -- |

## Code B105: T-24 – Nonresidential Alterations-HVAC-ASHRAE Measure-DDC

This code accounts for 1.4% of the total IOU claim building code kWh savings and 8.4% of the therm savings. It is treated as "pass-through."

### Savings

We reviewed the savings calculations presented in the Revised Impact Analysis report and found the assumptions and calculations to be reasonable. This is a "pass-through" code. The result is provided in Table 37.

Table 38: Savings Potential of Code B105

| | Evaluation Results |
|---|---|
| Description | Existing building stock |
| Effective Date | 1/1/2017 |
| California Units 2017 | 7,628,994 / |
| Unit Energy Savings (kWh) | 0.55 |
| Unit Demand Reduction (kW) | 0.00 |
| Unit Natural Gas Savings (Therms) | 0.07 |
| First Year Potential Energy Savings (GWh) | 4.20 |
| First Year Potential Demand Reduction (MW) | 0.93 |
| First Year Potential Natural Gas Savings (MMTherm) | 0.049 |

## Code B106: T-24 – Nonresidential Alterations-HVAC-ASHRAE Equipment Efficiency

This code accounts for 2.6% of the total IOU claim building code kWh savings and 0.0% of the therm savings. This is treated as a "pass-through" code. We reviewed the IOU calculations for reasonableness.

### Savings

We reviewed the savings calculations presented in the Revised Impact Analysis report and found the assumptions and calculations to be reasonable. The result is provided in Table 38.

Table 39: Savings Potential of Code B106

| | Evaluation Results |
|---|---|
| Description | Existing building stock |
| Effective Date | 1/1/2017 |
| California Units 2017 | 451,300,000 |
| Unit Energy Savings (kWh) | 0.03 |
| Unit Demand Reduction (kW) | 0.00 |
| Unit Natural Gas Savings (Therms) | - |
| First Year Potential Energy Savings (GWh) | 14.50 |
| First Year Potential Demand Reduction (MW) | 19.40 |
| First Year Potential Natural Gas Savings (MMTherm) | - |

## Code B107: T-24 – Nonresidential Alterations-Process-ASHRAE Measure Escalator Speed Control

This code accounts for 0.1% of the total IOU claim building code kWh savings and 0.0% of the therm savings. It is treated as "pass-through."

### Savings

We reviewed the savings calculations presented in the Revised Impact Analysis report and found the assumptions and calculations to be reasonable. The result is provided in Table 39.

Table 40: Savings Potential of Code B107

| | Evaluation Results |
|---|---|
| Description | Existing building stock |
| Effective Date | 1/1/2017 |
| California Units 2017 / 2018 | 40 / 40 |
| Unit Energy Savings (kWh) | 17,124.00 |
| Unit Demand Reduction (kW) | 0.07 |
| Unit Natural Gas Savings (Therms) | -- |
| First Year Potential Energy Savings (GWh) | 0.68 |
| First Year Potential Demand Reduction (MW) | 0.00 |
| First Year Potential Natural Gas Savings (MMTherm) | -- |

## Code B121: T-24 – Nonresidential New Construction-Whole Building

This code accounts for 22.1% of the total IOU claim building code kWh savings and 0.0% of the therm savings.

### Savings

We reviewed the savings calculations presented in the Revised Impact Analysis report and found the assumptions and calculations to be reasonable.[51] We estimated less total square footage than the IOUs (125 million square feet vs. 195 million square feet for 2017) and this resulted in lower total savings. The result is provided in Table 40.

Table 41: Savings Potential of Code B121

| | Evaluation Results |
|---|---|
| Description | New building permit square feet |
| Effective Date | 1/1/2017 |
| California Units 2017 / 2018 | 106,367,757 / 125,842,482 |
| Unit Energy Savings (kWh) | 0.66 |
| Unit Demand Reduction (kW) | 0.00 |
| Unit Natural Gas Savings (Therms) | -0.00 |
| First Year Potential Energy Savings (GWh) | 70.73 |
| First Year Potential Demand Reduction (MW) | 43.48 |
| First Year Potential Natural Gas Savings (MMTherm) | -0.18 |

### Market

Overall, the California Energy Commission reported less new construction activity than the IOUs projected in their forecast. For example, in 2018 the IOU forecast 174.270 million square feet and the California Energy Commission projected 125.842 million square feet (both exclude high-rise multifamily). Differences for eight building types are shown in Table 41.

[51] The IOU savings includes prescriptive and performance elements. The prevalence of performance elements will be assessed during on-site data collection.

Table 42: Nonresidential New Construction Examples

| Building Type | 2017 (million sq ft) | | |
|---|---|---|---|
| | Energy Commission actual | IOU estimate[52] | Difference |
| Hotel | 8.326 | 10.301 | -1.975 |
| Large Office | 22.040 | 30.821 | -8.781 |
| Ref Warehouse | 1.353 | 1.457 | -0.104 |
| Restaurant | 4.062 | 5.729 | -1.667 |
| Retail | 16.785 | 29.218 | -12.433 |
| School | 7.704 | 9.852 | -2.148 |
| Small Office | 5.509 | 10.264 | -4.755 |
| Warehouse | 24.367 | 24.228 | 0.139 |
| **Total** | **90.146** | **121.870** | **-31.724** |

[52] NORESCO (nonresidential), "IOU estimate from Revised Impact Analysis,2016 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings," September 13, 2016.

# Appendix E. Potential Savings: Residential

This section provides an overview of the assumptions and calculations used to develop savings potential for the residential sector.

## Code B130: T-24 – Residential New Construction-Single-Family Whole Building

This code accounts for 30.6% of the total IOU-claim building code kWh savings and 38.7% of the therm savings. For CPUC reporting and this evaluation, the definition of single-family whole building is any residential one-family house (detached, semi-detached and attached).

### Savings

We reviewed the savings calculations presented in the Revised Impact Analysis report and found the assumptions and calculations to be reasonable. To verify reasonableness, we developed 2,100 square foot prototype models for each of the sixteen climate zones and calculated savings by comparing energy use based on the 2013 code to the 2016 code. Next, we added in the lighting savings from the Revised Impact Analysis. We found comparable savings between totals when the savings from lighting were included in the calculation.[53] The number of building permits were updated, and the savings result is shown in Table 42.

Table 43. Savings Potential for Code B130

| | Evaluation Results |
|---|---|
| Description | New building permits |
| Effective Date | 1/1/2017 |
| California Units 2017 / 2018 | 58,853 / 63,027 |
| Unit Energy Savings (kWh) | 750.62 |
| Unit Demand Reduction (kW) | 0.42 |
| Unit Natural Gas Savings (Therms) | 76.45 |
| First Year Potential Energy Savings (GWh) | 44.18 |
| First Year Potential Demand Reduction (MW) | 24.63 |
| First Year Potential Natural Gas Savings (MMTherm) | 4.49 |

The California Energy Commission provides two single-family prototype buildings for simulating changes in energy use for different building configurations. One prototype is a one-story 2,100 square foot detached home. The other the is a two-story 2,700 square foot detached home. The average savings presented in Table 43 are a weighted average of the two prototypes at 2,430 square feet (2,100 sq.ft. = 45% and 2,700 sq.ft. = 55%).[54]

[53] Residential lighting savings are not part of the Title 24 models. Lighting is calculated separately (via spreadsheet or other calculator) and added to the model simulation savings output. In addition, we used the IOU savings from the 2,700 sq.ft. prototype and applied the same weighting factors.
[54] Developed from simulation runs comparing 2013 Title 24 to 2016 Title 24 using EnergyPro software.

Table 44: Weighted Average Savings per Prototype Home Built

| Savings | | | |
|---|---|---|---|
| CZ | kWh | kW | Therms |
| 1 | 581.52 | 0.00 | 94.19 |
| 2 | 580.64 | 0.45 | 81.54 |
| 3 | 567.12 | 0.00 | 66.69 |
| 4 | 609.89 | 0.55 | 85.03 |
| 5 | 562.36 | 0.00 | 65.20 |
| 6 | 548.46 | -0.09 | 48.06 |
| 7 | 548.93 | 0.00 | 46.83 |
| 8 | 719.48 | 0.59 | 64.78 |
| 9 | 772.40 | 0.57 | 66.21 |
| 10 | 868.75 | 0.48 | 69.65 |
| 11 | 967.07 | 0.71 | 84.03 |
| 12 | 839.89 | 0.89 | 96.51 |
| 13 | 1,029.40 | 0.69 | 84.47 |
| 14 | 879.49 | 0.50 | 84.94 |
| 15 | 1,281.20 | 0.93 | 52.87 |
| 16 | 653.30 | 0.44 | 132.15 |
| Avg | 750.62 | 0.42 | 76.45 |

## Market Size

The IOU's developed an estimate of permits across all sixteen climate zones. The evaluation team updated the total number of permits using data from the California Department of Finance[55] and the U.S Census Bureau[56]. We maintained the same ratio of permits across climate zones. For example, the IOUs estimated that 18.02% of statewide permits were issued in climate zone twelve. The evaluation team applied 18.02% to the actual number of permits to identify building activity assigned to climate zone twelve.

Table 44 shows the total single-family new construction (NC) permits issued and the allocation of permits across the state in 2017 and 2018.[57]

Table 45. Single-Family New Construction Permits

| CZ | 2017 | 2018 |
|---|---|---|
| | NC Permits | NC Permits |
| 1 | 359 | 380 |
| 2 | 1,345 | 1,422 |
| 3 | 2,696 | 2,852 |
| 4 | 3,096 | 3,275 |
| 5 | 602 | 636 |
| 6 | 2,140 | 2,264 |
| 7 | 3,373 | 3,568 |

[55] Starts and Valuations from the California Department of Finance: CALIFORNIA CONSTRUCTION AUTHORIZED BY BUILDING PERMITS, https://dof.ca.gov/forecasting/economics/economic-indicators/construction-permits/

[56] Annual History by State by Structure, United States Census: Building Permits by State, Annual. Number of New Residential Housing Units by State data file includes (Single-Family, Two-Unit, Three and Four Units, and Five or More Units), https://www.census.gov/construction/bps/ or https://www.census.gov/construction/bps/txt/tb2u2017.txt

[57] Different datasets make a distinction between housing starts that may include multiple permit vintages (used to forecast total energy use) and housing permits issued (used to estimate specific code vintages).

| CZ | 2017 NC Permits | 2018 NC Permits |
|---|---|---|
| 8 | 3,674 | 3,886 |
| 9 | 4,268 | 4,514 |
| 10 | 8,589 | 9,084 |
| 11 | 3,085 | 3,263 |
| 12 | 10,059 | 10,639 |
| 13 | 7,189 | 7,604 |
| 14 | 1,725 | 1,824 |
| 15 | 2,008 | 2,123 |
| 16 | 1,620 | 1,714 |
| **Total** | **55,827** | **59,049** |

## Code B132: T-24 – Residential Alterations- Single-family Whole Building

This code accounts for 13% of the total IOU claim building code kWh savings and 28.7% of the therm savings.

### Savings

We apply the same savings as residential new construction (See Table 43) to alterations and additions (remodels). These savings assume all permitted projects conform to the 2016 codes.

Table 46. Savings Potential for Code B132

| | Evaluation Results |
|---|---|
| Description | Existing building project permits |
| Effective Date | 1/1/2017 |
| California Units 2017 / 2018 | 23,276 / 22,774 |
| Unit Energy Savings (kWh) | 750.62 |
| Unit Demand Reduction (kW) | 0.42 |
| Unit Natural Gas Savings (Therms) | 76.45 |
| First Year Potential Energy Savings (GWh) | 17.47 |
| First Year Potential Demand Reduction (MW) | 9.74 |
| First Year Potential Natural Gas Savings (MMTherm) | 1.78 |

The same two California Energy Commission single-family prototype buildings for simulating changes in energy use for different building configurations were used for alterations. One prototype is a one-story 2,100 square foot detached home. The other is a two-story 2,700 square foot detached home. The average savings presented here are a weighted average of the two prototypes at 2,430 square feet (2,100 sq.ft. = 45% and 2,700 sq.ft. = 55%).[58]

Table 47: Weighted Average Savings per Prototype Home Built

| Savings | | | |
|---|---|---|---|
| CZ | kWh | kW | Therms |
| 1 | 581.52 | 0.00 | 94.19 |
| 2 | 580.64 | 0.45 | 81.54 |
| 3 | 567.12 | 0.00 | 66.69 |
| 4 | 609.89 | 0.55 | 85.03 |
| 5 | 562.36 | 0.00 | 65.20 |

[58] Developed from simulation runs comparing 2013 Title 24 to 2016 Title 24 using EnergyPro software.

| Savings | | | |
|---|---|---|---|
| CZ | kWh | kW | Therms |
| 6 | 548.46 | -0.09 | 48.06 |
| 7 | 548.93 | 0.00 | 46.83 |
| 8 | 719.48 | 0.59 | 64.78 |
| 9 | 772.40 | 0.57 | 66.21 |
| 10 | 868.75 | 0.48 | 69.65 |
| 11 | 967.07 | 0.71 | 84.03 |
| 12 | 839.89 | 0.89 | 96.51 |
| 13 | 1,029.40 | 0.69 | 84.47 |
| 14 | 879.49 | 0.50 | 84.94 |
| 15 | 1,281.20 | 0.93 | 52.87 |
| 16 | 653.30 | 0.44 | 132.15 |
| Avg | 750.62 | 0.42 | 76.45 |

## Market Size

We estimated savings from alterations using California Department of Finance's data for value of residential alterations and additions. For example, in 2017 the value of residential single-family permits totaled $17,167,000. Additions and alterations for the same year totaled $7,158,000 (41.7%). In 2018, this percentage dropped to 38.6%. To estimate the savings from residential alterations we applied these ratios to the number of new construction permits as a proxy for the number of home alterations (renovations).[59] The estimates of alterations are shown in Table 47.[60]

Table 48: Single-Family Alterations

| CZ | 2017 | | | 2018 | | |
|---|---|---|---|---|---|---|
| | NC Permits | Factor | Alterations | NC Permits | Factor | Alterations |
| 1 | 359 | 0.417 | 150 | 380 | 0.386 | 147 |
| 2 | 1,345 | 0.417 | 561 | 1,422 | 0.386 | 549 |
| 3 | 2,696 | 0.417 | 1,124 | 2,852 | 0.386 | 1,100 |
| 4 | 3,096 | 0.417 | 1,291 | 3,275 | 0.386 | 1,263 |
| 5 | 602 | 0.417 | 251 | 636 | 0.386 | 245 |
| 6 | 2,140 | 0.417 | 892 | 2,264 | 0.386 | 873 |
| 7 | 3,373 | 0.417 | 1,406 | 3,568 | 0.386 | 1,376 |
| 8 | 3,674 | 0.417 | 1,532 | 3,886 | 0.386 | 1,499 |
| 9 | 4,268 | 0.417 | 1,779 | 4,514 | 0.386 | 1,741 |
| 10 | 8,589 | 0.417 | 3,581 | 9,084 | 0.386 | 3,504 |
| 11 | 3,085 | 0.417 | 1,286 | 3,263 | 0.386 | 1,258 |
| 12 | 10,059 | 0.417 | 4,194 | 10,639 | 0.386 | 4,103 |
| 13 | 7,189 | 0.417 | 2,997 | 7,604 | 0.386 | 2,933 |
| 14 | 1,725 | 0.417 | 719 | 1,824 | 0.386 | 704 |
| 15 | 2,008 | 0.417 | 837 | 2,123 | 0.386 | 819 |
| 16 | 1,620 | 0.417 | 675 | 1,714 | 0.386 | 661 |
| **Total** | **55,827** | **0.417** | **23,276** | **59,049** | **0.386** | **22,774** |

[59] Starts and Valuations from the California Department of Finance: CALIFORNIA CONSTRUCTION AUTHORIZED BY BUILDING PERMITS, https://dof.ca.gov/forecasting/economics/economic-indicators/construction-permits/

[60] Home remodels are based on the dollar value associated with each permit. For example, in 2017 the dollar value of alterations was equal to 42% of the dollar value of new construction projects. In 2018, this value decreased to 39%.

# Code B131: T-24 – Residential New Construction-Multifamily Whole Building

This code accounts for 6.1% of the total IOU claim building code kWh savings and 18.6% of the therm savings. For CPUC reporting and this evaluation, the definition of for single-family whole building is any low-rise residential dwelling with two or more units per building. Code B131 is "passed-through".

## Savings

We reviewed the IOU calculations for reasonableness. Once we confirmed the calculations and the assumption documentation was checked, the savings were accepted. We updated the housing unit estimates for 2017 and recalculated the total savings for the evaluation results. The result is provided in Table 48.

Table 49: Savings Potential of Code B131

| | Evaluation Results |
|---|---|
| Description | New building permits |
| Effective Date | 1/1/2017 |
| California Units 2017 | 44,500 / 46,555 |
| Unit Energy Savings (kWh) | 667.53 |
| Unit Demand Reduction (kW) | 0.14 |
| Unit Natural Gas Savings (Therms) | 57.27 |
| First Year Potential Energy Savings (GWh) | 29.71 |
| First Year Potential Demand Reduction (MW) | 6.36 |
| First Year Potential Natural Gas Savings (MMTherm) | 2.55 |

## Market Size

The IOU's developed an estimate of housing units across all sixteen climate zones. The evaluation team updated the total number of housing units using data from the US Census Bureau.[61] We maintained the same ratio of permits across climate zones. For example, the IOUs estimated that 18.02% of statewide permits were issued in climate zone twelve. The evaluation applied 18.02% to the actual number of permits to identify building activity assigned to climate zone twelve.

Table 50: Multifamily New Construction Permits

| CZ | 2017 | 2018 |
|---|---|---|
| | NC Units | NC Units |
| 1 | 98 | 93 |
| 2 | 1,052 | 997 |
| 3 | 7,097 | 6,730 |
| 4 | 2,184 | 2,072 |
| 5 | 426 | 404 |
| 6 | 4,464 | 4,233 |
| 7 | 5,574 | 5,287 |
| 8 | 8,098 | 7,680 |
| 9 | 16,648 | 15,788 |

[61] https://www.census.gov/construction/bps/ or https://www.census.gov/construction/bps/txt/tb2u2017.txt. These numbers represent units, not buildings.

| CZ | 2017 | 2018 |
|---|---|---|
| | NC Units | NC Units |
| 10 | 3,875 | 3,675 |
| 11 | 451 | 428 |
| 12 | 3,110 | 2,949 |
| 13 | 1,598 | 1,516 |
| 14 | 1,021 | 968 |
| 15 | 897 | 851 |
| 16 | 1,054 | 1,000 |
| **Total** | **57,648** | **54,671** |

## Code B133: T-24 – Residential Alterations-Multifamily Whole Building

This code accounts for 2.6% of the total IOU claim building code kWh savings and 10.8% of the therm savings. Code B133 is treated as "pass-through."

### Savings

We reviewed the IOU calculations for reasonableness. Once we validated the calculations and checked the assumption documentation for reasonableness, we accepted the savings. We updated the dollar value of renovations relative to new construction as a percentage with actual figures from 2017 and 2018. Then, we recalculated total savings and "passed-through" savings to the evaluation results. The result is provided in Table 50.

Table 51: Savings Potential of Code B133

| | Evaluation Results |
|---|---|
| Description | Existing building project permits |
| Effective Date | 1/1/2017 |
| California Units 2017 / 2018 | 29,108 / 31,197 |
| Unit Energy Savings (kWh) | 667.53 |
| Unit Demand Reduction (kW) | 0.14 |
| Unit Natural Gas Savings (Therms) | 57.27 |
| First Year Potential Energy Savings (GWh) | 19.40 |
| First Year Potential Demand Reduction (MW) | 4.16 |
| First Year Potential Natural Gas Savings (MMTherm) | 1.67 |

### Market Size

We estimated energy saving from alterations using the California Department of Finance's data for value of residential multifamily alterations and additions. For example, in 2017 the value of residential multifamily units totaled $10,942,000. Additions and alterations for the same year totaled $7,158,000 (65.4%). In 2018, this percentage increased to 67.0%. To estimate the savings from multifamily alterations we applied these

ratios to the number of new construction units as a proxy for the number of alterations (renovations). The estimate for the number of alterations is provided in Table 51.

Table 52: Multifamily Alterations

| CZ | 2017 | | | 2018 | | |
|---|---|---|---|---|---|---|
| | NC Permits | Factor | Alterations | NC Permits | Factor | Alterations |
| 1 | 98 | 0.654 | 64 | 93 | 0.670 | 62 |
| 2 | 1,052 | 0.654 | 688 | 997 | 0.670 | 668 |
| 3 | 7,097 | 0.654 | 4,642 | 6,730 | 0.670 | 4,510 |
| 4 | 2,184 | 0.654 | 1,429 | 2,072 | 0.670 | 1,388 |
| 5 | 426 | 0.654 | 279 | 404 | 0.670 | 271 |
| 6 | 4,464 | 0.654 | 2,920 | 4,233 | 0.670 | 2,837 |
| 7 | 5,574 | 0.654 | 3,646 | 5,287 | 0.670 | 3,543 |
| 8 | 8,098 | 0.654 | 5,297 | 7,680 | 0.670 | 5,146 |
| 9 | 16,648 | 0.654 | 10,889 | 15,788 | 0.670 | 10,580 |
| 10 | 3,875 | 0.654 | 2,535 | 3,675 | 0.670 | 2,463 |
| 11 | 451 | 0.654 | 295 | 428 | 0.670 | 287 |
| 12 | 3,110 | 0.654 | 2,034 | 2,949 | 0.670 | 1,976 |
| 13 | 1,598 | 0.654 | 1,045 | 1,516 | 0.670 | 1,016 |
| 14 | 1,021 | 0.654 | 668 | 968 | 0.670 | 649 |
| 15 | 897 | 0.654 | 587 | 851 | 0.670 | 570 |
| 16 | 1,054 | 0.654 | 690 | 1,000 | 0.670 | 670 |
| **Total** | **57,648** | **0.654** | **37,708** | **54,671** | **0.670** | **36,635** |

# Appendix F. NOMAD: Code-Specific Results

The following sections discuss the NOMAD results for each of the codes in the evaluation scope. The results are organized first by group (whole building or stand-alone code) and by priority level within each group (i.e., those with the highest potential savings are discussed first). Each section includes code-specific insights from the survey respondents, as well as the NOMAD results for each product. The charts illustrating the NOMAD results include an area showing the range of responses among the experts to supply context for the varied predictions of the NOMAD curve. The results and the range do not include the first-round responses and are only representative of the second-round Delphi responses.

This section covers the following standards:

- Title 24-2016 Nonresidential Lighting Alterations (B101)
- Title 24-2016 Nonresidential New Construction of Whole Buildings (B121)
- Title 24-2016 Residential New Construction of Single-Family Whole Buildings (B130)
- Title 24-2016 Residential Alterations of Single-Family Whole Buildings (B132)

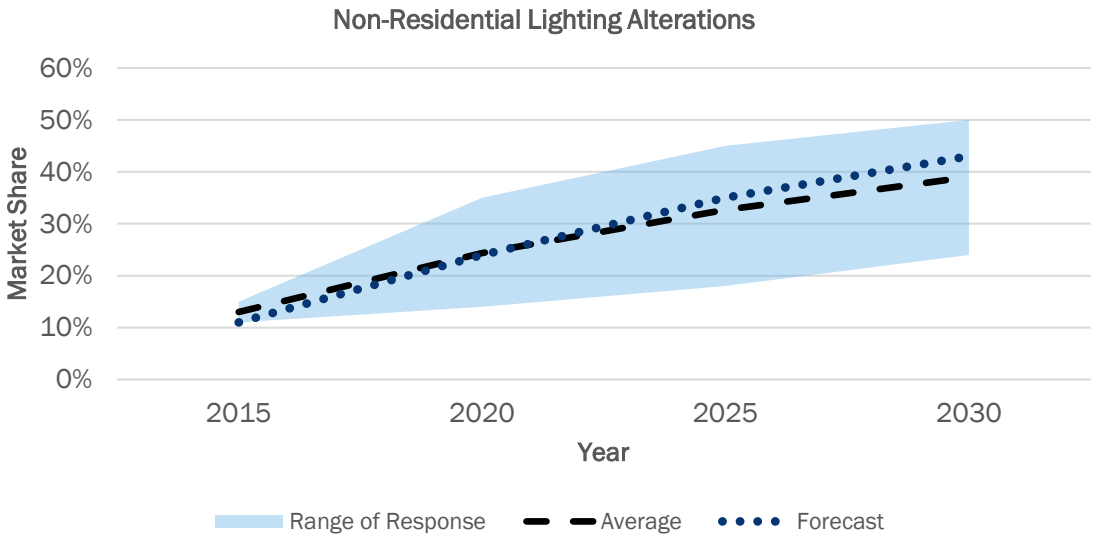
## Std B101 Nonresidential Lighting Alterations

Table 53. Summary Table for Nonresidential Lighting Alterations

| | |
|---|---|
| **Products Covered** | Nonresidential Lighting Alterations |
| **Standard Summary** | This new code sets requirements for indoor lighting power density, partial-on controls, and outdoor lighting power allowances for all nonresidential renovation projects. |
| **Priority** | N/A |
| **# of Respondents – Round 1** | 2 |
| **# of Respondents – Round 2** | 3[a] |

[a] One respondent on the panel for building codes only provided qualitative input for this code in the first Delphi round but provided percent values in the second Delphi round after reviewing other panelists' responses.

Figure 38: Title 24-2016 Nonresidential Lighting Alterations



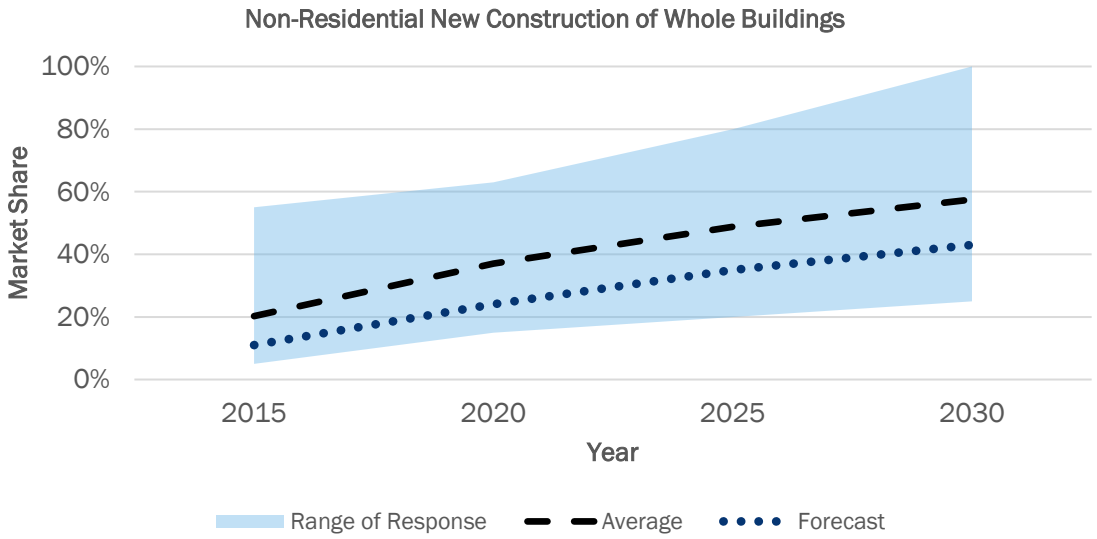

The respondents varied in their responses, but the consensus result generally agreed with the forecast market adoption curve. Respondents suggested technological advancements and cost reductions would support market adoption of these technologies. Any differences in responses were related to the magnitude of this effect.

## Std B121 Nonresidential New Construction of Whole Buildings

Table 54. Summary Table for Nonresidential New Construction of Whole Buildings

| | |
|---|---|
| **Products Covered** | Nonresidential New Construction |
| **Standard Summary** | This new code requires lighting, insulation, and HVAC equipment in new nonresidential buildings to meet new code levels of efficiency. |
| **Priority** | N/A |
| **# of Respondents – Round 1** | 4 |
| **# of Respondents – Round 2** | 4 |

Figure 39: Title 24-2016 Nonresidential New Construction of Whole Buildings




The respondents did not reach a consensus on the rate of adoption, with some respondents believing the building practices would be completely adopted by 2030 while others believed less than 40% of the market would adopt these practices. Most of the respondents mentioned the influence of ASHRAE 90.1 on market adoption of efficient equipment but disagreed on the rate at which it would promote market adoption of these technologies.

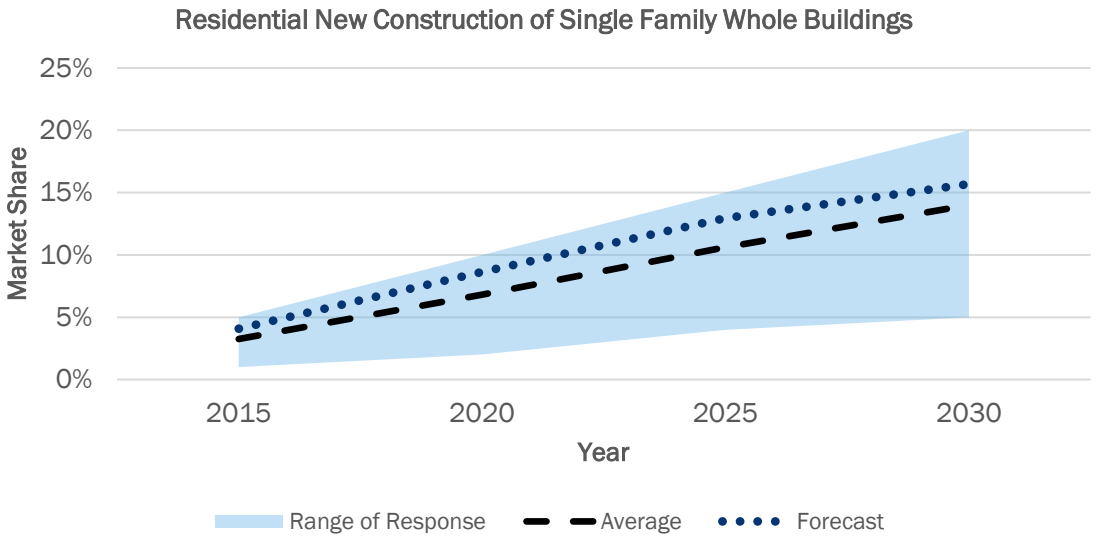
## Std B130 Residential New Construction of Single-Family Whole Buildings and Std B132 Residential Alterations of Single-Family Whole Buildings

Table 55. Summary Table for Residential New Construction of Single-Family Whole Buildings

| | |
|---|---|
| **Products Covered** | Residential New Construction |
| **Standard Summary** | This new code requires the use of high efficacy lighting, high performance attics (HPA), ducts in conditioned spaces (DCS), and heat transfer minimization via high performance walls in all new residential construction applications. |
| **Priority** | N/A |
| **# of Respondents – Round 1** | 4 |
| **# of Respondents – Round 2** | 5[a] |

[a] One respondent on the panel for building codes only provided qualitative input for this code in the first Delphi round but provided percent values in the second Delphi round after reviewing other panelists' responses.

Figure 40: Title 24-2016 Residential New Construction of Single-Family Whole Buildings




Respondents contended that market adoption in absence of the standard would be sluggish due to upfront cost concerns and that only a small minority would demand these building practices. One respondent added that even when builder incentives are available, it is difficult to get builders to implement non-standard energy efficiency items to their building. Others disagreed, believing trends towards efficient equipment and net zero buildings would favor market adoption of these building practices, especially considering the growing awareness of the negative effects of climate change.

# Appendix G. Attribution: Code-Specific Results

This table lists the claims included for the savings evaluation and presents the attribution scores for evaluated claims.

Table 56: Attribution Scores for Main Codes

| | Compliance Determination and Other Special Analytic Methods | Weight | Technical Information and Standard Language | Weight | Feasibility of Meeting the Standard | Weight | Evaluation Attribution Score | IOU Attribution Score |
|---|---|---|---|---|---|---|---|---|
| B101 Nonresidential Lighting Alterations | 0.05 | 0.08 | 0.66 | 0.71 | 0.48 | 0.21 | 0.57 | 0.75 |
| B121 Nonresidential New Construction of Whole Buildings | 0.30 | 0.22 | 0.68 | 0.49 | 0.37 | 0.29 | 0.51 | 0.75 |
| B130 Residential New Construction of Single-Family Whole Buildings | 0.50 | 0.10 | 0.79 | 0.41 | 0.62 | 0.49 | 0.68 | 0.75 |
| B131 Res - Multifamily Whole Building | 0.50 | 0.50 | 0.65 | 0.30 | 0.65 | 0.20 | 0.61 | 0.75 |
| B132 Res - Alterations | 0.50 | 0.10 | 0.79 | 0.41 | 0.62 | 0.49 | 0.68 | 0.75 |
| B133 Res - Multifamily Alterations | 0.50 | 0.50 | 0.65 | 0.30 | 0.65 | 0.20 | 0.61 | 0.75 |
| These claims were “pass-through” claims. Attribution scores did not factor into the net program savings calculation. | | | | | | | | |
| B102 Nonres Alt - Outdoor Lighting Controls | NA | NA | NA | NA | NA | NA | NA | 0.75 |
| B103 Nonres Alt - ASHRAE Elevator and Lighting Controls | NA | NA | NA | NA | NA | NA | NA | 0.75 |
| B105 Nonres Alt - ASHRAE Measure-DDC | NA | NA | NA | NA | NA | NA | NA | 0.75 |
| B106 Nonres Alt - ASHRAE Equipment Efficiency | NA | NA | NA | NA | NA | NA | NA | 0.75 |
| B107 Nonres Alt - ASHRAE Measure- Escalator Speed Control | NA | NA | NA | NA | NA | NA | NA | 0.75 |

Table 57: Summary of Attribution Scores for Other State Building Codes

| Comparison to IOU Estimates | Standard | Building Code | Factor Score | | | Factor Weight | | | Final Attribution Score | IOU Attribution Estimate |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Compliance | Technical | Feasibility | Compliance | Technical | Feasibility | | |
| Higher than IOU Estimate | Std B123 | Ducts in Conditioned Spaces / High Performance Attics | 44% | 80% | 78% | 10% | 45% | 45% | 76% | 75% |
| Lower than IOU Estimate | Std B108 | Indoor Lighting Power Density | 0% | 50% | 34% | 10% | 75% | 15% | 43% | 75% |
| | Std B109 | Partial-ON Controls | 24% | 73% | 68% | 10% | 45% | 45% | 66% | 75% |
| | Std B111 | Outdoor Lighting Power Allowance | 0% | 76% | 49% | 5% | 80% | 15% | 68% | 75% |
| | Std B113 | Envelope – Walls | 50% | 80% | 58% | 10% | 45% | 45% | 67% | 75% |
| | Std B115 | ASHRAE HVAC equip | 40% | 16% | 0% | 34% | 33% | 33% | 19% | 75% |
| | Std B116 | ASHRAE Direct Digital Controls | 46% | 74% | 30% | 34% | 33% | 33% | 50% | 75% |
| | Std B122 | Single Family Lighting | 56% | 80% | 57% | 10% | 40% | 50% | 66% | 75% |
| | Std B124 | Envelope – High Performance Walls | 0% | 68% | 56% | 10% | 45% | 45% | 56% | 75% |

For three building codes, the evaluated attribution score was lower than the IOU attribution estimate in the CCSR by more than ten percentage points. The following items address these discrepancies in more detail:

- For codes regarding **ASHRAE direct digital controls** (Std B116), the panelists noted there was no significant IOU action regarding test method development and no significant action to document avoidable costs and health externalities.
- For **indoor lighting power density codes** (Std B108), the panelists noted there was little program activity related to factor one, "compliance determination method."

- For **ASHRAE HVAC equipment codes** (Std B115), the panelists noted that ASHRAE HVAC codes are developed by ASHRAE's technical committees. The panelists did not find evidence that the IOUs had a considerable influence on the ASHRAE deliberations regarding HVAC equipment.

# Appendix H. Sample Site Visit Form (Nonresidential)

Opinion Dynamics

Boston | Headquarters

617 492 1400 tel
617 497 7944 fax
800 966 1254 toll free

1000 Winter St
Waltham, MA 02451

CPUC Codes & Standards Data Collection

| | |
|---|---|
| **ODC ID:** | 113 |
| **Region:** | C |
| **Project Type:** | New Construction |
| **Address:** | [redacted] |
| **Building Type:** | Office+Warehouse (Retail) |
| **Site Visit Date:** | July 13, 2022 |
| **SQ.FT.:** | 53,075 SF |

---

Link to project Folder: Opinion Dynamics (sharefile.com)

## Goals and Criteria

OBJECTIVE: Determine matching with Certificate of Compliance Forms at the project/site-level and, for residential only, gather additional forward-looking contextual information about electrification/decarb/etc. to inform beyond T24 2022.

Attempt to verify any actual equipment details listed below (make, model, quantity, efficiency, etc.) and determine a site-level Verification Rating of likely compliance (would be used as a flag and or multiplier for the realization rate across sites):

a. =OK (no change, equipment confirmed, no or minor discrepancies, or exceeded the specs)

b. =Indeterminant (unable to discern for sure, not enough info or inaccessible for inspection so assume compliant)

c. =Discrepant (equipment specs are completely different, systems not installed, etc.)

d. =Site eliminated, is not in scope (explain what was found on site to earn this rating)

## Indoor Lighting:

**FIXTURE SCHEDULE**

| Fixture Type | Fixture Specifications | | | | Volts | Lamps | | Load in | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | Manufacturer | Catalogue No. | Description | Mounting | | No. | Type | Watts | VA's | |
| AB4L4 | Lithonia | 2BLT-4-40L-MVOLT-LP835 | 2x4 Volumetric LED Troffer | Grid Troffer | M-VOLT | | LED - 4000 Lumen | 34 | 36 | 2 |
| AB4L4E | Lithonia | 2BLT-4-40L-MVOLT-LP835-EL14L | 2x4 Volumetric LED Troffer - Emergency | Grid Troffer | M-VOLT | | LED - 4000 Lumen | 34 | 36 | 2,5 |
| AB4L6 | Lithonia | 2BLT-4-60L-MVOLT-LP835 | 2x4 Volumetric LED Troffer | Grid Troffer | M-VOLT | | LED - 6000 Lumen | 53 | 59 | 2 |
| AB4L6E | Lithonia | 2BLT-4-60L-MVOLT-LP835-EL14L | 2x4 Volumetric LED Troffer - Emergency | Grid Troffer | M-VOLT | | LED - 6000 Lumen | 53 | 59 | 2 |
| B4L4 | Lithonia | LBL4-40L-MVOLT-LP835 | LED 4' wrap around | Surface | M-VOLT | | LED - 4000 Lumen | 41 | 43 | |
| C4L3 | Lithonia | ZL1N-L48-3000LM-MVOLT-35K-L/LENS | 4' LED strip - 3000L | Surface | M-VOLT | | LED | 31 | 33 | |
| C8L6 | Lithonia | TZL1N-L96-6000LM-MVOLT-35K-L/LENS | 8' LED strip - 6000L | Surface | M-VOLT | | LED | 62 | 66 | |
| DL1 | Lithonia | LDN6-35/10-LO6/AR-LSS-MVOLT-EZ10-WL | 1000 Lumen LED Down Light | Recess | 120/277 | | 13W LED | 13 | 14 | |
| DL1E | Lithonia | LDN6-35/10-LO6/AR-LSS-MVOLT-EZ10-EL-WL | 1000 Lumen LED Down Light - Emergency | Recess | 120/277 | | 13W LED | 13 | 14 | 5 |
| DL2 | Lithonia | LDN6-35/20-LO6/AR-LSS-MVOLT-EZ10-WL | 2000 Lumen LED Down Light | Recess | 120/277 | 1 | 35W LED | 23 | 25 | |
| DL2E | Lithonia | LDN6-35/20-LO6/AR-LSS-MVOLT-EZ10-EL--WL | 2000 Lumen LED Down Light - Emergency | Recess | 120/277 | 1 | 35W LED | 23 | 25 | 5 |
| HL24GMD | Lithonia | IBGN-24000LM-SEF-L/LENS-GND-480V-OZ10-50K-70CRI-OCS-LCM0SZU-DWH | LED Hibay - With Integrated Motion Day Light Dimmer - General Distr | Pendant | 480 | | LED | 167 | 176 | 9 |
| HL24NMD | Lithonia | IBGN-24000LM-SEF-L/LENS-ND-480V-OZ10-50K-70CRI-OCS-LCM0SZU-DWH | LED Hibay - With Integrated Motion Day Light Dimmer - Narrow Distr | Pendant | 480 | | LED | 167 | 176 | 9 |
| E1 | Lithonia | ELM2 | Emergency Lighting Unit | Surface | 120/277 | 1 | Furn W/ Fixt | 2 | 33 | 5 |
| PL3SS-HS | LSI | XLCM-3-LED-SS-CW-480-HSS | type 3 LED cutoff - Super Saver - House Side Shield | 17' Sq Steel Pole | 480 | 1 | LED | 193 | 203 | 3' Conc Base |
| WL3SS | LSI | XLCM-3-LED-SS-CW-480 | type 3 LED cutoff - Super Saver | Wall, +33' AFF | 480 | 1 | LED | 193 | 203 | |
| WLFTSS | LSI | XLCM-FT-LED-SS-CW-480 | type FT LED cutoff - Super Saver | Wall, +33' AFF | 480 | 1 | LED | 193 | 203 | |
| X1 | Lithonia | LQMSW3G-120/277-EL | emerg exit sign/single face | Universal mnt | 277(120) | 2 | LED | 5 | 5 | 5 |
| X2 | Lithonia | LQMSW3G-120/277-EL | emerg exit sign/double face | Universal mnt | 277(120) | 2 | LED | 5 | 5 | 5 |
| XE | E-conolight | E-XCL2GRCW | emg exit/ltg unit | Universal mnt | 277(120) | 2 | LED | 5 | 5 | 5 |
| WE | Elite | ELM-LED-807-WH | Exterior emg lighting unit w/ integral photosensor | Wall mount | 277(120) | 1 | LED | 7.5 | 7.5 | 5 |

Note 1 - Not all fixtures listed here may be used on this project
Note 2 - Fixtures in suspended ceilings to have 2#12 "slack" wires from fixture to structure above
Note 3 - Fixtures noted to have electronic ballasts.
Note 4 - Fixture noted to be tandem wired to utilize 2 or 4 lamp ballasts.
Note 5 - Fixture noted to be furnished with 90 minute self recharging emergency battery pack
Note 6 - Fixture noted to be furnished with magnetic dimmable ballast
Note 7 - Fixture to be factory lamped and furnished with 3 ckt modular wiring cable (a,b,EMG)
Note 8 - Fixture noted to have (1) 1-lamp ballast and (1) 2-lamp ballast.
Note 9 - Fixture noted to have factory motion sensor and automatic daylight dimming
Note 10 - Fixtures noted to have pole base height as specified on architectural drawings.

**F. INDOOR LIGHTING FIXTURE SCHEDULE**

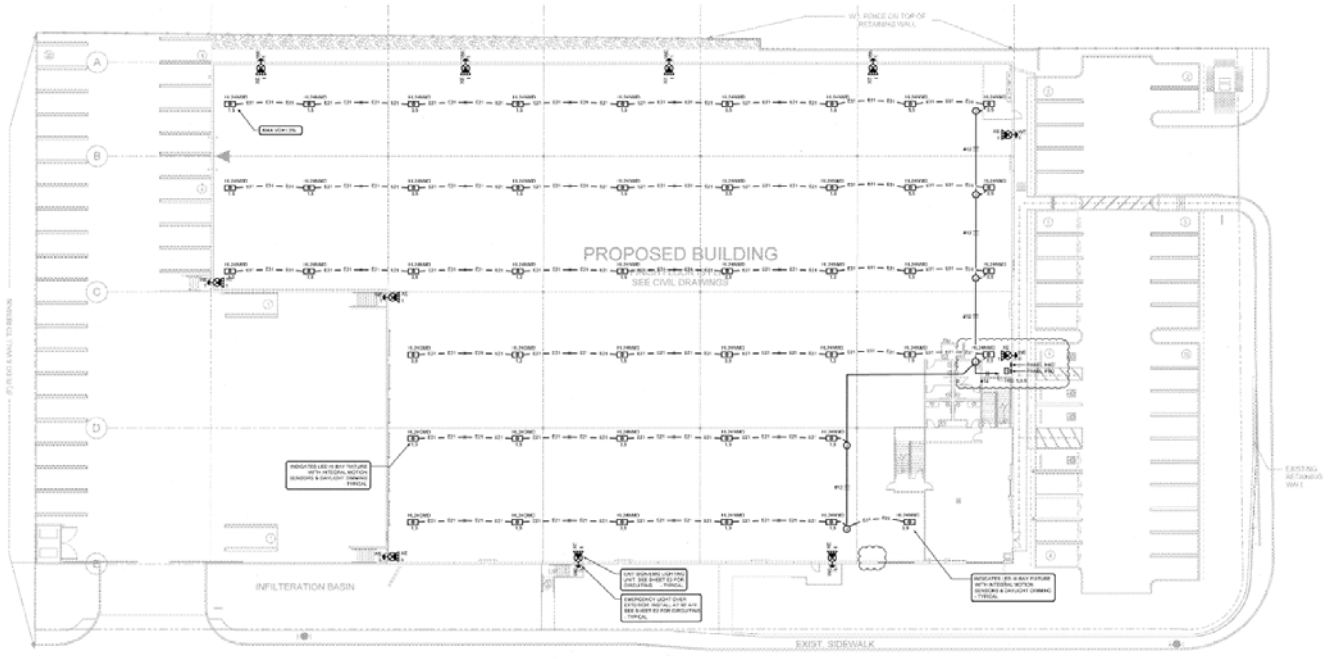
*Table Instructions: Include all permanent designed lighting and all portable lighting in offices.*

| 01 | 02 | 03 | | 04 | 05 | 06 | 07 | 08 | 09 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Name or Item Tag | Complete Luminaire Description | Specialized Luminaire Types | | Watts per luminaire[1] | How Wattage is determined | Total number luminaires | Exempt per §140.6(a)3 | Design Watts | Field Inspector | |
| | | Track | Portable | | | | | | Pass | Fail |
| AB4L4 | 2x4 LED 4000LM | ☐ | ☐ | 34 | Mfr. Spec[1] | 36 | ☐ | 1,224 | ☐ | ☐ |
| AB4L6 | 2x4 LED 6000LM | ☐ | ☐ | 53 | Mfr. Spec[1] | 4 | ☐ | 212 | ☐ | ☐ |
| B4L4 | LED 4' 4000L Wrap | ☐ | ☐ | 41 | Mfr. Spec[1] | 7 | ☐ | 287 | ☐ | ☐ |
| C4L3 | 4' 3000 Lumen LED Strip | ☐ | ☐ | 31 | Mfr. Spec[1] | 1 | ☐ | 31 | ☐ | ☐ |
| DL1 | 1000 Lumen LED Down Light | ☐ | ☐ | 13 | Mfr. Spec[1] | 6 | ☐ | 78 | ☐ | ☐ |
| | | | | | | **Total Designed Watts CONDITIONED SPACES:** | | **1,832** | | |

| 01 | 02 | 03 | | 04 | 05 | 06 | 07 | 08 | 09 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Name or Item Tag | Complete Luminaire Description | Specialized Luminaire Types | | Watts per luminaire[1] | How Wattage is determined | Total number luminaires | Exempt per §140.6(a)3 | Design Watts | Field Inspector | |
| | | Track | Portable | | | | | | Pass | Fail |
| HL24GMD | 24,000L LED HIBAY | ☐ | ☐ | 167 | Mfr. Spec[1] | 6 | ☐ | 1,002 | ☐ | ☐ |
| HL24NMD | 24,000L LED HIBAY | ☐ | ☐ | 167 | Mfr. Spec[1] | 39 | ☐ | 6,513 | ☐ | ☐ |
| | | | | | | **Total Designed Watts UNCONDITIONED SPACES:** | | **7,515** | | |

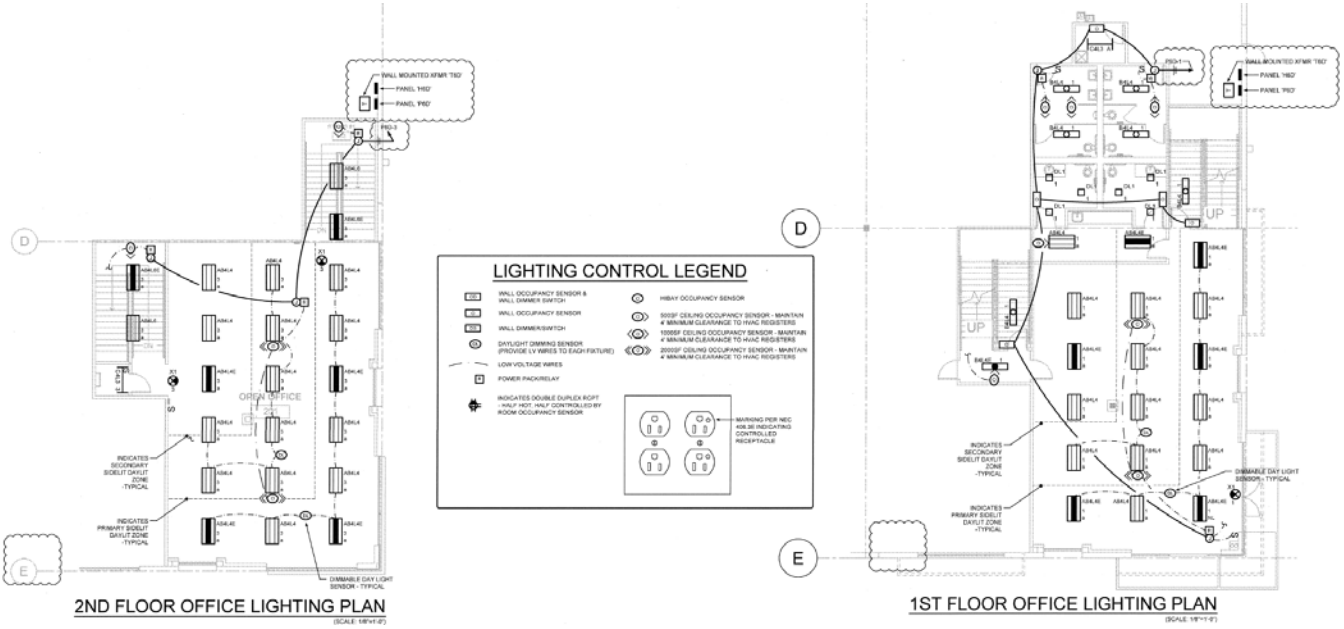
*[1]NOTES: Authority Having Jurisdiction may ask for Luminaire cut sheets to confirm wattage used for compliance per §130.0(c) Wattage used must be the maximum rated for the luminaire, not the lamp.*

## Warehouse Lighting Plan:




WAREHOUSE LIGHTING PLAN

## Office Lighting Plan:



## Mechanical Systems:

| M. HVAC SYSTEM SUMMARY (see NRCC-PRF-MCH-DETAILS for more information) | | | | | | | | | | § 110.1 / § 110.2 | | Confirmed | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dry System Equipment [1] (Fan & Economizer info included below in Table N) | | | | | | | | | | | | | |
| 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | | 10. | 11. | | |
| Equip Name | Equip Type | System Type (Simple [2] or Complex [3]) | Qty | Total Heating Output (kBtu/h) | Supp Heat Source (Y/N) | Supp Heat Output (kBtuh) | Total Cooling Output (kBtu/h) | Efficiency | | Acceptance Testing Required? (Y/N) [4] | Status [5] | Pass | Fail |
| | | | | | | | | Cooling | Heating | | | | |
| HP-1 | SZHP (Packaged3Phase) | Simple | 1 | 70 | No | 0 | 72 | EER-12.0 | COP-3.4 | Yes | N | ☐ | ☐ |
| HP-2 | SZHP (Packaged3Phase) | Simple | 1 | 70 | No | 0 | 72 | EER-12.0 | COP-3.4 | Yes | N | ☐ | ☐ |

[1] *Dry System Equipment includes furnaces, air handling units, heat pumps, etc.*
[2] *Simple Systems must complete NRCC-CXR-03-E commissioning design review form*
[3] *Complex Systems must complete NRCC-CXR-04-E commissioning design review form*
[4] *A summary of which acceptance tests are applicable is provided in NRCC-PRF-MCH-DETAILS*
[5] *Status: N - New, A – Altered, E – Existing*

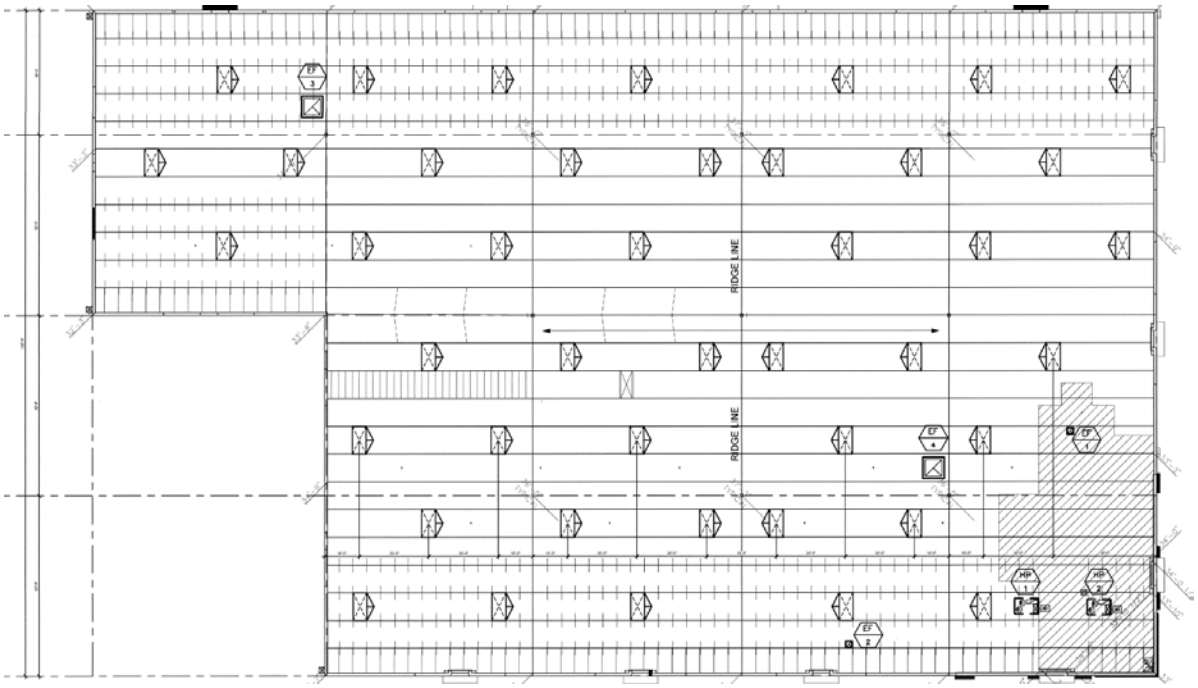
| Wet System Equipment Section Does Not Apply |
|---|

| **Discrepancy between modeled and designed equipment sizing?** (if "Yes", see Table F. "Additional Remarks" for an explanation) | No |
|---|---|

| N. ECONOMIZER & FAN SYSTEMS SUMMARY[1] | | | | | | | | | | | | § 140.4 | Confirmed | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 2. | 3. | | | | | 4. | | | | | 5. | | |
| Equip Name | Outside Air | Supply Fan | | | | | Return Fan | | | | | Economizer Type (if present) | Pass | Fail |
| | CFM | CFM | HP | BHP | TSP (inch WC) | Control | CFM | HP | BHP | TSP (inch WC) | Control | | | |
| HP-1 | 325 | 2400 | 0.960 | 0.960 | 1.52 | ConstantVolume | NA | NA | NA | NA | NA | DifferentialEnthalpy | ☐ | ☐ |
| HP-2 | 265 | 2400 | 0.960 | 0.960 | 1.52 | ConstantVolume | NA | NA | NA | NA | NA | DifferentialEnthalpy | ☐ | ☐ |

[1] *Mechanical ventilation calculations and exhaust fans are included in the NRCC-PRF-MCH-DETAILS section*

## Roof Plan:



# Appendix I. Table of Recommendations

| Study ID | Study Type | Study Title | Study Manager |
|---|---|---|---|
| CALMAC ID: CPU0235.01 | Impact Evaluation | 2016-2018 CODES & STANDARDS ADVOCACY PROGRAM IMPACT EVALUATION VOLUME II – FINAL REPORT | CPUC |

| Recommendation | Program or Database | Summary of Findings | Additional Supporting Information | Best Practice / Recommendations | Recommendation Recipient | Affected Workpaper or DEER |
|---|---|---|---|---|---|---|
| 1 | Advocacy Programs / CEDARS | Documentation for ISSM parameters can be inconsistent from CASE reports to IOU documentation to CEDARS claims. | | Provide all ISSM parameter data with claims. This recommendation was proposed (and agreed to) during the standards advocacy evaluation (Volume I). It is included here as a reminder that transparency of these data and their underlying assumptions supports continuous improvement for evaluation and forecasting. | C&S Program Administrator and CPUC | |
| 2 | Code Advocacy Program | We found documentation, especially for nonresidential whole building savings, to be convoluted and in some instances contradictory with other IOU-produced documentation. | | Provide a step-by-step analysis to present a clearer mapping of whole building assumptions and savings. Typically, there is confusion among evaluators, regulators, and other data users about how whole building savings are derived. To address this, we recommend including interim steps with savings per square foot by climate zone and building type in documentation. This will streamline the evaluation process and provide value to other data users. | C&S Program Administrator | IOU Code Change Savings Reports, other IOU generated supporting documentation |

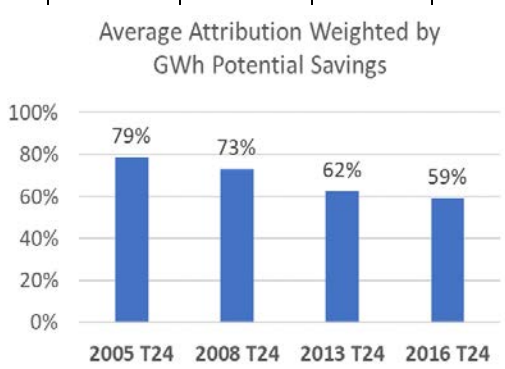
| Recommendation | Program or Database | Summary of Findings | Additional Supporting Information | Best Practice / Recommendations | Recommendation Recipient | Affected Workpaper or DEER |
|---|---|---|---|---|---|---|
| 3a | Code Advocacy Program | Economic conditions seem to be changing more frequently than in the past. Forecasts of housing units or commercial square feet are produced and updated frequently as well. There are two main options for source data on housing units in California depending on the use case. | | For consistency across programs and studies, we recommend the continued use of California Energy Commission Demand Analysis Office forecasts on building stock and additions for residential housing units and additional square footage for nonresidential buildings. As each dataset has pros and cons; however, we recommend the data set used should be explicitly stated, along with an explanation of why it reflects the most expected outcome. | C&S Program Administrator | |
| 3b | Code Advocacy Program | | | Consider using **number of dwelling units when forecasting multifamily** savings rather than total square feet. Using number of dwelling units is more relatable than square feet and aids in understanding of housing trends for policy makers and other stakeholders. | C&S Program Administrator | |
| 4a | Code Advocacy Program | Codes cycles are not equal in terms of new codes (or standards) approved, impact on industry, and energy savings generated. Some cycles include aggressive changes, other cycles may only be comprised of minor updates due to focus on other related issues or to allow the industry to "catch-up." Consequently, each evaluation will not produce the same value in terms of supporting the State's goal of reducing greenhouse gas emissions. | | Review the changes to codes or standards before initiating an evaluation of the C&S advocacy programs. Do the potential savings warrant a full impact evaluation? | CPUC | |

| Recommendation | Program or Database | Summary of Findings | Additional Supporting Information | Best Practice / Recommendations | Recommendation Recipient | Affected Workpaper or DEER |
|---|---|---|---|---|---|---|
| 4b | Code Advocacy Program | Consider individual studies for individual sectors or building types. For example, a study can focus on a certain sector and building type. Going forward we recommend a focus on multifamily dwellings. Multifamily dwellings are becoming the more common type of residential new construction structure in California. Highrise and larger low- to mid-rise developments promise to become even more common as available land decreases and urban infill becomes more necessary to stay coordinated with the State's climate goals. | | | CPUC | |
| 5 | Code Advocacy Program | The C&S advocacy evaluation is really four separate studies that each require different skill sets and a broad set of participants (experts from various industries and property owners/operators). These four studies include macro-economic research and engineering simulation modeling (Potential savings), plan review and field studies (Compliance), market research (NOMAD) | | After reviewing IOU savings and assumptions for a given Title 24 code cycle, we recommend deciding which study or studies to commission. The IOUs are scheduled to provide all ISSM parameters along with their annual claim filings. These parameters, along with an analysis of the new building code, can be the basis for determining the study or studies to commission. | CPUC | |

| Recommendation | Program or Database | Summary of Findings | Additional Supporting Information | Best Practice / Recommendations | Recommendation Recipient | Affected Workpaper or DEER |
|---|---|---|---|---|---|---|
| | | and process evaluation (Attribution). | | | | |
| 6 | Code Advocacy Program | The most time-consuming and costly task for this C&S evaluation was identifying and recruiting participant buildings, particularly residential homes. The COVID-19 pandemic restrictions and Building owners, facility managers, and homeowners working remotely, in some instances outside the city or even state, were two of the highest hurdles we encountered to access buildings. Even with a $100 incentive, homeowners were understandably reluctant to let anyone into their home. Additionally, building departments were closed or working at minimal staffing levels for nearly two years. We found, in most cases, that digitized plans were rare before 2018. Due to this, many jurisdictions stored plans offsite, and these older plans could only be accessed physically. Even then, legal issues of confidentiality and State agency access had to be | prior evaluations of residential new construction | Going forward, consider an alternate evaluation approach that does not rely heavily on access to homes and businesses. For example, the results from single-family residential evaluations have been consistent over time. Compliance rates for residential properties hover at or near 100%. Residential savings also account for less than a quarter (21%) of C&S portfolio savings from new codes. As a result, under most code cycles, visiting homes is unlikely to be worth the time and monetary investment. Where plans with Title 24 compliance documents can be accessed, they could be reviewed for energy budgets and types of equipment. In addition, homes could be accessed virtually to review basic equipment (e.g., lighting and cooking) by using real estate websites or other public data websites. | CPUC | |

| Recommendation | Program or Database | Summary of Findings | Additional Supporting Information | Best Practice / Recommendations | Recommendation Recipient | Affected Workpaper or DEER |
|---|---|---|---|---|---|---|
| | | dealt with on an individual basis, jurisdiction by jurisdiction. | | | | |

# Appendix J. Table of Comments and Responses

| ID # | Source | Priority, high=1, low=3 | Page | Text or section | Comment/feedback/change requested | Response |
|---|---|---|---|---|---|---|
| 1 | PG&E | 1 | Throughout | Attribution evaluation results | The accompanying figure shows the average attribution score of past cycles of Title 24, Part 6 (Energy Code) advocacy based on CASE Reports and developed by the C&S program. This figure shows that attribution scores assigned by CPUC C&S evaluation to IOUs' Title 24 advocacy efforts has been steadily reduced over time. Compared to the overall attribution score for 2005 Energy Code advocacy, the attribution score for 2016 Energy Code advocacy is 20% less. This downward trend in the evaluated attribution scores is not consistent with the continued increase in advocacy efforts by C&S team in terms of the increasing program budget, the expanding advocacy scope and activities, and the increasing work to help overcome more resistance and objections to Energy Code improvements. We are concerned that the draft attribution evaluation results do not adequately reflect the IOUs' C&S program efforts, as evidenced by the attribution evaluation results for the two residential new construction code measures discussed in a later comment and in the attached technical memo. We also are curious about the evaluators' thoughts on what other stakeholders might have been increasing their attributed contributions to code savings over this time, if not the IOU C&S Advocacy program. We would welcome further discussion with the evaluation team and Energy Division on these issues.<br>  | Each code cycle is an independent event that brings different codes with different impacts. As a result, one cannot view attribution over time as a continuous trend. There is no reason why attribution cannot be high in one cycle and low in another cycle.<br>We cannot comment on attribution scores from prior evaluations since we were not involved in their development. Nor were they considered in the current evaluation.<br>In addition, panelists and moderators can and do change since identification and recruiting of experts is the responsibility of the current evaluation team.<br>Our interpretation of your chart is that the perceived level of IOU influence for the 2016 code development cycle was on average nearly 60%. The implication is that IOUs drove nearly two-thirds of the changes, while the combined influence of the California Energy Commission, ASHRAE 90.1, the Natural Resources Defense Council (NRDC), Consortium for Energy Efficiency (CEE), American Council for an Energy Efficient Economy (ACEEE), International Code Council's International Building Code (IBC), other stakeholders and manufacturers, were responsible for about one-third of the code cycle outcomes.<br>Future scores will depend on the types of code changes and the level of detailed documentation on IOU proactive code change efforts (who, what, when, where, and why). |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | PG&E | 1 | throughout | p.4 -- 2017 MM Therm of -26.5%<br>p.11 -- 2016 MMTherm total of 13<br>p.17 -- Region A NC total Sample of 47<br>p.34 --567%<br>p.57 --In 2017 NOMAD accounted for a 4% reduction | Calculations: There appear to be some math errors in the tables or text of the referenced pages. Proofreading: There are what seem to be some cut and paste sentence errors on p. 36 and 38. | Thank you for bringing this to our attention. The final version reflects the following changes.<br>p.4 -- 2017 MM Therm of -26.5% (rounding difference - no change made)<br>p.11 -- 2016 MMTherm total of 14<br>p.17 --Region A NC total Sample of 38<br>p.34 --567% 700% (therm nonres total changed a bit also)<br>p.57 --In 2017 NOMAD accounted for a 41% reduction |
| 3 | PG&E | 1 | throughout | 2017 and 2018 | Throughout the document, there are instances where data are discussed for one year, either 2017 or 2018, but not for both, or where the time period is not stated at all. Can the evaluators please go through and, if one year was intentionally excluded, explain why? Here are some of the page numbers and the instances.<br>p. 3 -- In 2018, the IOUs filed claims<br>p. 4 -- The 2018 nonresidential new construction evaluation found<br>p. 57 -- For PY 2018<br>p. 65, 70 - for all these figures, can the evaluators tell us which years of Dodge Data they are showing?<br>p. 73 -- The evaluation adopted the values for 2017 existing square feet from IOU workpapers<br>p. 74 -- Table 34 (only contains 2017 data)<br>p. 73 -- Appendix C (is this one year, two years…?) | p. 3 -- updated<br>p. 4 -- updated<br>p. 57 -- updated<br>p. 65, 70 - updated<br>p. 73 -- This is correct. The source provided by the IOUs did not provide square footage by building type for 2018. Other IOU documentation contains only total square feet for 2018. One caveat is that during review, we found that Table 41 inadvertently compares 2018 energy commission data with 2017 IOU data. The table has been updated to reflect all 2017 data. A separate table for 2018 was added to show energy commission square foot data only because the IOUs did not provide a breakout of 2018 square feet by building type - only total square feet.<br>p. 74 -- Correct: This is data for 2017, the first effective year of 2016 T24.<br>p. 73 -- This is data for the first effective year of 2016 T24 |

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| 4 | PG&E | 1 | 2 | Method | This is really important: Can the authors include a section discussing the limitations of this study? This is a best practice, and would help transfer knowledge to future evaluators. | There are two main limitations to this type of study.<br>1) the C&S evaluation is for a specific program year. Given the nature of the protocols (requiring new savings estimate calculations, market update estimates, and field verifications) the results from advocacy efforts in one code cycle cannot be applied to another code cycle<br>2) This study was governed by CPUC protocol, scope, schedule, and budget while dealing with COVID-19 shutdowns across non-res buildings and permit offices. The current scope for C&S evaluations is very broad, but the budget does not allow "deep dives" into all topics. This is the impetus behind recommendation 3b. |
| 5 | PG&E | 1 | 3, 23 | through an in-person panel; asked a group of experts to anonymously predict | It seems that the use of Delphi panels is fairly widespread across disciplines now, and is understood to provide a lot of structure and controls against bias. We are curious as to why a Delphi panel was used for NOMAD but not for attribution? Can the authors include a discussion of any limitations that the reader should keep in mind about the methodology of the attribution panel? In particular, we are concerned about the lack of anonymity and a possible tendency towards biases such as "groupthink". | The promise of anonymity will be difficult to overcome given that industry experts must operate within the same industry, and often in the same areas, as the IOUs.<br>Avoiding "groupthink" is one of the responsibilities of the panel moderator(s). The ability of subject matter experts to voice their opinion and not fall into "groupthink" also is considered in the final selection of panelists. Finally, the evaluation protocols specify a Delphi approach for NOMAD, but a "preponderance of the evidence" approach for assigning Attribution. See page 91 in "California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals" for details on how to approach this task. |
| 6 | PG&E | 1 | 8 | Figure 6 | Can the evaluators please show a table with the portfolio kWh numbers with and without C&S, by year? CEDARS only contains savings from 2016 forward, and, it would be important to understand whether the increasing percentage is due to lower resource acquisition program savings over time, or if it's due to increasing C&S savings, or both. | The IOUs do not have access to their own historical data. CEDARS goes back to 2016 only. Earlier program year values were obtained via separate data request to Energy Division data team. We have provided the requested data in CodeData.ZIP file directly to the IOUs. |
| 7 | PG&E | 1 | 12 | details in the work plan | In previous years and in other impact evaluations, program administrators and other stakeholders are given opportunities to comment on evaluation workplans before the evaluation is initiated. This provides an opportunity to ensure mutual understanding of the program, discuss changes that have been made since prior evaluations, and consolidate lessons learned across prior evaluations for newer members of the evaluation team. The utilities did not have the opportunity to comment on this work plan, and | We agree that the process should be collaborative to emphasize program improvement. There was a comment process for the 2016 codes evaluation; it was conducted under Basecamp project: "2018-2021 Codes and Standards".<br>- For example, on Feb 22, 2019 we held the first webinar to go over the T24 data sources, data collection, and ideal sampling approach (This case was a bit unique since adjustments needed to be made between pre-pandemic plans and post-pandemic realities.)<br>- The C&S PCG provided additional questions to the |

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| | | | | | respectfully ask for the opportunity to comment on future C&S evaluation work plans. | evaluation team and responses were posted on May 3, 2019. Comments on the building codes sampling plan were provided on May 17, 2019. The final research plan for codes and standards was posted for comment on July 5, 2019.<br>-On Sept 16, 2019 we reached out to the IOUs for Delphi panel nominations and<br>on Oct 1, 2019 the IOUs provided a preliminary contact list.<br>-On Sept. 10, 2021 the IOUs took the opportunity to provide comments on the potential savings estimates.<br>-Attribution scores for codes (excluding whole building) were provided for comment on June 8, 2020.<br>-NOMAD estimates for Res and Non-res whole building new construction, and NR Lighting alterations were provided for comment on April 6, 2020. |
| 8 | PG&E | 1 | 12, 71 | The residential multifamily segment is not included in this evaluation. | Throughout this report, it's unclear how the multifamily segment was treated, which becomes particularly important since there is a recommendation to focus on multifamily in the future. Can the evaluators please include an explanation of why the multifamily segment was not included in this evaluation, as well as provide the evaluation team's operation definition of multifamily? On p. 37, it says "The plans they provided included single-family and multifamily projects ". Can the evaluators please spell out the implications of this for this evaluation study? On p. 71, it says that the evaluators "did not distinguish between single-family and multifamily properties". This wording suggests that both single family and multifamily properties were sampled indiscriminately, not that multifamily properties were excluded from being sampled. Can the study authors please clarify whether or not multifamily properties were excluded from being sampled? The report also states that "Separation of single-family and multifamily homes into separate sample groups would result in sample sizes too small", but the NR sample was stratified into samples of 44 each (except "other"). We are confused as to why the Res segment could not have been stratified into, say, 50 SF and 50 MF? | The report has been edited for clarity. The multifamily unit count was updated for the potential savings estimate. Unit savings estimates were reviewed but not recalculated. When we received building plans, there was a mix of single-family, multifamily, and mixed use. We did not visit multifamily projects. |

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| 9 | PG&E | 2 | 15 | Data gathered from other CPUC evaluation activities. | Can the evaluators please give some examples of these data, and which analyses in this report they informed? Or is language this from the appliance standards evaluation and not applicable to the building codes evaluation? | The language meant to convey that we were open to using other evaluation data and studies that may have added insight to this evaluation. Examples for market Potential include an internal CPUC C&S program study and third-party reports such as the California Association of Realtors reports, "firsttuesday Journal" market reports, and construction company regional research from CBRE. NOMAD was determined by participants, but these information sources provided additional context to the evaluation findings. |
| 10 | PG&E | 2 | 16 | based on Dodge reported project type (nonresidential and residential construction) and construction type (alteration and new construction) | Can the evaluators please provide a table showing the Dodge reported project types so that the reader may understand the distribution of project types in the different regions? | These were provided in the sampling plan memo dated June 5, 2019. We have provided the requested data to the IOUs in CodeData.ZIP file. |
| 11 | PG&E | 1 | 17 | The specific sites in the final sample; | Because this was not a random sample, can the evaluators show the characteristics of the final sample compared with the population, and clarify whether this sample is or is not representative of all new construction projects during the evaluation period? | The number of sample points per city is provided in the report appendix. |
| 12 | PG&E | 3 | 18 | Building permit records | It would be really useful to have this information to inform future permit data collection efforts and for the compliance improvement program. Can the evaluators provide a description of the permit records that were received? If this data was tracked, what percentage of them were missing the records listed in the bullets? | Table 12 has been expanded to include more detail about permit records |
| 13 | PG&E | 1 | 18 | Site Recruitment | Please provide a disposition of the permit data received. For example, a waterfall chart showing how many projects were removed from further consideration after each type of eligibility check would be very useful (if not possible, a listing would be enough). Please also provide details of the process of recruiting and visiting sites. For | How many residential sites were sent a letter? Letters mailed = 379.<br>Name(s) of occupant(s) = 0<br>How many sites had phone numbers? Available phone or email = 0<br>What was the disposition of these phone calls? = N/A<br>Were the evaluators able to access every site? If not, what |

| | | | | | | |
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| | | | | | example, How many residential sites were sent a letter? How many sites had phone numbers? What was the disposition of these phone calls? Were the evaluators able to access every site? If not, what then? Overall, more detail about these compliance site visits would be very much appreciated. | then? The number of sites accessed is provided in the Report. See Table 12. |
| 14 | PG&E | 1 | 18 | See Appendix G | We notice that the site visit form listed a second objective, which is to "gather additional forward-looking contextual information about electrification/decarb/etc. to inform beyond T24 2022." Can the evaluators please share this information with the C&S program team? | We looked specifically for solar panels, induction stoves, smart water heaters, heat pump water heaters, and EV chargers. We found 1 EV charger and 2 smart water heaters (for Res Alterations). This technically isn't part of the evaluation scope or protocols and cannot be generalized given the sample size. This has been added to the report as section 4.3.3. |
| 15 | PG&E | 2 | 19 | On-site interview | Can evaluators tell us how many on-site interviews were conducted, and for what building types? | Interviews included building owners, facility managers, or tenants to<br>1) gain access to the building and back office areas (roofs, electrical rooms, etc.)<br>2) to document operating hours<br>3) to learn other information about the project – mainly for alterations (when it was done, how long it took, and for small business owners, what impressions it left)<br>See report Table 18 and 19 for number and type of nonresidential buildings visited.<br>--Nonresidential new construction: On-site interviews were conducted at 26 sites. Exceptions were 1 Retail.<br>--Nonresidential lighting alterations interviews were conducted with owners/managers at 85 sites. Exceptions were 3 Food Service establishments. |
| 16 | PG&E | 1 | 20, 39, 44 | verifying building envelope parameters (U value) … using thermal imaging | This is very interesting! We are very glad to see this exploration of new techniques. Can the evaluators include a section explaining how thermographic imaging was used to verify building envelope parameters? For example, did evaluators attempt to visually verify insulation, and if that was unsuccessful, used thermographic images? How did the evaluators translate the image into an R value? How was this technique useful for this current evaluation, and did the evaluators base any compliance decisions on thermographic imaging data? Would the evaluation team recommend this technique in the future to other evaluators? In the | The IR camera was an experimental approach. We found it helpful, but the images cannot be used exclusively as an evaluation tool. Interpreting results must consider the indoor and outdoor temperature differentials and camera color scale. We used these photos as an indicator rather than a measuring tool. For example, from the IR images we could not determine the rating of wall insulation. We could, however, determine that insulation was installed. A better use may be in quality control. The example Figure 20 in the report shows two homes in the same subdivision, but with different builders. From the IR photo one door – with higher temperatures recorded around the frame – may not have been installed correctly. |

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| | | | | | assessment of thermographic imaging, how many buildings did the evaluation team decide to visit and how did the team decide which ones to visit? In the discussion of IR photos starting p. 44: When an IR photo is used, can the evaluators help the reader understand how these data were used in the determination of compliance for that project? Providing such concrete examples would be very helpful for understanding the potential of IR imaging as a code compliance and/or evaluation tool. | |
| 17 | PG&E | 1 | 20 | but the additional savings must be attributed to the building design or other factors outside the specific code | Did the evaluation team find any instances of additional savings? How many, for what types of buildings, and how much additional savings? | We did not model the buildings to produce savings estimates. For savings calculations we reviewed 2016 T24 "Certificate of Compliance" documentation. These reports provide energy use summaries compared to code in terms of TDV. According to this measurement res new construction averaged 4.11% more efficient than code on a square foot weighted basis.<br>We did not track TDV for nonresidential projects. |
| 18 | PG&E | 3 | 21, 72 | We targeted jurisdictions without reach codes but verified that if a reach code did exist during the 2016–2018 period, it did not coincide with the attributes we were evaluating | This is unclear: did the evaluators target jurisdictions without reach codes, and found out afterwards that they *did* have reach codes after all? Also, on p.72, were any reach code program participants included in this evaluation? Which jurisdictions? | The original plan was to avoid "Reach" code jurisdictions. Conditions after the pandemic changed that. Given that the majority of reach codes associated with 2016 T24 were related to solar requirements or reporting, we included reach code jurisdictions in the sample. Only 1 jurisdiction included in the analysis had an active Reach Code (effective 7/21/2016). This was the City of Berkeley that required a home energy score for detached units or townhouse units over 600 square feet at the time of sale. |

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| 19 | PG&E | 1 | 22, 23 | NOMAD evaluation methods and findings | In section 3.3.1 NOMAD, the draft C&S Evaluation Report discussed that "Historically, IOUs and evaluators have used a BASS diffusion model" to evaluate NOMAD and IOUs commented that "In some cases, a Markov decision process may be a better estimator". The draft C&S Evaluation Report further stated that "Using either method, the evaluation estimates NOMAD using a pool of experts providing their insights through an iterative process known as the Delphi method." Which method did the evaluation team decide to use to evaluate NOMAD? What instructions on NOMAD evaluation method were given to experts to determine NOMAD? The evaluators state "To assist the participants, the IOUs' determined forecast adoption curve was included as a baseline. "Is this what was done in the 2013 T24 evaluation? Could the evaluators please note and explain any changes in the Delphi process and input materials from previous years?" | The NOMAD participants developed adoption curves essentially by creating actual curves using an excel tool created for this task.<br>BASS parameters were not estimated beforehand and plugged into a BASS equation.<br>Before implementing the NOMAD task, we asked the IOUs if they needed the BASS parameters for any reason or if the curve values were sufficient. The answer from the IOUs was that BASS parameters were not needed and knowing the curves were sufficient.<br>Please refer to the 2013 evaluation for questions about the 2013 evaluation. |
| 20 | PG&E | 3 | 23 | Calculation and reporting Methods | In section 3.3.1 NOMAD (end of page 22), the draft C&S Evaluation Report stated that "The estimated level of natural market adoption curve generated from the Delphi panel is subtracted from the IOU forecast market adoption curve (this can be expressed as availability of equipment, building industry standard practices, or both) and the difference reflects the net C&S savings attributable to the code." This calculation procedure is not reflected in the C&S program impact model presented in Figure 7. | The curves used to estimate savings are developed by the panelists. To understand the difference, we compare the two. The report has been rephrased to avoid confusion on how various curves are treated. |
| 21 | PG&E | 1 | 23 | Expert Selection Process Description | We feel that the Delphi process could be improved in future evaluations with more panelists, as it is documented that there is a linear relationship between the number of Delphi panelists and the reliability of their estimates (see Dalkey, 1969). To assist future evaluations, can this report please include a disposition of the 500 potential panelists? How many of the 500 were identified as being appropriate for T20 vs T24? How many potential panelists remained after each step of the screening process, i.e. how many expressed interest, how many provided | The experts were identified based on industry exposure, credentials, and nominations from IOU staff (11 nominated), nominee contacts, and consultant contacts. For example, through the CCSR documentation alone we identified 133 contacts specifically for building codes. Additional experts were identified through this initial group. They were vetted for expertise and bias using a questionnaire. Industry bias was not an immediate disqualifier but was noted. Candidates that passed the vetting process were invited to participate, noting the process would include multiple iterations and last several weeks. The final panels are dependent on the willingness and ability of these experts to participate. |

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| | | | | | brief statements? Of those who did provide statements, what was the distribution of professional experience or credentials across the different standard groups? Were any people on both panels? Were any of the T24 panelists also on the T20 panels? If yes, how many? Were there more experts in one area than another? Which source was the most fruitful? The Delphi (and attribution panel) methodology details can be put into an Appendix. | To assist in future evaluations (as in this evaluation), the IOUs should nominate experts or organizations when requested by the evaluators. |
| 22 | PG&E | 1 | 25 | The evidence for this influence is provided by the IOUs in a Code Change Savings Report (CCSR). | Please explain the evaluator's process for measures for which there is not a CCSR, as for the NR Lighting Alterations Measure. | Where no CASE or CCSR was available, the evaluators used other CASE reports that made up parts of whole buildings. Additional documentation included material provided by the IOUs. The IOUs did provide calculations in the form of third-party report and Excel spreadsheets for these savings claims and the assumptions. These helped to inform some of the efforts involved. Also, the evaluation team arranged a call with the IOU codes team to discuss lighting and whole building calculations. See also comment #43. |
| 23 | PG&E | 2 | 27 | and interviews with C&S experts who participated in rulemaking proceedings. | How many were interviewed, and what topics did the interviews address? Per the Evaluators Protocols, please provide their titles. | This comment applied primarily to Federal standards proceedings. This language is modified in the final report for codes advocacy. Topics covered general experiences with the process of code development, state political considerations, and perceived relationship between state action and federal policy for codes and standards.<br>Titles (at the time) of 3 subject matter experts we discussed California code development aspects with included: Managing Director, Managing Consultant, and Director Sustainable Buildings and Communities. |
| 24 | PG&E | 1 | 27 | The scoring process should be transparent, documented, and repeatable. | Can the evaluators please describe the methodology of this attribution scoring process in enough detail so that another evaluator could replicate these findings? This can be put into an Appendix. For example, what materials were presented, and what were the scoring instructions? In particular, please tell us if the scoring questions and methodologies are identical to those used in past evaluation cycles, so that the readers can use these scores as metrics for how the program changes over the years. | The IOUs provided the weighting factors. The panelists then submitted their scores independently. We have provided the requested data in CodeData.ZIP file directly to the IOUs.+G25:G43 |

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| 25 | PG&E | 1 | 28 | The team presented evidence describing the C&S Program's contributions | Can the evaluators please provide the IOUs with a copy of this evidence? Or, please include these presentation materials in an Appendix. | We provide the initial presentation slides (based on the CASE and CCSR documents). The majority of backup evidence for panelist questions came from the CCSRs. We have provided the requested data in CodeData.ZIP file directly to the IOUs. |
| 26 | PG&E | 1 | 28 | contributions of other stakeholders . | Please list these other stakeholders who contributed to T24 Advocacy, for each code. As mentioned in the first comment, we are concerned about the decline in the evaluated attribution scores, and would like to understand what other stakeholders are being attributed with greater contributions over time. | See question 1. Also, for details on "other stakeholders who contributed to T24 Advocacy", please refer to the "Key Stakeholders" section of the specific CASE report for the code you are interested in. |
| 27 | PG&E | 1 | 28 | panelists asked the evaluation team questions about the rulemaking activities; In cases where the panel could not reach agreement on factor scores, | What were these questions? What were the evaluation team's responses? On which panels did the group reach agreement, and on which panels did the evaluators have to calculate an average? Overall, more rigorous documentation of both the Delphi and the attribution panels would inspire greater confidence in the estimates. We recommend that the study authors review some practical guidance for documenting Delphi panels in Boulkedid et al, 2011; the guidance also would apply to non-Delphi panels and can be used for the attribution panel methodology write up as well. | Thank you for bringing this to our attention. The comment applies to the evaluation of both appliance standards and building codes. There was one panel with 5 members for codes. For codes all scores were straight averaged. CCSR documents were used as reference material when clarification was needed for most questions. See comment 25. We have provided the requested data in CodeData.ZIP file directly to the IOUs. |
| 28 | PG&E | 2 | 28 | evaluation team members developed scores | Please provide more details on this process. For example, how many evaluation team members participated, and was there any discussion? How many scores were provided for each code? For which scores did the evaluation team reach agreement, and for which scores did the evaluators have to calculate an average? | The attribution workshop - Included two evaluation team moderators and scoring from 5 paid panelists for each code on each of three factors. Panelists were anonymized using a 2-digit number that corresponded to where their initials were on a phone dial pad. These scores were straight averaged.<br>The IOU-provided factor weights – The file also includes suggested weights and rationale for the weights that the IOUs provided via data request.<br>Attribution Final Values – The attribution scores from the workshop were averaged into an attribution score weighted by the three factor weights. Where code detail was not provided (for example whole building), component scores were weighted by kWh and averaged. We have provided the requested data in CodeData.ZIP file directly to the IOUs. |

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| 29 | PG&E | 1 | 34 | Data source of IOU claimed savings parameters | The notes below Table 10, Summary of California Potential Energy, Demand, and Gas Savings, by Code, stated that "Building Code IDs ending with "-P" indicate that evaluation results are "passed through" from CEDARS claim data". CEDARS claim data provided by IOUs does not have enough information to determine potential savings. Please clarify the data source of potential savings for related 2016 Title 24 code measures. | The evaluation focuses on final savings claimed by the IOUs. For pass through savings claims we reviewed available data (CCSR, etc.) for reasonableness. If a code passed that test, we accepted the net program savings claim. We calculated potential savings using one of the files we received in 2019 via data request. No new potential values were developed for these measures. |
| 30 | PG&E | 1 | 35 | reluctant to share data due to perceived legal requirements | How many building departments expressed this reluctance? Please provide a disposition of the jurisdictions throughout the selection process. For the jurisdictions in Table 11, of the barriers to participation discussed, how many jurisdictions experienced each barrier? How many had staff turnover barriers? How many of those showed reluctance due to perceived legal requirements? In how many jurisdictions did CPUC's legal staff intervene? Of those, how many subsequently agreed to participate (and how many continued to refuse)? This information would be invaluable for informing future evaluation studies. | All building departments expressed reluctance on first contact. All offices experienced staff reductions and turnover during the lockdowns (March 2020 - June 2021) and only some offices had electronic records at that time, further complicating the request to locate and share paper files. CPUC legal staff produced a general letter explaining the request and the relevant language. This was provided to jurisdictions during email correspondence. CPUC legal staff directly intervened in 2 cases: Santa Rosa and San Diego. Both eventually complied - Santa Rosa after one call, San Diego took a little over two months and several interactions to comply. We have provided the requested data in CodeData.ZIP file directly to the IOUs. |
| 31 | PG&E | 1 | 36 | The residential project plans obtained consisted of both single-family attached and detached homes | How many plans did each participating jurisdiction provide? How relevant permits did they issue during the period under evaluation? Do the evaluators consider the plans they received to be representative of the three regions being evaluated? | Our knowledge of annual permit issuance is what we gleaned from the Dodge dataset. We asked jurisdictions for specific types of projects and as many projects as they could give us, up to 50 max and request specific projects and addresses from the Dodge dataset. This was not well received by the depts as they could not easily locate those specific projects. When we encountered resistance due to the limitations in accessing these project documents, lack of staff, or both we asked for at least 15 to 20 projects at random that were built to 2016 code. The depts indicated that this was a more reasonable request that they could fulfill.<br>--As a practical matter the plans provided to the evaluation were determined by the jurisdictions.<br>--We cannot say definitively that the residential new construction sample perfectly represents the state, but we can say that the sample includes a diverse set of homes across the 3 regions in the state that were built to 2016 code including tract homes in large developments, "quasi-custom" homes, and ADUs. In our experience in the field, most residential tract homes and "quasi-custom" plans do not deviate significantly in design and size. |

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| | | | | | | --Nonresidential is much more varied in building types and sizes. This is most apparent in lighting and HVAC design. Given that buildings conformed to their approved plans nearly unanimously, we can say that construction follows plan design - at least for envelope and major systems. |
| 32 | PG&E | 1 | 37 | Table 12: Sample Disposition | Why is the proportion of site visits to viable projects so much lower for Residential projects than for Non-residential? | Residential projects are much more difficult to recruit. For example, building plans typically have lot numbers - not addresses. Once we have identified the street addresses, we do not know the occupant's name - it may or may not be the owner. We don't have email information, so recruitment is based on generic mailings. Even with a $100 gift card, convincing an occupant to allow someone to look through their home is not an easy sell - especially true at the end of a global pandemic.<br>For nonresidential properties one can call ahead to make an appointment, show up and conduct the review, or show-up and make an appointment for a later day and/or time. |
| 33 | PG&E | 1 | 38 | Table 15: Sample and Margin of Error | What were the population proportions for these calculations? With a p of .5 and a sample size of 37, the margin of error is plus or minus 13.52% at a 90% confidence level. How were the population proportions determined? These are still all within the 90/30 targets, but please explain. | Since the population sizes are over 5,000, the equation to determine these calculations does not require the population counts/proportions. In other words, there is no need to correct for a small population factor and the calculation is the same regardless of the population size.<br>The equation was included in the report to help avoid this confusion. |
| 34 | PG&E | 1 | 46 | Table 17: Summary of Compliance Findings, by Code | Can the evaluators please provide the numbers that went into these compliance estimates, so that the reader can review the calculations? For example, how many projects in each category, and did the evaluators assign 100% to Categories A and B, and 0% to Categories C and D? | The compliance factor was calculated on a pass/fail basis per project. For example, of 10 projects if 9 matched the T24 compliance documentation and 1 did not, then the compliance factor is 90% (9 projects / 10 projects). This term has been renamed in the report from "Compliance" to "Energy Savings Adjustment Factor (ESAF)" to avoid confusion with regulatory definitions for compliance. See response to comment 49. |
| 35 | PG&E | 1 | 50 | NOMAD values | In section 4.5.1 NOMAD, the draft C&S Evaluation Report did not provide NOMAD evaluation findings for all 2016 Title 24 code measures. The draft C&S Evaluation Report stated that "NOMAD for medium and low priority codes were reviewed for reasonableness but not subject to the NOMAD survey." However, the draft C&S Evaluation Report did not provide any finding on reviews for reasonableness. Appendix | We have provided the requested data in CodeData.ZIP file directly to the IOUs. |

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| | | | | | E provided NOMAD curves for the four high-priority code measures. Please provide numeric NOMAD values for each year from 2016 to 2030 to allow IOUs and other stakeholders to have a reliable data source of evaluated NOMAD for 2016 Title 24. | |
| 36 | PG&E | 2 | 50 | In 2018, the four high priority codes made up over 84% of new code evaluated kWh savings and 13% of all evaluated C&S kWh savings | What about 2017? Can the report please include a table showing each new code, their high, medium, or low priority assignment, and their evaluated savings, by year, so that the reader may verify the calculations? | The new codes reported by the IOUs are the same for 2017 and 2018. The only difference is the level of savings. We identified Res and Nonres whole building new construction and nonres Lighting Alterations as high priority for the evaluation effort. |
| 37 | PG&E | 1 | 51 | include an area showing the range of responses, The evaluation team evaluated the range of time between 2015 and 2030 | Can the evaluators show the actual NOMAD curves, as was done in the 2013-2015 evaluation? Because of the low reliability associated with the low number of responses (see Dalkey, 1969), it is important for the reader to understand how robust these estimates are. A robust estimate is one that would not change very much if a few (or in this case, one) participants' responses were excluded. Please also provide these data to the IOUs for use in forecasting savings. | Where we developed new NOMAD curves, we provide the range and average of these curves in the report appendix. The NOMAD curves in this evaluation apply to 2016 T24 for years 2017 and 2018 only. We have provided the requested data to the IOUs in CodeData.ZIP file. |
| 38 | PG&E | 1 | 51, 53 | Attribution discrepancies | For Table 23, we appreciate the accompanying discussion about the reasons given by the attribution for lower attribution scores for the "other" state building codes. This kind of detail provides not only transparency, but an opportunity for C&S to learn how to improve their work in the future. Given that the IOU Attribution Estimate submitted to the evaluation team was 75% for all building codes, and not 61%, this means that there was an attribution discrepancy for 8 of the 9 codes in the table, not just for 4. Can the evaluation team please provide the | The IOU reported attribution scores of 61% (actually 60.50%) were from a data request dated Jan 31, 2019, and carried forward. Via phone call with PG&E, the IOUs emphasized that the attribution used for cost-effectiveness calculations was 75%. Using this data source, we agreed to change the IOU reported attribution value to 75% in the report tables. The report has been updated to show the IOU estimated 75% attribution value.<br>This change does not change any evaluation calculations, only the difference between IOU estimates and evaluated findings reported in the tables |

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| | | | | | reasons for the lower attribution scores for all 8? Also, in Table 21, for the "main" building codes, there was an attribution discrepancy for all 4 codes, but no corresponding explanation. Can the evaluation team please explain the reasons for this discrepancy, as they did for Table 23? | |
| 39 | PG&E | 2 | 51, 53 | IOU Estimate 0.800 | Where did the evaluation team obtain the estimate of 0.800 in Table 21 and why does it differ from the 61% reported in Table 23? | See the answer to comment 38 |
| 40 | PG&E | 2 | 57 | 86% of the total 2018 savings | Earlier references state that the 4 codes account for 86% across both 2017 and 2018, but this sentence only references 2018. Can the evaluators please break out the claims of the 11 codes by year, for clarity? | A chart showing 2017 has been added on page 57 and page 58 just before the chart showing 2018. |
| 41 | PG&E | 1 | 58 | rather than | NOMAD and Attribution are orthogonal dimensions, did the evaluators really mean to pit the two against one another? | Thank you for bringing this to our attention. There is no intent to "pit" these adjustments against one another. Section 3 of the report explains each term.<br>To clarify these concepts, the section cited has been edited. |
| 42 | PG&E | 1 | 58 | completely driving innovative technology and techniques | Is this the criterion for evaluating attribution? If the attribution panels were directed to base scores on the code's achievement in driving "innovative technology and techniques", then that is a serious misunderstanding of the C&S Advocacy program primary objectives, and would have led to inaccurate attribution scores. | Thank you for bringing this to our attention. The sentences have been edited in the FINAL version to minimize confusion between interpretations of NOMAD and Attribution. |

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| 43 | PG&E | 1 | 61 | Conclusion 2: Typically, there is confusion about how whole building savings are derived | The answer to these questions can be found in the previous evaluation report "California Statewide Codes and Standards Program Impact Evaluation Phase Two, Volume Two: 2013 Title 24", CALMAC ID CPU0170.01, under section 2.1.4 "Relationship Between Whole Building Estimates and Individual Standards". | Thank you for the reference. We stand by our statement that, "typically, there is confusion about how whole building savings are derived." The documentation provided by the IOUs does not coincide with the savings reported and this leads to confusion. Even after meeting with the IOU building code team, the evaluators could not replicate IOU savings values.<br>As the evaluators note in your reference (page 14), "... Cadmus found that the IOU savings estimates for individual standards included in the whole building analyses did not account for the implementation of multiple standards at once, and thus do not account for interactions and the resulting impact on savings."<br>Previous evaluation report source: https://www.calmac.org/results.asp?flag=&searchtext=CPU0170.01&pubsearch=1&dFrom=1%2F18%2F1990&dTo=3%2F20%2F2023&yFrom=1980&yTo=2023&selPubDates=&selToDate=&selProgYear=&selToYear=&pubsort=1&Submit=Search |
| 44 | PG&E | 1 | 62 | ED Conclusion 3: unoccupied buildings, due mainly to remote working, were two of the highest hurdles we had to access buildings | Can the evaluators please include a discussion in the appropriate section (perhaps in a section reporting the building sample disposition), and provide data on how many buildings were visited but were unoccupied so that the reader can understand the extent of this barrier? How many instances were there of owners being offsite, outside of the city or state? This has not been mentioned previously and it is a best practice not to introduce new information in the conclusions, but rather to share them earlier in the document with accompanying data showing the basis for the conclusion. | This is a broader question that can be answered based on "early-lockdown" findings and "post-lockdown" findings. Table 12 in the report has been expanded to break out findings from the "post-lockdown" period. |

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| 45 | PG&E | 1 | 63 | Both IOU/ED Conclusion: within the lifespan of the original equipment | The IOUs were not aware of any third-party questions about C&S reporting policies and procedures, and would have welcomed any questions. To clarify, IOUs did not claim any savings during the 2016 – 2018 period for the original equipment installed before 2016 . Rather, the C&S program claims first-year energy savings from appliances and building measures installed in the year for which energy savings are claimed. The C&S program follows the same savings reporting procedure as incentive programs by using CPUC Cost-Effectiveness Tool to obtain lifecycle savings based on new installations in the year for which lifecycle energy savings are reported. Please clarify which specific CPUC C&S reporting policies and procedures have been often questioned by third parties, and if there any public records of these questions for us to better understand the context. Can the evaluation team please discuss their analysis and the data driving their conclusion earlier in the document, before including it as a final conclusion? We cannot find any information and analysis in the draft C&S Evaluation Report to support this conclusion. The basis for claiming for continuing savings from past codes is discussed in the 2006-2008 evaluation: "Volume III: Codes & Standards (C&S) Programs Impact Evaluation", CALMAC ID CPU0030.06, and we would be happy to meet to discuss this further if needed. | Thank you for this comment. We agree. In retrospect this conclusion is out of scope for this evaluation. This conclusion has been removed from the final report. This will not resolve the outstanding question; however, it only moves it to another time and venue. This comment was meant to start a conversation on whether continuing to report savings from prior code years presents an accurate picture of current savings from the program.<br>Given the numerous changes in energy efficiency policy and practice since 2006, this question should be revisited to validate or refute current evaluation and reporting procedures.<br><br>For more details and arguments against including prior code activities also refer to "https://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/49859-06.htm#P605_149602". |
| 46 | PG&E | 1 | 64 | Evaluation Scope | It is not clear which 2016 Title 24 code measures were covered by the 2016-2018 codes and standards (C&S) evaluation and which of these code measures were used to determine evaluated savings. Table 29 *Evaluation Scope* in Appendix A provided a list a code measures. However, the draft C&S Evaluation Report provided evaluation results for several other codes measures not included in Table 29. For example, Table 23 provided attribution evaluation results for Std B122, B123, and 124, which were not included in Table 29. On the other hand, IOUs provided savings information on | The savings addressed in the evaluation are listed in Appendix A. We evaluated savings for codes where savings were reported in CEDARS. Tankless water heaters (B125) were not evaluated separately because the IOUs did not report savings for them separately.<br>The "other" codes you reference were used during the attribution panel as components to the whole building savings. These codes provide more detail on the overall whole building score given that IOU whole building documentation is limited.<br>The report has been updated to clarify why these codes appear in the report. |

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| | | | | | Std B125 RNC(SF)-DHW-Tankless Water Heater and draft C&S Evaluation Report discussed field inspection results related to instantaneous water heater in Figure 18. However, the draft C&S evaluation Report did not provide evaluation results on this measure. It is unclear if Std B125 was included in the evaluation scope. It is not in Table 55. Please add it or explain why. We understand that energy savings for some code measures were included in nonresidential or residential whole building measures. The draft C&S Evaluation Report needs to clearly indicate which code measures were considered as components of a building measure. For whole building code measures, draft C&S Evaluation Report needs to explain if and how evaluation results of individual code measures were used to determine energy savings parameters of related whole building code measures. | |
| 47 | PG&E | 3 | 67 | the total value between 2016–2018 | Why did was 2016 included, if the 2016 Energy Code did not go into effect until Jan 1, 2017? | You are correct that the building codes being evaluated went into effect in 2017. There were no savings from new codes reported in 2016. The only 2016 savings reported were from codes effective from 2005 to 2016. 2016 was included to reflect overall program reported savings and for date consistency between the Vol 1 "Appliance Standards" and Vol 2 "Building Code" evaluations. |
| 48 | PG&E | 1 | 90 | Attribution evaluation score for B130 Residential New Construction of Single-Family Whole Buildings | Appendix F in the draft C&S Evaluation Report provided attribution weighting factors and scores for standard B130 in three attribution areas. The sum of the three weighting factors is not 100%. Please clarify how the weighting factors and attribution scores were obtained. | Thank you for bringing this to our attention. The weights in the table were copied from excel to word incorrectly and have been updated. The factor scores and final attribution scores were copied correctly and remain the same. We have provided the requested data in CodeData.ZIP file directly to the IOUs. |

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| 49 | ZYD Energy Inc. | | | The attribution score for B122 is 66%. | The attribution score for 2016 B122 Single Family Lighting (66%) is lower than appropriate. Full comment in letter dated March 29, 2023. | For the most part panelists agreed on scoring. The IOUs provided the weights. The highest score (80%) was assigned to Factor 2 where IOUs "Developed definitions, countered industry attempts to derail, estimated energy use, analyzed cost-effectiveness". This was paired with an IOU provided weight of 40%.<br>The lowest score (56%) was for factor 1 with an IOU provided weight of 10%. The low weight and score were assigned due to the considerable overlap with LED lighting standards.<br>While panelists did recognize that the IOUs were "heavily involved with stakeholders", four panelists scored this factor at 60% and one dissented and assigned a score of 45%. The average of these five scores was 57% and was applied to a weight of 50%. The result was a final score of 66%.<br>The slide for B122 that was presented to the panel has been shared directly with the IOUs in the CodeData.ZIP file. See file #25. |
| 50 | California Energy Alliance | | Compliance sections | Use and definition of the term "Compliance " throughout the evaluation report | Compliance levels must have one meaning within and between California's energy agencies. Full comment provided in memo dated April 7, 2023. | Thank you for the comment. Overall, we cannot disagree with your discussion of the how the term "compliance" is used differently in different venues.<br>The purpose of the CPUC program evaluation is to assess the level of energy savings reported by the IOU programs. As such evaluators review assumptions and calculations for reasonableness of estimated energy savings including using a sample of buildings and equipment. This purpose is different than inspecting buildings and equipment to enforce all title 24 regulations.<br>-To help avoid confusion for readers we accept your recommendation to refer to our comparison of data collected on-site to plan documentation as "Energy Savings Adjustment Factor" (ESAF) rather than "compliance". Furthermore, the final report includes additional language to make this distinction more explicitly. |
| 51 | California Energy Alliance | | | Data Request re: Sample size and composition | Please list, for each of the four measures where compliance was assessed, the field inspection building count by jurisdiction. Full data request provided in memo dated April 7, 2023 (page 23). | We have added this information as an Appendix C in the final report |
| 52 | California Energy Alliance | | | Application of site visit results | It is not possible to extrapolate from a non-random sample. | Thank you for the comment. Your assertion is correct. Our savings estimates are representative of our sample. A truly representative study of code compliance would entail many more sample points for each building type and region. While a study of this magnitude is possible, it would require a much larger budget than what has been allocated. |

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| 53 | California Energy Alliance | | | Gross savings estimates | IOUs do not have the requisite independence to provide compliance values for the CPUC evaluation of IOU programs. | The IOU forecast compliance rate estimates are presented as default values. Without some degree of field verification any replacement value would be arbitrary under the current evaluation structure. Rather than field data collection however, one option for future evaluations is to have compliance estimates either a) stipulated (70%?) or b) developed in a similar fashion as NOMAD. Use a Delphi panel of subject matter experts from throughout the state to estimate relevant aspects of regional compliance with Title 24 part 6. These aspects would differ depending on the IOU savings claims for a given program year. |
| 54 | NLCAA | | | Use and definition of the term "Compliance " throughout the evaluation report | The evaluation definition/approach to "compliance" does not address actual code compliance. | Thank you for the comment. We agree. Please see response to comment 50. |
| 55 | NLCAA | | | Models for estimating vs data collection to reflect reality | The use of estimates and assumptions is reasonable for modeling, but does not represent what is being encountered in the field. | Thank you for the comment. We agree. Typically, models are used to simplify complex systems. For example, taking a state with 16 climate zones (at a minimum), 541 separate building departments, approximately 1,300 construction companies, and multiple stakeholders and interveners, and boiling it down to a few summary tables.<br>While we can capture broader trends with models and assumptions, we do not purport to be able to reflect the nuance involved statewide in each of the 4 studies that serve as inputs to Net Program Savings. This issue is referenced in section 5.1.2 conclusions 1 and 2 of the evaluation report. |
| 56 | NCLAA | | | Data collection and compliance | The sections of the report listing issues encountered obtaining field compliance data were of particular interest to NLCAA. Those sections address some of the real-world issues that we have experienced as Title 24 acceptance testers. | Thank you for the comment. From our perspective, this relates to comment 53. Specifically, the evaluation protocol descriptions for each sub-study are relatively straight forward. The value gained from each sub-study (as we continue to see from comments across code evaluations) may be debatable. |

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