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CONSULTANT REPORT

Impact Analysis

2022 Update to the California Energy Code

Prepared for: **California Energy Commission**
Prepared by: **NORESCO and Frontier Energy**

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ABSTRACT

This report estimates the energy and greenhouse gas emissions impacts of the 2022 Building Energy Efficiency Standards (Energy Code). The 2022 Energy Code was adopted by the California Energy Commission (CEC) on August 11, 2021, approved by the California Building Standards Commission on December 14, 2021, and went into effect on January 1, 2023. The analysis in this report compares the prescriptive and mandatory requirements of the 2019 Energy Code with the prescriptive and mandatory requirements of the 2022 Energy Code. This analysis considers 16 distinct California climate zones and uses various prototypical building energy models to represent California's building stock in the residential, multifamily, and nonresidential building sectors.

Keywords: impact analysis, energy efficiency, energy savings, Energy Code, Building Energy Efficiency Standards, building standards

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EXECUTIVE SUMMARY

Consistent with California Law (Public Resources Code §§ 25000, 25402), California's Building Energy Efficiency Standards (also referred to as the Energy Code) serve to reduce wasteful, uneconomic, inefficient, or unnecessary consumption of energy in the state. The Energy Code is updated roughly every three years. The California Energy Commission (CEC) adopted the 2022 Energy Code on August 22, 2021, which took effect on January 1, 2023. After major updates to the Energy Code, the CEC performs an analysis of the estimated statewide energy and greenhouse gas emissions impacts of the new set of standards, called the *Impact Analysis*. This analysis compares the prescriptive and mandatory requirements of the 2019 Energy Code with the prescriptive and mandatory requirements of the 2022 Energy Code.

Among many other improvements, the 2022 Energy Code updates include the encouragement of efficient electric heat pump usage for space heating and water heating, establishing electric-ready requirements for new homes, and strengthening ventilation standards. For the first time in the nation, this update also includes solar-electric systems in addition to battery systems as the performance standards baseline for select nonresidential building types. The 2022 Energy Code contains several additional measures regarding energy efficiency and covered processes to increase the stringency of the Energy Code. New construction and alterations of existing residential, multifamily, and nonresidential buildings constitute the scope of this analysis. The analysis estimates savings based on time-dependent valuation (TDV) and hourly source energy (HSE), as well as estimating energy demand reductions and greenhouse gas (GHG) emissions reductions.

Methodology

The methodology for the *Impact Analysis* follows:

1. **Qualitative Analysis.** The first step was to perform a qualitative assessment comparing the prescriptive and mandatory requirements of the 2019 and 2022 Energy Code editions. The qualitative analysis identified individual code changes between the two code editions, characterized the changes in terms of the affected building types and climate zones, and determined whether each change directly affected building energy consumption.
2. **Quantitative Analysis.** Quantitative analysis was completed using predictive building energy modeling software and a set of prototypical building energy models (prototypes) developed by the CEC, which represent California's building stock. Prototype models conforming to the mandatory and prescriptive requirements of the 2019 and 2022 Energy Code editions were created and these models were simulated for comparison in each of California's 16 climate zones. Covered processes that could not be directly modeled were separately quantified using supplementary calculation methods.
3. **Results Scaling.** To scale the site energy savings produced by predictive building energy models to the statewide level, results were multiplied by CEC-developed forecasted construction floor areas, by building type and climate zone. Impacts from covered processes were added to the statewide modeled totals to estimate the total statewide impact of the 2022 Energy Code. Site energy savings estimates were

converted to TDV, HSE, and GHG emissions (in the form of carbon dioxide equivalent) using CEC-developed conversion factors.

Results

Qualitative analysis identified a total of 60 unique Energy Code changes or "measures" directly impacting the energy consumption of buildings and covered processes. Of these measures, 41 were quantified in the quantitative analysis. The impact of certain measures was not assessed because either the code change was due to a change to federal efficiency standards, the measure savings could not be readily modeled with existing building energy modeling tools, or the change was made to one of many already-available compliance options or exceptions in the Energy Code. The estimated impact analysis presented in this report could be considered conservative as a result.

Table ES1 shows the statewide impact of the 2022 Energy Code relative to the 2019 Energy Code. HSE and site energy are not reported for covered processes because those metrics were not covered by the CASE reports, which were the source of the data for covered process measures. Annually, the 2022 Energy Code is estimated to:

- Save 5,472 GBtus, 1,565 GWh, and 14.39 MTherms of site energy.
- Save 46,782 GTDV, 2,954 GBtu HSE, and 285,214 tonnes of CO2e.
- Provide 123 MW of non-coincident peak demand reduction.

Table ES1: Annual Statewide Energy Savings of the 2022 Energy Code

Sector	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Sector	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2e]**
New Construction							
Nonresidential	2,077.63	511.04	2.21	5.52	12,513	803	49,277
Multifamily	801.26	116.77	3.81	0.81	3,973	441	29,059
Single-Family	361.12	(48.54)	5.27	(2.71)	657	326	22,667
Subtotal: New Construction	3,240	579.27	11.29	3.62	17,143	1,570	101,003
Alterations							
Nonresidential	1,382.88	398.35	0.23	35.49	11,320	856	52,762
Multifamily	457.08	126.94	0.24	13.20	3,657	301	18,647
Single-Family	392.42	91.22	0.81	43.33	4,599	227	14,271
Subtotal: Alterations	2,232	616.51	1.28	92.02	19,576	1,384	85,680
Covered Processes							
Subtotal: Covered Processes	NA	369.36	1.82	27.34	10,063	NA	98,531
Total Statewide Savings							
Total	5,472	1,565	14.39	122.98	46,782	2,954	285,214

1.0 Introduction

1.1 Background

Title 24, Part 6, Building Energy Efficiency Standards were developed in 1978 to regulate the energy consumption of new and existing buildings. These regulations fulfilled the mandate established by the Warren-Alquist Act (CEC 2022) of 1975. Since then, the California Energy Commission (CEC) has updated California's Energy Code (now in Parts 1 and 6 of Title 24) every three years, continuously improving the energy efficiency of California's buildings. After the new building code is adopted, the CEC analyzes the statewide impact of the new regulations, called "Impacts Analysis" relative to previous regulations.

The CEC adopted the 2022 edition of Title 24, Parts 1 and 6 ("Energy Code") in August 2021, and it was approved by the California Building Standards Commission in December 2021. The 2022 Energy Code took effect on January 1, 2023. This report describes the Impacts Analysis of the 2022 Energy Code and provides an estimate of the energy, demand, and emissions savings from incremental changes to the 2022 Energy Code relative to the 2019 Energy Code.

The primary purpose of the Impact Analysis is to estimate the annual energy savings of the adopted 2022 Energy Code relative to the 2019 Energy Code and to provide an estimate of future code savings for new and existing buildings. A secondary objective is to demonstrate that the 2022 Energy Code is at least as stringent as the national model energy codes for nonresidential and residential buildings, ASHRAE Standard 90.1-2019 (ASHRAE 2019) and the 2021 International Energy Conservation Code (IECC) (ICC 2021), respectively. The nonresidential state certification analysis is presented in APPENDIX B-1: 2022 Energy Code DOE Certification for Nonresidential Buildings, and the residential state certification analysis is presented in APPENDIX B-2: 2022 Energy Code DOE Certification for Residential Buildings.

New to the 2022 Energy Code are standards for heat pumps in single-family, multifamily, and nonresidential buildings for space heating and water heating under certain conditions, as well as standards for photovoltaic (PV) and battery systems in nonresidential and multifamily buildings. Other measures were adopted that target energy efficiency and covered processes.

1.2 Objective

The objective of this analysis is to determine the statewide energy savings of prescriptive and mandatory changes adopted in the 2022 Energy Code, relative to the 2019 Energy Code using time-dependent valuation (TDV) and hourly source energy (HSE). The analysis also estimates demand savings and greenhouse gas (GHG) emissions reductions. New construction and alterations of existing residential, multifamily, and nonresidential buildings constitute the scope of this analysis.

1.3 Report Layout

The report is organized as follows:

- Section 1 defines the objectives of the Impact Analysis.

- Section 2 documents the methodology used to estimate savings between the 2022 and 2019 Energy Code editions.
- Section 3 presents the summary of results from the Impact Analysis.
- Section 4 lists references cited in the report.
- Appendix A presents results from the qualitative analysis of the 2022 Energy Code.
- Appendix B-1 describes an analysis to demonstrate that the nonresidential provisions of the 2022 Energy Code are at least as stringent as the national model code for nonresidential buildings, ASHRAE Standard 90.1-2019.
- Appendix B-2 describes an analysis to demonstrate that the residential provisions of the 2022 Energy Code are at least as stringent as the national model code for residential buildings, 2021 IECC.
- Appendix C presents detailed results from the impact analysis in terms of energy savings, energy demand reduction, and GHG emissions reductions for residential, multifamily, and nonresidential buildings.
- Appendix D presents the projected floor area, a mapping of the prototype models, and new construction forecasts for each building type.

2.0 Methodology

2.1 Overview

The steps below were followed to develop savings estimates for the 2022 Energy Code:

1. A qualitative analysis comparing the prescriptive and mandatory requirements of the 2019 and 2022 Energy Code was performed. This qualitative analysis identified individual code changes between the two codes, whether the change directly affected building energy consumption, the building types and climate zones impacted by the change, and whether the change will be captured in the quantitative analysis through energy modeling or other means. Code changes that were primarily editorial in nature or clarifications that do not directly affect energy consumption were identified in the qualitative analysis but omitted from the quantitative analysis.
2. The measures that were identified by the qualitative analysis as affecting energy consumption were assessed in the quantitative analysis. The quantitative analysis used whole building energy modeling and a set of prototypical building models, which represent the building stock, to perform the analysis. Prototype models conforming to the mandatory and prescriptive requirements of the 2019 and 2022 Energy Code editions were created and these models were simulated in each of California's 16 building climate zones. Covered processes that cannot be directly modeled as part of a building were assessed separately using supplementary calculations.
3. Site energy results from energy modeling and from covered processes were converted to other metrics, including TDV, HSE, and GHG emissions (in the form of carbon dioxide equivalent) using conversion factors. To aggregate the results to the statewide level, the results from energy modeling of individual prototypes were scaled with the forecasted construction floor area by building type and climate zone and then summed across prototypes, climate zones, and building sectors (residential, multifamily, and nonresidential). These energy modeling results were then combined with savings estimates for covered processes to determine the statewide impact of the 2022 Energy Code.

The scope of the analysis was limited to changes in the 2022 Energy Code enacted by the state in Title 24, Part 6. Changes to Part 6 resulting from changes to federal equipment efficiency standards (for example, a change to the minimum SEER requirements for air-conditioners) were excluded by making the equipment efficiency the same between the 2019 and 2022 building models for those changes. Changes to other parts of Title 24 that may impact the energy consumption of a building were not captured under the assumption that the impact from those changes is captured elsewhere and there should be no double-counting of the impact.

Further details about the methodology of different measures, savings from alterations, prototypes, climate zones, conversion, and weighting factors, and forecasted floor area are below.

2.2 Qualitative Analysis

The objective of the qualitative analysis was to characterize the changes between the 2019 and 2022 Energy Codes. The change characterization includes:

1. A brief description of the change.
2. Whether the change impacts energy consumption. There may be changes to the 2022 Energy Code that are clarifications or that are editorial, or changes resulting from section renumbering or moving of requirements within the standard (for example, changes related to multifamily restructuring). It is important to identify and distinguish these changes from those that directly impact the energy consumption of buildings. Only those changes that have a direct impact on energy consumption were included in the quantitative analysis.
3. Whether the change will be captured in the quantitative analysis. For cases in which the change was not captured in the quantitative analysis, the reason was provided. The main reasons for not capturing a change are:
    a. The change was due to federal efficiency standards updates. For example, the packaged heat pump heating COP (47^{o} F) for heat pumps between 65 kBtu/h and 136 kBtu/h changed from 3.3 for units installed before January 1, 2023, to 3.4 for units installed after January 1, 2023. This was a change to the federal efficiency standards (CFR 2022) that would have impacted several building types but was not captured in the quantitative analysis because it is not attributable to the 2022 Energy Code.
    b. Measures that cannot be readily modeled with prototypes. For example, covered processes that could not be directly modeled were separately quantified using supplementary calculation methods.
    c. The change was made to one of many options or exceptions that was not taken or is not represented in the prototypes. For example, the dedicated outdoor air system (DOAS) requirements introduced in the 2022 Energy Code would apply only where DOAS systems were installed. The prototypes, which represent the California building stock, do not have DOAS systems and therefore the impact of this change was not captured. Another example is the display lighting credit typically used by jewelry stores. This credit was not taken in the prototypes.

The qualitative analysis identified 60 measures in the 2022 Energy Code that directly affect the energy consumption within buildings and covered processes. Of these measures, 41 were captured in the quantitative analysis. APPENDIX A provides the complete list of changes, whether they were captured in the quantitative analysis and the reason if they were not captured. Table 1 summarizes the most impactful changes between the 2019 and 2022 Energy Code. Since this analysis excludes the impact of certain measures, the estimated statewide savings is a conservative estimate of the 2022 Energy Code’s impact. The actual impact may be higher.

Table 1: High impact measures in the 2022 Energy Code

Code Change Brief Name	Sector	Change Description	Qualitative Impact
Heat pumps for space heating and water heating	New construction: Nonresidential, multifamily, and single family	Heat pumps are standard for single-zone space heating systems in a majority of climate zones and a number of nonresidential and high-rise multifamily building types. Heat pump water heaters are required prescriptively in school buildings in climate zones 2 through 15. For single-family, a heat pump space heater is prescriptively required in climate zones 3, 4, 13, and 14 and a heat pump water heater is prescriptively required in climate zones 1-2, 5-12, and 15-16.	Very high gas savings and carbon savings. Single zone systems are the dominant system type in single-family and multifamily buildings and a number of nonresidential buildings.
PV and battery standards	New construction: Nonresidential and mid- and high-rise multifamily	PV and battery systems are standard for a number of nonresidential building types and high-rise multifamily buildings. The PV and battery systems are sized to limit exports to 5%.	This measure is widely applicable and results in significant electricity and carbon savings. The battery measure is highly impactful in reducing demand during peak hours and therefore results in utility bill savings.
Fan power allowance	New construction: Nonresidential Alterations: Nonresidential	A new approach to calculating the fan power allowance was developed for the 2022 Energy Code.	This measure affects fan systems in all prototypes and affects nearly the entire nonresidential building stock. This results in very high electricity savings.
Controlled environment horticulture (CEH)	Covered processes: CEH facilities	This measure regulates the energy use from lighting, dehumidification, and envelope components of a CEH facility or building.	CEH is a growing sector in California and the regulation of processes within the CEH facility results in a large amount of electricity savings.
Single-family alterations	Alterations: Single-family and low-rise multifamily	A group of measures is required when performing alterations to single-family and low-rise multifamily buildings: cool roofs, low-sloped roof insulation, electric replacement heating equipment, duct sealing, duct insulation, attic insulation	These measures result in substantial savings and affect a large portion of the existing building stock.

2.3 Quantitative Analysis

The quantitative analysis estimated the impact of code changes that were deemed to have a direct impact on the building energy consumption in the qualitative analysis. The quantitative analysis used a combination of whole building energy modeling and engineering calculations to estimate the impact of measures.

2.3.1 Simulation Engines

Excluding measures affecting covered processes, the impacts of the measures were captured using whole building energy modeling. For the nonresidential, high-rise multifamily, and mid-rise multifamily buildings, the United States Department of Energy's (U.S. DOE) EnergyPlus (DOE, 2021) simulation was used. EnergyPlus is a state-of-the-art simulation engine that can model the impact of renewables, building energy efficiency, and demand response measures. It is under continuous development with funding from the DOE. It is also the basis of California's code compliance software for nonresidential and multifamily buildings (CBECC 2020).

For single-family and low-rise multifamily buildings CBECC-Res (CEC 2022) and the underlying California Simulation Engine (CSE) were used. For the 2022 code cycle, multifamily building analysis was combined with a new software tool. As a result, multifamily modeling capability has been removed from the latest CBECC-Res 2022 software and an interim version (subversion 2174) that retained the ability to model multifamily buildings was used for this analysis.

2.3.2 Prototypes

Prototype building models are computer models that represent building types within the building stock and generally conform to the average features of the building stock, thereby allowing for analysis of the impact of energy efficiency and other measures on the stock. Nonresidential prototype building models used in the impact analysis were derived from the state-approved compliance software—California Building Energy Code Compliance (CBECC) software for nonresidential (CBECC-Com) and residential buildings (CBECC-Res). The models are sometimes referred to as "zero compliance" models because they are minimally compliant with the performance path requirements of the Energy Code.

The prototype models were developed as follows:

1. Begin with prototype models that meet the 2019 Energy Code requirements. These models were output from CBECC-Com and CBECC-Res and represent the 'baseline' condition.
2. Changes or measures identified in the qualitative analysis were incorporated into the baseline models to develop the 2022 Energy Code models.
3. Both sets of models were simulated and the resulting change in annual energy consumption represents the impact of the 2022 Energy Code. The change in energy consumption was divided by the prototype floor area to calculate the unit energy savings.

Table 2: Prototype Model Description

Prototype Name	Number of Stories	Floor Area (square ft)	Description
Nonresidential Prototypes			
Hospital	3	241,374	5-Story Hospital prototype model, identical to the DOE Hospital prototype model.
HotelSmall	4	42,554	4-story Hotel with 77 guest rooms. WWR-11%
OfficeLarge	12	498,589	12-story + 1 basement office building with 5 zones and a ceiling plenum on each floor. WWR-40%
OfficeMedium	3	53,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR-33%
OfficeMediumLab	3	52,628	3-story office building with 5 zones and a ceiling plenum on each floor. WWR-33%
OfficeSmall	3	5,502	1-story, 5 zone office building with pitched roof and unconditioned attic. WWR-24%
RestaurantFastFood	1	2,501	Fast food restaurant with dining areas and a small kitchen. WWR-14%. Pitched roof with an unconditioned attic
RetailLarge	1	240,000	Big-box type retail building with WWR-12% and SRR-0.82%
RetailMixedUse	1	9,375	Retail building with WWR -10%. Roof is adiabatic
RetailStandAlone	1	24,563	Similar to Target or Walgreens.WWR-7% on the front façade, none on other sides. SRR-2.1%
RetailStripMall	1	9,375	Strip mall building. WWR-10%
SchoolPrimary	1	24,413	Elementary school. WWR-36%
SchoolSecondary	2	210,866	High school. WWR-35% and SRR-1.4%
Warehouse	1	49,495	Single-story high-ceiling warehouse. Includes one office space. WWR-0.7%, SRR-5%
Assembly	1	68,013	Assembly building with WWR of 19.0% equally distributed on all four facades
Data Center (Computer Room)	1	2,280	12' ceiling, adiabatic walls, and roof, internal loads from CBECC Computer Room space type. For containment, 7 tile spacing: 5 cold aisles, 4 hot aisles

Multifamily Prototypes			
HighRiseResidential	5	113,100	88-unit building with 4-story residential plus first-floor common areas. Concrete podium construction with wood framed wall construction, and flat roof. Window to Wall Ratio-0.10 (ground floor) 0.25 (residential floors). Individual space conditioning systems and a central domestic hot water system.
MidRiseResidential	10	125,400	117-unit building with 9-story residential + first floor common areas. Concrete podium construction with steel framed wall construction, and a flat roof. Window to Wall Ratio-0.10 (ground floor) 0.40 (residential floors). Individual space conditioning systems and a central domestic hot water system.
3-Story Loaded Corridor Multifamily	3	39,372	36-unit residential building with slab-on-grade foundation, wood-framed wall construction, and a flat roof. Window to Wall Ratio 0.25. Dwelling units flank and central corridor and common area spaces are included on the bottom floor. Individual space conditioning systems and shared DHW system.
2-Story Garden Multifamily	2	7,320	8-unit residential building with slab-on-grade foundation, wood framed wall construction, and a sloped roof. Individual space conditioning serving each unit. Window to Wall Ratio 0.15. Each dwelling unit has individual HVAC and DHW systems.
Single-Family Prototypes			
Single-Family New Construction 1-Story	1	2,100	1-story detached single-family home with an attached garage, slab-on-grade foundation, wood-framed wall construction, and a vented attic.
Single-Family New Construction 1-Story	2	2,700	2-story detached single-family home with an attached garage, slab-on-grade foundation, wood framed wall construction, and a vented attic.
Single-Family Existing Home	1	1,665	1-story existing single-family house for evaluation of alteration measures. Two variations: the steep-sloped roof above the attic with the ducts in the attic; low-sloped roof with the ducts in conditioned space

2.3.3 Climate Zones

Representative cities and weather stations were selected for each of California's 16 building climate zones in the analysis. The TDV and HSE conversion factors (described in section 2.4.2 of this report) are tied to these specific weather files. Table 3 shows the climate zone, the city representing the climate zone, the weather file selected to represent the city, and the county where the city is.

Table 3: Weather files used for modeling California climate zones

Climate Zone	Representative City	Weather File	County
1	Arcata	ARCATA_725945_CZ2010.epw	Humboldt
2	Santa Rosa	SANTA-ROSA_724957_CZ2010.epw	Sonoma
3	Oakland	OAKLAND_724930_CZ2010.epw	Alameda
4	San Jose	SAN-JOSE-REID_724946_CZ2010.epw	Santa Clara

Climate Zone	Representative City	Weather File	County
5	Santa Maria	SANTA-MARIA_723940_CZ2010.epw	Santa Barbara
6	Torrance	TORRANCE_722955_CZ2010.epw	Los Angeles
7	San Diego-Lindbergh	SAN-DIEGO-LINDBERGH_722900_CZ2010.epw	San Diego
8	Fullerton	FULLERTON_722976_CZ2010.epw	Orange
9	Burbank-Glendale	BURBANK-GLENDALE_722880_CZ2010.epw	Los Angeles
10	Riverside	RIVERSIDE_722869_CZ2010.epw	Riverside
11	Red Bluff	RED-BLUFF_725910_CZ2010.epw	Tehama
12	Sacramento	SACRAMENTO-EXECUTIVE_724830_CZ2010.epw	Sacramento
13	Fresno	FRESNO_723890_CZ2010.epw	Fresno
14	Palmdale	PALMDALE_723820_CZ2010.epw	Los Angeles
15	Palm Springs	PALM-SPRINGS-INTL_722868_CZ2010.epw	Riverside
16	Blue Canyon	BLUE-CANYON_725845_CZ2010.epw	Placer

2.3.4 Covered Process Measures

Several measures could not be modeled because they applied to processes that are typically not part of buildings. For example, there is a new requirement for steam traps in industrial facilities where the savings are dependent solely on the covered process and have no relationship to the building in which the process is housed. The savings calculations for steam traps were also not amenable to a building energy model. Therefore, the impact of such measures was determined using supplementary sources and calculations.

During the code development process for the 2022 Energy Code, detailed reports were produced by the Codes and Standards Enhancement (CASE) Team to justify the code change. These reports describe the assumptions behind the code change and provide the energy impact from the measure. If a covered process measure could not be modeled, but there was a report documenting the engineering calculations behind the measure, that report and the results therein were utilized to account for the impact of the measure.

2.3.5 Alterations Measures

For existing buildings, alterations that trigger Energy Code requirements were evaluated by applying an estimate of the effective useful life (EUL) of each measure to the existing building stock. For instance, an HVAC measure that has a EUL of 20 years will see a replacement rate of 1/20, or 5% each year. This replacement rate was multiplied by the percentage of building stock impacted by the measure, and by the total existing building stock, to determine the statewide impact. Early retirement and upgrades of equipment were not included in the impact calculation, resulting in a conservative estimate of savings.

The approach to calculating per unit and statewide savings for single-family and low-rise multifamily alterations were taken from the Residential Energy Savings and Process Improvements for Additions and Alterations CASE Report (Statewide CASE Team 2020a) with three exceptions, described below.

1. The cool roof for steep-sloped roofs measure was not adopted for multifamily buildings in Climate Zone 2 as proposed in the CASE Report. The savings in this climate zone were removed for this analysis.
2. HERS verification of the air sealing requirement as part of the new attic insulation and air sealing requirements was not adopted as proposed in the CASE Report. Without third-party verification of air sealing, it is expected that the work will not be conducted properly in many instances, at least initially as the workforce gains familiarity with the new requirement. In the absence of direct data to inform the reduction in savings, it was assumed that without third-party verification air sealing would be done properly only 25 percent of the time and the air sealing savings were reduced by 75 percent. This percentage was chosen because it provides a conservative estimate of savings and actual savings in the field may be higher.
3. In most cases, the alteration measures would be triggered under different conditions independently and it is appropriate to evaluate the savings for each measure individually. However, the low-sloped cool roof and low-sloped roof insulation measures are triggered at the same time when a low-sloped roof is replaced. These two measures were modeled together, and the adjusted savings were applied in the climate zones and scenarios where they are both required.

2.3.6 Single-Family and Low-Rise Multifamily Fuel Aggregation

The 2019 Energy Code is agnostic toward fuel selection for water heaters and space heaters, but the 2022 Energy Code prescriptively establishes fuel type for each of these two end-uses by climate zone. To arrive at the average energy use for a 2019 dwelling unit, both all-electric and mixed fuel prescriptively compliant models were developed. The results were then weighted based on data from the 2019 Residential Appliance Saturation Study (RASS) (DNV 2021). Savings for the 2022 prescriptive package were calculated relative to this weighted average 2019 prescriptive package.

Table 4 presents the shares of gas and electric appliances for water heating and space heating of single-family and multifamily buildings. These data were based on the newest construction vintage available in RASS, i.e., buildings constructed between 2013 and 2019. The single-family data was based on the following RASS categories: single-family, townhouse, duplex, and row house. The multifamily data was based on the following RASS categories: apartment/condo 2-4 units and apartment/condo 5+ units.

Table 4: Percentage of Units with Gas and Electric Appliances

Category	Units with Gas Appliance	Units with Electric Appliance
Single Family Space Heating	82.8%	17.2%
Single Family Water Heating	94.9%	5.1%
Multifamily Space Heating	46.6%	53.4%
Multifamily Water Heating	97.0%	3.0%

2.4 Results Aggregation

2.4.1 Results Weighting

Unit savings (for example, kWh per square foot and therms per square foot) from prototype models were scaled up to the climate zone and statewide levels by multiplying unit savings by the forecasted construction floor area. The construction forecast was developed by the CEC Demand Analysis Office, which produce electricity and natural gas demand forecasts for the state that are used by other energy agencies and utilities for energy system planning. The construction forecast used was identical to the "mid" forecast scenario from the California Integrated Energy Policy Report (IEPR). Further, the forecast is based on certain building categories deemed appropriate for the Demand Analysis Office's forecasting purposes. These categories were mapped to prototypes used in the impact analysis. Table 5 shows the mapping of prototypes to the construction forecast building categories. APPENDIX D provides further details on the actual floor area (in million square feet) and the construction weight for each prototype in each climate zone. The construction floor area for each prototype and climate zone was used to convert unit savings to statewide savings.

Table 5: Mapping of Prototypes to Construction Forecast Building Categories

Construction Forecast Building Category	Prototype	Weighting
Office Small	Office Small	100%
Office Large	Office Medium	50%
Office Large	Office Large	50%
Restaurant	Restaurant Fast Food	100%
Retail	Standalone Retail	10%
Retail	Large Retail	75%
Retail	Strip Mall	5%
Retail	Retail Mixed Use	10%
Food	Non-Refrigerated Warehouse	100%
Refrigerated Warehouse	Refrigerated Warehouse	100%
School	Primary School	60%
School	Secondary School	40%
College	Office Small	5%
College	Office Medium	15%
College	Office Medium Lab	20%
College	Public Assembly	5%
College	School Secondary	30%
College	Apartment High-Rise	25%
Hospital	Hospital	100%
Hotel	Hotel Small	100%
Multifamily	Apartment Mid-Rise	58%
Multifamily	Apartment High-Rise	5%
Multifamily	Garden Style Low-Rise	4%
Multifamily	Loaded Corridor Low-Rise	33%
Single-Family	2,100 ft^2 1-story	45%
Single-Family	2,700 ft^2 2-story	55%
Miscellaneous	Public Assembly	100% [1]

2.4.2 Metric Conversion Factors

The CEC adopted TDV as a metric for evaluating the cost-effectiveness of newly proposed measures to the Energy Code in 2005 (Sontag, et al. 2020). TDV accounts for the time value of energy use, i.e., energy used at different times during the day and year is valued at

[1] The Miscellaneous category contains a number of building types. A review of building stock entries that comprise the forecast revealed that a majority of buildings in the miscellaneous category most closely align with the assembly building type. Therefore, the Public Assembly prototype was used to represent building stock in this building classification.

different rates. It represents the marginal cost to produce and deliver an additional unit of energy to the building. TDV promotes building designs and measures that save energy during times of peak grid demand. TDV is integral to the energy accounting and code development process and is used in energy code compliance software to evaluate compliance. For the 2022 Energy Code, the TDV factors were updated and are linked to the hourly weather files used in this analysis for various climate zones (Sontag, et al. 2020). For converting from hourly electricity and natural gas consumption, hourly conversion factors (kBtu/kWh and kBtu/therm) were used, and the resulting values were reported in terms of TDV kBtu. Statewide impacts may be reported in a unit called GTDV, which represents a million TDV kBtus.

In addition to the TDV update, an hourly source energy metric, HSE, was also added for evaluating code changes in the 2022 cycle (Sontag, et al. 2020). Results of this report are also presented in HSE because it more directly connects building energy consumption to the resulting carbon emissions, thereby allowing the measurement of the Energy Code's progress towards decarbonization, a major goal of the CEC. Lastly, emissions factors were developed based on the updated TDV factors. These emissions factors have been docketed in the CEC 2022 Energy Code docket[2] were applied to the hourly electricity and natural gas consumption from the models to calculate the emissions impact.

[2] TN #: #233260. Accessed here: 2022 Energy Code Pre-rulemaking Docket

3.0 Results

Table 6 shows the statewide impact of the 2022 Energy Code relative to the 2019 Energy Code. Annually, the 2022 Energy Code is estimated to:

- Save 5,472 GBtus, 1,565 GWh, and 14.39 MTherms of site energy.
- Save 46,782 GTDV, 2,954 GBtus HSE, and 285,214 tonnes of CO2e.
- Provide 123 MW of non-coincident demand reduction.

Table 7 through Table 14 provide detailed results by sector and climate zone for statewide savings of various metrics. APPENDIX C provides further detailed results separated by building sector, construction type (new construction and alterations), and building type.

As described in the qualitative analysis (section 2.2), the space and water heating heat pump standards, PV and battery standards, and fan power allowance requirements generated the greatest statewide impact. New construction heat pump standards decreased site energy and gas energy, HSE, and GHG significantly. They also resulted in increased electric site energy and peak demand. However, this increase was mitigated by envelope and other HVAC measures.

Peak demand savings (peak energy demand reduction) were summed on a non-coincident basis, i.e., peak demand reductions from individual prototypes and climate zones were summed without consideration for when the peak demand occurs. On a statewide basis, there are peak demand savings but in certain climate zones, the peak is expected to increase and shift to winter when heat pump heating will require significant electric demand while PV output will be reduced. These increases in peak demand in specific climate zones are a function of the portion of forecasted construction allotted to buildings that will require heat pump heating.

HVAC alterations measures, and in particular, the increase in fan efficiency, resulted in significant savings. However, an increase in fan efficiency causes a decrease in fan heat added to the air stream. During space heating, this fan heat may be replaced with gas heat, increasing gas use. For new construction, this gas use is mitigated by other measures such as improvements in envelope insulation. But there is no such mitigation for alterations as HVAC alteration requirements do not trigger envelope alteration improvements.

Compared to the Environmental Impact Report (EIR) published by the CEC during the adoption process (CEC 2021), the statewide savings from this analysis are slightly higher because unit savings from measures have been applied to more prototypes than were analyzed for the EIR and thus the resulting construction floor area to which the savings are applicable is higher.

Table 6: Statewide Impact of the 2022 Energy Code

Sector	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Sector	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
New Construction							
Nonresidential	2,077.63	511.04	2.21	5.52	12,513	803	49,277
Multifamily	801.26	116.77	3.81	0.81	3,973	441	29,059
Single-Family	361.12	(48.54)	5.27	(2.71)	657	326	22,667
Subtotal: New Construction	3,240	579.27	11.29	3.62	17,143	1,570	101,003
Alterations							
Nonresidential	1,382.88	398.35	0.23	35.49	11,320	856	52,762
Multifamily	457.08	126.94	0.24	13.20	3,657	301	18,647
Single-Family	392.42	91.22	0.81	43.33	4,599	227	14,271
Subtotal: Alterations	2,232	616.51	1.28	92.02	19,576	1,384	85,680
Covered Processes							
Subtotal: Covered Processes	NA	369.36	1.82	27.34	10,063	NA	98,531
Total Statewide Savings							
Total	5,472	1,565	14.39	122.98	46,782	2,954	285,214

Table 7: Nonresidential New Construction Statewide Savings

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
1	6.44	1.42	0.01	(0.00)	31	2	152
2	48.17	11.03	0.08	(0.03)	274	19	1,143
3	203.84	47.99	0.28	0.38	1,110	79	4,871
4	118.41	28.73	0.13	0.29	720	43	2,660
5	20.75	5.03	0.02	0.03	110	8	480
6	166.95	42.84	0.10	0.66	997	61	3,732
7	112.29	29.36	0.05	0.49	652	42	2,558
8	234.29	62.07	0.10	0.91	1,566	84	5,189

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	[GBtu]	[GWh]	[MTherms]	[MW]	[GTDV]	[GBtu]	[tonnes CO2-e]
9	417.97	107.91	0.24	1.92	2,691	153	9,417
10	202.32	53.17	0.12	0.47	1,277	74	4,526
11	45.33	10.24	0.09	(0.03)	259	19	1,144
12	285.09	61.84	0.61	0.16	1,563	124	7,551
13	104.30	22.17	0.25	(0.03)	584	49	2,998
14	59.84	13.84	0.10	0.04	359	25	1,545
15	37.14	9.46	0.03	0.15	230	15	937
16	14.48	3.96	0.00	0.11	91	6	375
Total	**2,077.63**	**511.04**	**2.21**	**5.52**	**12,513**	**803**	**49,277**

Table 8: Multifamily New Construction Statewide Savings

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	[GBtu]	[GWh]	[MTherms]	[MW]	[GTDV]	[GBtu]	[tonnes CO2-e]
1	4.06	0.36	0.03	0.00	17	3	179
2	25.81	3.29	0.14	0.03	124	15	1,000
3	110.78	13.15	0.64	(0.14)	494	66	4,345
4	62.27	8.31	0.31	(0.02)	305	35	2,291
5	10.43	1.28	0.06	(0.01)	46	6	406
6	52.79	7.83	0.24	0.06	257	29	1,905
7	54.51	8.03	0.26	0.13	259	31	2,020
8	72.56	11.35	0.33	0.13	385	39	2,585
9	174.74	27.00	0.78	0.24	900	94	6,171
10	58.36	9.66	0.24	0.06	300	30	1,958
11	18.10	2.67	0.09	0.03	92	10	658
12	98.27	14.42	0.46	0.15	491	54	3,507
13	28.76	4.62	0.12	0.07	149	15	997

Climate Zone	**Site Energy**	**Electric Energy**	**Gas Energy**	**Electric Demand**	**TDV Energy**	**HSE**	**GHG**
Climate Zone	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
14	14.77	2.27	0.06	0.02	76	8	520
15	9.43	1.87	0.03	0.05	52	4	288
16	5.62	0.66	0.03	0.01	25	3	230
Total	**801.26**	**116.77**	**3.81**	**0.81**	**3,973**	**441**	**29,059**

Table 9: Single Family New Construction Statewide Savings

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	[GBtu]	[GWh]	[MTherms]	[MW]	[GTDV]	[GBtu]	[tonnes CO2-e]
1	0.97	(0.25)	0.02	(0.04)	0	1	82
2	8.21	(1.44)	0.13	(0.16)	13	9	606
3	34.94	(5.09)	0.52	0.04	41	24	1,690
4	15.95	(2.34)	0.24	0.01	19	11	788
5	4.14	(0.64)	0.06	(0.08)	6	4	290
6	22.75	(2.78)	0.32	(0.23)	47	22	1,506
7	18.79	(2.24)	0.26	(0.19)	38	18	1,235
8	34.60	(3.86)	0.48	(0.34)	80	32	2,255
9	46.29	(5.37)	0.65	(0.44)	105	44	3,050
10	57.50	(6.74)	0.80	(0.53)	128	55	3,836
11	12.40	(1.84)	0.19	(0.11)	23	13	887
12	52.08	(8.07)	0.80	(0.59)	90	55	3,721
13	26.33	(4.15)	0.40	0.01	27	18	1,271
14	12.32	(2.46)	0.21	0.00	5	7	551
15	10.40	(0.90)	0.13	(0.03)	27	9	654
16	3.45	(0.37)	0.05	(0.05)	7	4	244
Total	**361.12**	**(48.54)**	**5.27**	**(2.71)**	**657**	**326**	**22,667**

Table 10: Nonresidential Alterations Statewide Savings

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
1	3.69	1.53	(0.02)	0.11	36	2	125
2	21.97	8.11	(0.06)	0.71	224	12	719
3	112.01	35.87	(0.10)	2.86	959	66	4,084
4	62.75	19.21	(0.03)	1.69	545	37	2,312
5	12.04	3.79	(0.01)	0.28	94	7	431
6	96.95	28.86	(0.02)	2.34	784	56	3,466
7	68.86	20.65	(0.02)	1.98	551	41	2,561
8	159.98	45.70	0.04	4.05	1,310	97	5,965
9	267.85	75.36	0.11	6.82	2,253	165	10,172
10	148.25	49.27	(0.20)	4.06	1,327	81	4,993
11	27.30	9.55	(0.05)	0.92	254	16	966
12	209.10	50.82	0.36	4.84	1,524	145	8,874
13	94.76	22.10	0.19	2.38	679	68	4,139
14	48.20	13.63	0.02	1.19	393	32	1,959
15	35.03	8.77	0.05	0.85	256	23	1,429
16	14.13	5.12	(0.03)	0.44	130	9	568
Total	**1,382.88**	**398.35**	**0.23**	**35.49**	**11,320**	**856**	**52,762**

Table 11: Multifamily Alterations Statewide Savings

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
1	2.18	0.44	0.01	0.06	15	2	107
2	13.29	3.11	0.03	0.37	101	10	602
3	47.66	14.51	(0.02)	1.54	398	30	1,835
4	24.09	7.13	(0.00)	0.77	203	16	973
5	4.24	1.28	(0.00)	0.13	33	3	161
6	28.92	8.44	0.00	0.83	232	19	1,155
7	26.13	7.52	0.00	0.75	206	17	1,075
8	49.23	14.07	0.01	1.36	393	32	1,957
9	107.56	31.06	0.01	3.11	872	69	4,234
10	31.73	9.36	(0.00)	0.91	256	20	1,234
11	12.64	3.02	0.02	0.33	98	9	557
12	62.69	15.16	0.11	1.79	486	44	2,774
13	23.03	5.77	0.03	0.65	183	16	990
14	12.29	3.05	0.02	0.33	94	8	523
15	6.53	1.84	0.00	0.17	52	4	257
16	4.86	1.19	0.01	0.13	35	3	212
Total	**457.08**	**126.94**	**0.24**	**13.20**	**3,657**	**301**	**18,647**

Table 12: Single Family Alterations Statewide Savings

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
1	2.46	0.02	0.02	0.00	9	2	144
2	14.80	0.80	0.12	0.34	100	12	813
3	7.96	0.14	0.07	0.08	51	7	467
4	27.11	6.14	0.06	4.34	331	18	1,117
5	0.19	0.00	0.00	(0.00)	1	0	11

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
6	1.71	4.19	(0.13)	2.78	139	(3)	(277)
7	(0.03)	2.41	(0.08)	1.96	69	(2)	(171)
8	69.60	19.95	0.02	7.76	1,075	29	1,784
9	81.37	22.98	0.03	14.09	1,068	44	2,704
10	37.90	9.12	0.07	3.02	386	19	1,183
11	20.85	4.52	0.05	0.76	181	16	1,020
12	52.12	8.85	0.22	4.51	536	37	2,394
13	41.56	6.50	0.19	2.12	361	25	1,657
14	12.72	2.54	0.04	1.14	142	7	438
15	6.88	1.69	0.01	0.25	67	2	135
16	15.23	1.38	0.11	0.16	84	13	852
Total	**392.42**	**91.22**	**0.81**	**43.33**	**4,599**	**227**	**14,271**

Table 13: Process New Construction Statewide Savings

New Construction Process Savings	Site Energy[1]	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE[1]	GHG[2]
New Construction Process Savings	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
Total	Not available	262.41	0.93	18.59	7,059	Not available	98,531

[1]Site energy and HSE were not calculated in the CASE reports.

[2]GHG savings for both new construction and alterations are shown here. They were not separated in the CASE reports.

Table 14: Process Alterations Statewide Savings

Alterations Process Savings	Site Energy[1]	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE[1]	GHG[2]
Alterations Process Savings	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
Total	Not available	106.95	0.89	8.75	3,004	Not available	Not available

[1]Site energy and HSE were not calculated in the CASE reports.

[2]GHG savings for both new construction and alterations are shown in Table 13. They were not separated in the CASE reports.

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GLOSSARY

BUILDING ENERGY MODEL – A software simulation of building energy use.

CARBON DIOXIDE EQUIVALENT – A measure used to compare emissions from various greenhouse gases based on the related global warming potential. The carbon dioxide equivalent for a gas is derived by multiplying the mass of the gas by the associated global warming potential.

CLIMATE ZONE – A climate zone is a region of California with a distinct climate. California is divided into 16 climate zones.

COVERED PROCESS – An aspect of a building that affects building energy consumption, but cannot be accounted for by building energy modeling software.

ENERGY EFFICIENCY – Using the least amount of energy possible to perform the same task or produce the same result.

GREENHOUSE GAS – Any gas that absorbs infrared radiation in the atmosphere. Common examples of greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated fluorocarbons (HCFCs), ozone (O_3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

PHOTOVOLTAIC (PV) – Relating to the production of electric current at the junction of two substances exposed to light. Solar panels convert sunlight into electricity by using photovoltaic cells made of materials that generate electrons when exposed to sunlight.

SEASONAL ENERGY EFFICIENCY RATIO (SEER) – A measure of a system's cooling performance.

SITE ENERGY – The amount of heat and electricity consumed by a building.

TIME DEPENDENT VALUATION (TDV) – A code compliance metric that considers the societal and environmental impact when determining the cost of energy during a given hour

APPENDIX A:
Qualitative Analysis of the 2022 Energy Code

Table 15 shows the results of the qualitative analysis of the 2019 and 2022 Energy Code. Changes that directly impact energy consumption are shown in the table, along with whether the change was included in the quantitative analysis, and if it was not included, then the reason for excluding it.

Table 15: Qualitative analysis of the 2022 Energy Code

#	2022 Title 24, Part 6 Section No./Table No., Section Title	Change Description	Included in Quantitative Analysis	Reason If not Included in Quantitative Analysis
1	110.2, Table 110.2-A, Air Conditioners and Condensing Units--Minimum Efficiency Requirements	More stringent equipment efficiencies: 11.0 EER, 14.8 IEER for 65-135 kBtu/h 11.0 EER, 14.2 IEER for 135-240 kBtu/h	No	Change from federal efficiency standards, not attributable to the 2022 Energy Code.
2	110.2, Table 110.2-B, Heat Pumps, Minimum Efficiency Requirements	More stringent equipment efficiencies: 11.0 EER, 14.2 IEER for 65-135 kBtu/h 10.6 EER, 13.5 IEER for 135-240 kBtu/h 2.25 COP heating for 65-135 kBtu/h 3.3 COP heating for >135 kBtu/h	No	Change from federal efficiency standards, not attributable to the 2022 Energy Code.
3	120.10(a), Mandatory Requirements for Fans	Minimum FEI of 1.0 for fan systems> 1 HP, or >0.95 for variable air volume (VAV). This only applies to non-packaged air handling unit and standalone exhaust fans.	Yes	
4	120.2(c)3, Occupant Sensing Zone Controls 130.1(c)6D, Shut-off Controls	Adds occupancy-based shutoff control requirement for large open offices.	Yes	
5	120.2(i), Economizer Fault Detection and Diagnostics (FDD)	Lowers threshold at which fault detection and diagnostics is required from 54,000 Btu/h to 33,000 Btu/h.	No	Difficult to quantify savings from FDD because savings are dependent on behavioral assumptions.

6	120.4(g), Duct Sealing 160.3(c)2H, Requirements for Air Distribution System, Duct and Plenum	Systems serving hotel/motel buildings and nonresidential buildings other than healthcare facilities, the duct system shall be sealed to a leakage rate not to exceed 6 percent of the nominal air handler airflow rate as confirmed through field verification and diagnostic testing. The requirement is limited to single-zone systems serving less than 5,000 sf of floor area that have at least 25% of duct surface area outdoors or in unconditioned spaces.	No	Ducts assumed to be in conditioned spaces within prototypes.
7	120.6(a)8, Refrigerated Warehouses, Transcritical CO2 Gas Coolers 120.6(b)5, Commercial Refrigeration, Transcritical CO2 Gas Coolers	Adds requirements for new fan-powered gas coolers for transcritical CO2 refrigeration systems for refrigerated warehouses and commercial refrigeration facilities.	No	Requirements were deemed to implement standard practice for these types of systems.
8	120.6(a)9, Automatic door closers	Requires automatic door closers for doors designed for passage of people between freezers and higher temperature spaces.	Yes	
9	120.6(d)3, Mandatory Requirements for Process Boilers	Reduces process boiler input capacity to 5 MMBtu/h from 10 MMBtu/h for maintaining oxygen concentration to 3% (lowered from 5%).	Yes	
10	120.6(e), Mandatory Requirements for Compressed Air Systems	Specifies monitoring for compressed air systems larger than 100 hp, requires leak testing, and specifies pipe sizing of compressed air piping systems greater than 50 ft in length.	Yes	
11	120.6(h), Mandatory Requirements for Controlled Environmental Horticulture (CEH)	Specifies dehumidification, lighting, and envelope requirements for CEH spaces.	Yes	
12	120.6(i), Mandatory Requirements for Steam Traps	Specifies fault detection and diagnostics for process systems with operating steam pressure greater than 15 psi and combined connected boiler input is greater than 5 MMBtu/h.	Yes	
13	120.6(j), Computer Room HVAC	Prohibits non-adiabatic humidification and fan speed control required when cooling capacity exceeds 60 kBtu/h.	No	No impact because requirement was simply moved from prescriptive to mandatory section.
14	130.1(d)3C, Automatic Daylighting Controls	Revises mandatory daylight dimming requirement from 65% to 90%.	Yes	

15	140.3, Table 140.3-B, Prescriptive Envelope Criteria for Nonresidential Buildings	Steel-framed wall U-factor change from 0.082 to 0.071 and from 0.062 to 0.055.	Yes	
16	140.3, Table 140.3-B, Prescriptive Envelope Criteria for Nonresidential Buildings	Adds steep-slope cool roof requirements for climate zones 2 and 4 through 16.	Yes	
17	140.3, Table 140.3-B, Prescriptive Envelope Criteria for Nonresidential Buildings	Improves fixed window U-factor and SHGC from U-0.36, SHGC 0.25 to U-0.34-0.36, SHGC – 0.22-0.25, depending on climate zone.	Yes	
18	170.2(a)2, Table 170.2-A, Envelope Component Package – Multifamily Standard Building Design	Provides two different sets of requirements for steel-framed walls based on fire rating.	Yes	
19	170.2(a)3Ai, Table 170.2-A, Envelope Component Requirements – Multifamily Standard Building Design (Prescriptive Approach)	Adds window area requirement for max 20% window-floor area.	Yes	
20	170.2, Table 170.2-A, Envelope Component Requirements – Multifamily Standard Building Design, Prescriptive Approach	Adds new window category for architectural window.	No	Prototypes assumed to use windows other than architectural window type.
21	170.2, Table 170.2-A, Envelope Component Package – Multifamily Standard Building Design	Revises multifamily window performance requirements (U, SHGC).	Yes	
22	140.3(a)9C, Verification of Air Barriers	Adds retest requirement if air leakage rate exceeds 0.40 cfm/sf.	No	Air barrier verification is optional, not required.
23	170.2, Table 170.2-A, Option D, Envelope Component Package – Multifamily Standard Building Design	Modifies high-rise residential U-factor to be consistent with multifamily requirements, option D.	Yes	

24	140.4(a)2, Single Zone Space Conditioning System Type	Single zone heat pumps are standard for systems serving offices, schools, retail, and grocery in certain climate zones. Dual fuel heat pumps are standard in a few climate zones.	Yes	
25	140.4(c)1, Fan Power Budget	Revises calculation methodology for calculating fan power.	Yes	
26	140.4(d)2A, Variable air volume (VAV) Systems: Space-conditioning Zone Controls with direct digital controls (dead band airflow rate)	Removes 20% VAV minimum limit; limit set to outside air requirements.	Yes	
27	140.4(e)1, Prescriptive Requirements for Economizers	Lowers threshold at which economizer is required from 54,000 Btu/h to 33,000 Btu/h.	Yes	
28	140.4(k)8, High Capacity Space Heating Gas Boiler Systems	Requires higher thermal efficiency (Et) for gas boilers > 1MMBtu/h and < 10 MMBtu/h.	Yes	
29	120.4(g), Duct Sealing	Changes prescriptive requirement to mandatory for constant volume, single zone systems with 25%+ duct area outside conditioned space.	No	No change in stringency with move from prescriptive to mandatory
30	140.4(p), Dedicated Outdoor Air Systems (DOAS) 170.2, Prescriptive Approach	Adds various requirements for when dedicated outside air systems are used in a building.	No	Prototypes do not use DOAS systems.
31	140.4(q), Table 140.4-K, Energy Recovery Requirements by Climate Zone and Percent Outdoor Air at Full Design Airflow (≥8,000 hours / year)	Provides heat recovery for high CFM systems and high outside air requirements. Separate heat recovery requirements for buildings with >8,000 operating hours.	Yes	
32	140.5(a)1, Heat Pump Service Water Heater Prescriptive Requirement	Requires HPWH for school buildings with floor area <= 25,000 sf.	Yes	
33	140.5(c), High Capacity Service Water Heating Systems	Requires SWH systems with a total gas heating capacity of 1 MMBtu/h or greater to have a capacity-weighted heating efficiency of at least 90 percent.	Yes	

34	140.6(a)2, Table 140.6-A, Lighting Power Adjustment Factors (PAF)	Reduces occupancy sensing control power adjustment factor (PAF) from 0.3-0.4 to 0.2-0.3.	No	Additional lighting power adjustment credits not taken.
35	140.6(b)3-A, Table 140.6-B, Complete Building Method Lighting Power Density Values	Reduces maximum lighting power allowances in the complete building area method.	Yes	
36	140.6(b)3-B, Table 140.6-C, Area Category Method - Lighting Power Density Values (Watts/Ft2)	Reduces maximum lighting power allowances in the area category method.	Yes	
37	140.6(b)3-C, Table 140.6-D, Tailored Method Lighting Power Allowances Table 140.6-G, Tailored Method General Lighting Power Allowances - By lluminance and Room Cavity Ratio	Reduces maximum lighting power allowances in the Tailored Method.	No	Completed building and space-by-space approach used.
38	140.6(c)3Jiv, Tailored Method	For lighting covered in 140.6(c)3Jii, allowed display case lighting=min(0.50 W/sf, 7 W/sf case area, adjusted indoor lighting power).	No	Additional display case lighting not used in retail spaces.
39	140.7(d)1, Table 140.7-A, General Hardscape Lighting Power Allowance	Reduces general hardscape lighting power allowances.	Yes	
40	140.9(a)1, Prescriptive Requirements for Computer Room Economizers	Increases economizer dry-bulb high limit to 80F.	Yes	
41	140.9(a)3, Prescriptive Requirements for Computer Rooms, Air Containment	Requires containment for server load of 10 kW or higher (essentially all computer rooms).	Yes	
42	140.9(a)4, Prescriptive Requirements for Computer Rooms, Alternating Current-Output Uninterruptible Power Supplies (UPS)	Sets minimum uninterruptible power supply (UPS) efficiency requirements based on Table 140.9-A.	No	Specified code requirement assumed to be standard practice.

43	150.0(a), Roof Deck, Ceiling and Rafter Roof Insulation	Sets new mandatory requirement for roof deck insulation in certain climate zones.	No	Prescriptive requirement, which is modeled, exceeds this new mandatory requirement.
44	150.0(m)1B, Duct Insulation	Allows lower insulation levels when ducts are in conditioned space.	No	Impact is negligible and difficult to quantify using energy models or otherwise.
45	150.1(c)6, Heating System Type	Prescribes heat pumps in CZs 3,4,13,14.	Yes	
46	150.1(c)8, Domestic Water-Heating Systems	Prescribes heat pumps in CZs 1-2,5-12,15-16.	Yes	
47	150.2(a)1B, Addition Ceiling Insulation	Increases ceiling insulation requirements for additions 700 ft2 or less to R-38 in CZs 2,4,8-10.	Yes	
48	150.2(b)1D, Duct Sealing	Reduces length of duct to trigger duct sealing requirements to 25 feet.	No	Trigger only, see #49 below for change to duct sealing requirements evaluated.
49	150.2(b)1D, Duct Sealing	Reduces duct sealing target to 10% total leakage.	Yes	
50	150.2(b)1Di, Table 150.2-A, Duct Insulation	Increases duct insulation requirements for new ducts in alterations to R-8 in CZs 12,4,8-10,12-13.	Yes	
51	150.2(b)1G, Heating System	Limits allowance for electric resistance replacement heaters when existing system is electric resistance.	Yes	
52	150.2(b)1Ii, Steep-Sloped Roofs	Expands cool roof requirements to CZs 4,8,9.	Yes	
53	150.2(b)1Iii, Low-Sloped Roofs	Expands cool roof requirements to CZs 4,6-12,14.	Yes	
54	150.2(b)1Iii, Low-Sloped Roofs	Specifies new roof insulation requirement of R-14 in CZs 1,2,4,8-16.	Yes	
55	150.2(b)1J, Ceiling	Adds new section requiring attic insulation and air sealing. Specific requirements vary by climate zone.	Yes	
56	160.2(b)2Aivb, HRR Balanced Ventilation	Requires either balanced ventilation with heat recovery in some climate zones or dedicated supply or exhaust ventilation if HERS tested air leakage < 0.3 cfm/sf of dwelling unit.	Yes	
57	160.2(b)2B2Aiv(b)1, Whole-Dwelling Unit Mechanical Ventilation, Balanced Ventilation	Requires systems that use balanced ventilation to serve multifamily dwelling units must have a minimum fan efficacy of 1.0 W/cfm.	Yes	

58	160.2(b)2Ci, Central Ventilation System Duct Sealing	Requires duct leakage testing to confirm duct leakage not exceeding 6% for ventilation systems serving multiple units.	No	Analysis assumes balanced ventilation with heat recovery
59	160.3(b)5K, Duct System Sealing and Leakage Testing	For multifamily dwellings with the air-handling unit installed and the ducts connected directly to the air handler, regardless of duct system location: i. The total leakage of the duct system shall not exceed 12 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or ii. The duct system leakage to outside shall not exceed 6 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4.	No	Assumes ducts are fully sealed.
60	170.2(e)6-D, Table 170.2-R General Hardscape Multifamily Lighting Power Allowance Table 170.2-S, Additional Multifamily Lighting Power Allowance for Specific Applications	Adds tables with outdoor lighting allowances tailored to multifamily buildings.	Yes	

APPENDIX B-1: 2022 Energy Code DOE Certification for Nonresidential Buildings

Background and Objective

The U.S. DOE is required by law (ECPA 1976) to issue a determination on whether the latest ASHRAE Standard 90.1 edition is more efficient than the previous edition for nonresidential and high-rise multifamily buildings. DOE issued an affirmative determination for ASHRAE Standard 90.1-2019 (ASHRAE 2019), which is the latest ASHRAE Standard 90.1 edition, stating that it would increase efficiency relative to the previous edition. Upon publication of an affirmative determination, states are required to certify that their energy code meets or exceeds the stringency set by the latest ASHRAE Standard 90.1 edition (42 U.S.C. 6833 n.d.). For ASHRAE Standard 90.1-2019, state certifications must be submitted by July 28, 2023. To certify, states must demonstrate that their energy code is as stringent as ASHRAE Standard 90.1.

The objective of the analysis presented here was to demonstrate that the 2022 Energy Code for California's nonresidential and high-rise multifamily buildings is as stringent or more stringent than ASHRAE Standard 90.1-2019. An analysis was performed to provide this demonstration by comparing ASHRAE Standard 90.1-2019 with the 2022 Energy Code. This Appendix describes the methodology used and the results comparing the stringency of ASHRAE Standard 90.1-2019 with the 2022 Energy Code.

Nonresidential Buildings DOE Certification Methodology

ASHRAE Standard 90.1-2019 is a national model energy code and, similar to the 2022 Energy Code, has two main compliance paths: prescriptive and performance. There are two performance compliance paths available to comply with ASHRAE Standard 90.1, which are known as the Energy Cost Budget (ECB) method and the Performance Rating Method (PRM). Both approaches are intended for performance building compliance. This analysis used the PRM to compare the stringency of the two standards.

The PRM specifies a stable and independent "baseline design" to which the "proposed design" is compared. The proposed design must demonstrate that its performance is better than the baseline design by a specific margin, called the "building performance factor" or BPF. The BPF represents the stringency established by ASHRAE Standard 90.1-2019 and meeting or exceeding this level of stringency would demonstrate that the "proposed design" meets or exceeds the code. The calculation methodology for BPFs is explained below. The target BPFs are specified in section 4.2.1.1 of ASHRAE Standard 90.1-2019 and are provided here for reference.

Table 16 shows the BPFs by building area type for ASHRAE climate zones (further described in the climate zone section below) applicable to California.

Table 16: ASHRAE Standard 90.1-2019 BPFs for ASHRAE Climate Zones Applicable to California

PRM Building Area Type	Climate Zone	Climate Zone	Climate Zone
PRM Building Area Type	**3B**	**3C**	**4C**
Multifamily	0.68	0.59	0.74
Healthcare/Hospital	0.55	0.55	0.54
Hotel/motel	0.54	0.54	0.52
Office	0.56	0.48	0.49
Restaurant	0.61	0.58	0.61
Retail	0.5	0.53	0.54
School	0.42	0.40	0.38
Warehouse	0.44	0.43	0.46
All others	0.54	0.53	0.54

Prototypes

Table 17 shows the prototypes selected for the analysis and their mapping to the PRM building area types. The multifamily, office, retail, school, and warehouse sectors comprise more than 60% of the new construction building floor area in California. Therefore, it was assumed that the group of selected prototypes are sufficiently representative of the building stock for this analysis.

Table 17: Prototypes selected for DOE Certification analysis

PRM Building Area Type	Selected Prototypes
Multifamily	Apartment Mid-rise
Healthcare/Hospital	None
Hotel/motel	None
Office	Office Small Office Medium Office Large
Restaurant	None
Retail	Retail Large Retail Standalone
School	School Small
Warehouse	Warehouse

Climate Zone Mapping

ASHRAE Standard 169-2020 (ASHRAE 2020) provides a mapping of counties within the U.S. to 16 climate zones created within Standard 169. These climate zones are then used by a variety of other standards including ASHRAE Standard 90.1. The California Energy Code uses climate zones that are different from those used by ASHRAE Standard 90.1. Table 18 shows the mapping of California climate zones to the ASHRAE Standard 90.1 climate zones. Of the 16 climate zones within ASHRAE, only three are mapped to California counties. This mapping is used to determine the BPFs applicable to the California building climate zones used in the analysis.

Table 18: California to ASHRAE climate zone mapping

California Building Climate Zone	Representative Weather File	Representative City	County	ASHRAE Standard 169-2020 County to Climate Zone Mapping
01	ARCATA_725945_CZ2010.epw	Arcata	Humboldt	4C
02	SANTA-ROSA_724957_CZ2010.epw	Santa Rosa	Sonoma	3C
03	OAKLAND_724930_CZ2010.epw	Oakland	Alameda	3C
04	SAN-JOSE-REID_724946_CZ2010.epw	San Jose	Santa Clara	3C
05	SANTA-MARIA_723940_CZ2010.epw	Santa Maria	Santa Barbara	3C
06	TORRANCE_722955_CZ2010.epw	Torrance	Los Angeles	3B
07	SAN-DIEGO-LINDBERGH_722900_CZ2010.epw	San Diego	San Diego	3B
08	FULLERTON_722976_CZ2010.epw	Fullerton	Orange	3B
09	BURBANK-GLENDALE_722880_CZ2010.epw	Burbank	Los Angeles	3B
10	RIVERSIDE_722869_CZ2010.epw	Riverside	Riverside	3B
11	RED-BLUFF_725910_CZ2010.epw	Red Bluff	Tehama	3B
12	SACRAMENTO-EXECUTIVE_724830_CZ2010.epw	Sacramento	Sacramento	3B
13	FRESNO_723890_CZ2010.epw	Fresno	Fresno	3B
14	PALMDALE_723820_CZ2010.epw	Palmdale	Los Angeles	3B
15	PALM-SPRINGS-INTL_722868_CZ2010.epw	Palm Springs	Riverside	3B
16	BLUE-CANYON_725845_CZ2010.epw	Blue Canyon	Placer	3B

Procedure for Calculating BPFs

The steps below describe the procedure for calculating BPFs for prototype models that are minimally compliant with the 2022 Energy Code. These models represent the "proposed design" in the BPF calculation. The "baseline design" models are specified by rules established within the PRM (Appendix G within ASHRAE Standard 90.1-2019).

The PRM uses energy cost as the metric for calculating compliance[3]. This same metric was used in the analysis to compare the stringency of the two standards. The PRM stipulates that either the energy cost provided in the PRM could be used or a jurisdiction-specific energy cost could be used from a source such as the Energy Information Administration (EIA). In either case, the energy cost represents an average or blended rate. In California, the TDV and HSE metrics are used for compliance purposes. Standards such as the PV and battery standard in the 2022 Energy Code would show an increase in energy cost when following the PRM metric but would show a reduction in TDV energy and in HSE. For this analysis, a blended rate was sourced from EIA and is shown in Table 19.

Table 19: Blended energy cost rate used in the DOE Certification analysis

Fuel	Blended energy cost rate
Electricity Average retail price of electricity for California commercial sector (EIA 2022)	$0.1921/kWh
Natural Gas Average retail price for California commercial sector (EIA 2022)	$1.47/therm

1. Calculate performance cost index of the proposed design.

   BBP = baseline building energy cost, $

   PBP = proposed building energy cost, $

   PCI = performance cost index, equal to proposed building energy cost / baseline building energy cost

3 A new addendum to ASHRAE Standard 90.1-2019, addendum CH, will allow jurisdictions to use metrics other than energy cost for compliance.

$$PCI = \frac{PBP}{BBP}$$

2. Calculate target performance cost index.

   BBUEC = baseline building unregulated energy cost

   BBREC = baseline building regulated energy cost

   (Regulated energy cost is the cost of energy used for components of the building with requirements in Sections 5 through 10 of the standard. This includes the cost of energy used for HVAC, lighting, service water heating, motors, transformers, vertical transportation, refrigeration equipment, computer-room cooling equipment, and other building systems, components, and processes with requirements prescribed in Sections 5 through 10. Unregulated energy cost is the cost of energy used for all other end-uses in the building, which will primarily be covered processes.)

   BPF = from Table 4.2.1.1 in ASHRAE Standard 90.1-2019

   PCIt = target performance cost index

$$PCI_t = \frac{BBUEC + (BBREC \times BPF)}{BBP}$$

3. Calculate renewable contribution.

   PBPnre = proposed building energy cost without PV, $

   PBP = proposed building energy cost with PV, $

$$Renewable\ Fraction = (PBP_{nre} - PBP)/BBP$$

4. Check compliance:

   When the *Renewable Fraction* exceeds 0.05, compliance is shown when:

$$PCI + [(PBP_{nre} - PBP)/BBP] - 0.05 \ \leq \ PCI_t$$

$$PCI + Renewable\ Fraction - 0.05 \ \leq \ PCI_t$$

The formula above caps the benefit of PV systems to 5% of the baseline design energy cost. This cap is intended to prevent trade-offs between renewable energy generation and energy efficiency when a building applies for compliance. In all the prototypes selected for the analysis, the renewable fraction exceeds 0.05. This analysis focuses on the comparison between two energy codes and is not a typical compliance comparison. Thus, even though the 2022 Energy Code requires PV installations that would provide greater benefit than the maximum 5% that is allowed, the extra credit is not taken in this comparison to ASHRAE Standard 90.1-2019.

Results

Table 20 shows the results of the analysis by prototype. The target PCI is compared to the PCI achieved by the "proposed design," which in this case were the prototype models compliant with the 2022 Energy Code. For each prototype, results by climate zone for the proposed and baseline models were aggregated to the statewide level using construction weighting and construction forecasts for new construction buildings described in section 2.4.1 of this report. Table 21 shows results aggregated up to the building area type as specified by ASHRAE Standard 90.1-2019. The 2022 Energy Code exceeds the target PCI at the prototype level and the building area type level. The results are further aggregated to the statewide level in which the 2022 Energy Code exceeds the target PCI by 10%. Therefore, the 2022 Energy Code is deemed to be more stringent than ASHRAE Standard 90.1-2019.

Table 20: PRM performance comparison by prototype

Prototype	**Target PCI**	**PCI**	**PCI Margin**
Prototype	**[$/$]**	**[$/$]**	**[$/$]**
Small Office	0.66	0.56	0.10
Medium Office	0.71	0.67	0.04
Large Office	0.66	0.57	0.09
Large Retail	0.63	0.49	0.14
Stand-Alone Retail	0.63	0.43	0.19
Small School	0.49	0.42	0.08
Warehouse	0.50	0.38	0.11
Mid-Rise Apartment	0.76	0.68	0.08
Floor-area weighted average	**0.64**	**0.54**	**0.10**

Table 21: PRM performance comparison by building area type

PRM Building Area Type	**Target PCI**	**PCI**	**PCI Margin**
PRM Building Area Type	**[$/$]**	**[$/$]**	**[$/$]**
Multifamily	0.76	0.68	0.08
Office	0.68	0.61	0.07
Retail	0.63	0.49	0.14
School	0.49	0.42	0.08
Warehouse	0.50	0.38	0.11
Floor-area weighted average	**0.64**	**0.54**	**0.10**

APPENDIX B-2:
2022 Energy Code DOE Certification for Residential Buildings

Background and Objective

The U.S. DOE is required by law (ECPA 1976) to issue a determination on whether the latest version of the International Energy Conservation Code (IECC) is more efficient than the previous edition for low-rise residential buildings. DOE has issued an affirmative determination stating that the 2021 IECC (ICC 2021) will improve energy efficiency in residential buildings. Upon publication of an affirmative determination, states are required to certify that they have reviewed the provisions of their residential building code regarding energy efficiency and decide whether they must revise their code to meet or exceed the updated edition of the IECC. State certifications for the 2021 IECC must be submitted by July 28, 2023.

The objective of the analysis presented here was to demonstrate that the 2022 Energy Code for California's residential buildings is at least as stringent as the 2021 IECC. An analysis was performed to demonstrate this by comparing the requirements of the two codes. This Appendix describes the methodology applied and subsequent results.

Residential Buildings DOE Certification Methodology

Prototypes

Table 22 shows the prototypes applied in this analysis. These are the same as the single family new construction prototypes used elsewhere in this report. The results were weighted to represent 45% of the 2,100 prototype and 55% of the 2,700 prototype.

Table 22: Prototypes selected for residential DOE certification analysis

Prototype Name	Number of Stories	Floor Area (square ft)	Description
Single Family New Construction 1-Story	1	2,100	1-story detached single-family home with an attached garage, slab-on-grade foundation, wood-framed wall construction, and a vented attic.
Single Family New Construction 2-Story	2	2,700	2-story detached single-family home with an attached garage, slab-on-grade foundation, wood framed wall construction, and a vented attic.

Climate Zone Mapping

The California to IECC climate zone mapping mimics that presented for the ASHRAE comparison in APPENDIX B-1. Table 23 presents the corresponding IECC climate zones for each of California's 16 climate zones.

Table 23: California to IECC climate zone mapping

California Building Climate Zone	Representative City	County	IECC Climate Zone Mapping
01	Arcata	Humboldt	4C
02	Santa Rosa	Sonoma	3C
03	Oakland	Alameda	3C
04	San Jose	Santa Clara	3C
05	Santa Maria	Santa Barbara	3C
06	Torrance	Los Angeles	3B
07	San Diego	San Diego	3B
08	Fullerton	Orange	3B
09	Burbank	Los Angeles	3B
10	Riverside	Riverside	3B
11	Red Bluff	Tehama	3B
12	Sacramento	Sacramento	3B
13	Fresno	Fresno	3B
14	Palmdale	Los Angeles	3B
15	Palm Springs	Riverside	3B
16	Blue Canyon	Placer	3B

Analytical Approach

CBECC-Res 2022 software was utilized to estimate energy use. For each California climate zone and prototype, two models were developed, one minimally code compliant with the 2022 Energy Code and another minimally code compliant with the 2021 IECC. Table 24 presents the 2021 IECC code-compliant building specifications for the two IECC climate zones applicable to this analysis.

Table 24: IECC building specifications

Description	IECC Climate Zone 3	IECC Climate Zone 4C (Marine)
Exterior Wall Assembly	2x6 R-20	2x6 R-20 R-5
Interior Demising Wall Assembly	2x6 R-20	2x6 R-20
Quality Insulation Installation	none	none

Description	IECC Climate Zone 3	IECC Climate Zone 4C (Marine)
Air Leakage	3 ACH50	3 ACH50
Slab Edge Insulation	R-10 edge, 2ft deep	R-10 edge, 4ft deep
Raised Floor Insulation	R-19	R-30
Attic Type	Ventilated	Ventilated
Ceiling Insulation	R-49	R-60
Roof Deck Insulation	None	None
Radiant Barrier	None	None
Roof Reflectivity	No requirement (0.10)	No requirement (0.10)
Roof Emissivity	No requirement (0.85)	No requirement (0.85)
Glazed Door U-factor	0.3	0.3
Window U-factor	0.3	0.3
Window SHGC	0.25	0.4
HVAC System Type	same as Title 24 CZs 3,4,13,14: Heat pump CZs 1,2,4-12,15-16: Gas furnace + AC	same as Title 24 CZs 3,4,13,14: Heat pump CZs 1,2,4-12,15-16: Gas furnace + AC
Heating Efficiency	80 AFUE or 8.2 HSPF	80 AFUE or 8.2 HSPF
Cooling SEER	14 SEER	14 SEER
Cooling EER	11.7 EER	11.7 EER
Cooling System Airflow	No requirement (350 cfm/ton)	No requirement (350 cfm/ton)
Refrigerant Charge Verification	Not verified	Not verified
Cooling System Fan Efficacy	No requirement (0.58 W/cfm)	No requirement (0.58 W/cfm)
Duct Location	Attic	Attic
Duct Leakage	4 cfm per 100 square feet (see Table 25)	4 cfm per 100 square feet (see Table 25)
Duct Insulation	R-8	R-8
IAQ Fan Type	Exhaust	Exhaust
IAQ Fan W/cfm	0.26 W/cfm	0.26 W/cfm
DHW System Type	same as Title 24 CZs 3,4,13,14: Gas tankless CZs 1,2,4-12,15-16: Heat pump water heater	same as Title 24 CZs 3,4,13,14: Gas tankless CZs 1,2,4-12,15-16: Heat pump water heater
DHW Compact Distribution	No requirement	No requirement

Description	IECC Climate Zone 3	IECC Climate Zone 4C (Marine)
Drain water Heat Recovery	None	None
PV System	None	None
Appliance Fuel	same as Title 24 Gas stove/oven and dryer	same as Title 24 Gas stove/oven and dryer

The 2021 IECC requirement for duct leakage is based on a maximum cfm of leakage per 100 square feet of conditioned floor area. To evaluate this requirement in CBECC-Res, the maximum cfm of leakage per 100 square feet of conditioned floor area had to be converted to a percent of system airflow instead. Total allowable leakage was calculated as 84 cfm for the 2,100 square foot prototype and 108 cfm for the 2,700 square foot prototype. Total system airflow was calculated based on the modeled system cooling capacity for each climate zone and applying 350 cfm per ton. Leakage as a percentage of system airflow was calculated by dividing the IECC allowable leakage by the system airflow. Where the results differed for the two prototypes, the lower percentage value was used for this analysis. The results are presented in Table 25.

Table 25: Duct leakage calculation

Climate Zone	Duct Leakage (percentage of system airflow)
1	19%
2	9%
3	9%
4	12%
5	9%
6	9%
7	9%
8	10%
9	10%
10	9%
11	9%
12	10%
13	9%
14	10%
15	6%
16	12%

Results

Table 26 presents CBECC-Res simulation results comparing site energy, TDV, and source energy between the 2021 IECC and 2022 Energy Code cases. Figure 1 and Figure 2 present the comparison of TDV and source energy between the 2021 IECC and 2022 Energy Code, respectively.

The 2022 Energy Code uses less total energy than the 2021 IECC in every climate zone for the single-family prototypes. Total source energy use is 2% to 34% lower and TDV energy use is 23% to 63% lower. Low-rise multifamily buildings were not directly evaluated. IECC and Title 24 code requirements are very similar between single-family and low-rise multifamily buildings; as a result, the conclusions found for single-family buildings are expected to apply to low-rise multifamily buildings. The 2022 Energy Code is deemed to be more stringent than the 2021 IECC for residential buildings.

Table 26: 2021 IECC and 2022 Energy Code energy use comparison

California Building Climate Zone	Site Electric Energy (kWh)	Site Electric Energy (kWh)	Site Fuel Use (Therms)	Site Fuel Use (Therms)	TDV (kTDV/ft²-yr)	TDV (kTDV/ft²-yr)	Source Energy (kBtu/ft²-yr)	Source Energy (kBtu/ft²-yr)
California Building Climate Zone	**2021 IECC**	**2022 Title 24**	**2021 IECC**	**2022 Title 24**	**2021 IECC**	**2022 Title 24**	**2021 IECC**	**2022 Title 24**
01	6,339	1,664	375	398	134.7	103.6	20.8	20.5
02	5,915	1,348	268	246	123.7	80.9	16.4	14.5
03	5,760	966	171	171	95.6	59.7	13.6	11.9
04	6,035	906	163	163	117.1	67.0	13.4	11.7
05	5,676	1,297	186	133	96.6	56.5	13.0	9.9
06	5,484	975	83	84	82.0	46.3	9.0	7.8
07	5,471	954	68	69	76.5	42.4	8.4	7.1
08	6,604	884	76	67	104.0	44.6	9.6	7.4
09	6,529	923	98	84	107.0	50.1	10.4	8.1
10	7,118	939	120	107	115.2	55.4	11.6	9.1
11	8,075	1,107	260	226	158.0	87.2	17.8	14.3
12	6,676	1,174	246	212	139.2	79.5	16.3	13.4
13	9,187	1,139	154	154	159.0	80.9	15.8	12.9
14	8,684	1,680	159	159	145.5	76.7	16.1	13.2
15	11,621	589	58	53	164.8	61.2	12.3	8.2
16	6,972	1,331	583	403	177.2	103.7	28.8	20.2
Average	7,009	1,117	192	171	124.8	68.5	14.6	11.3

Figure 1: 2021 IECC and 2022 Energy Code TDV comparison

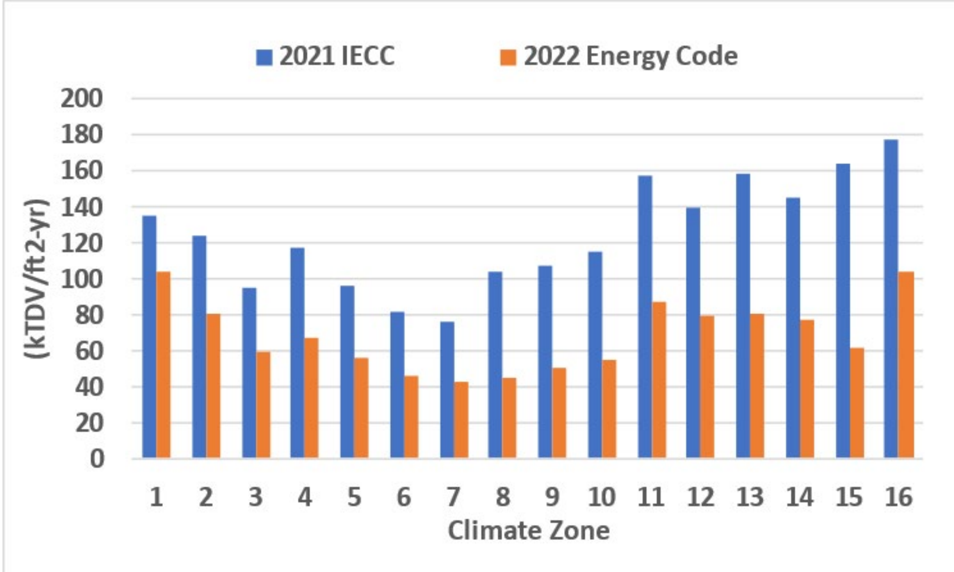
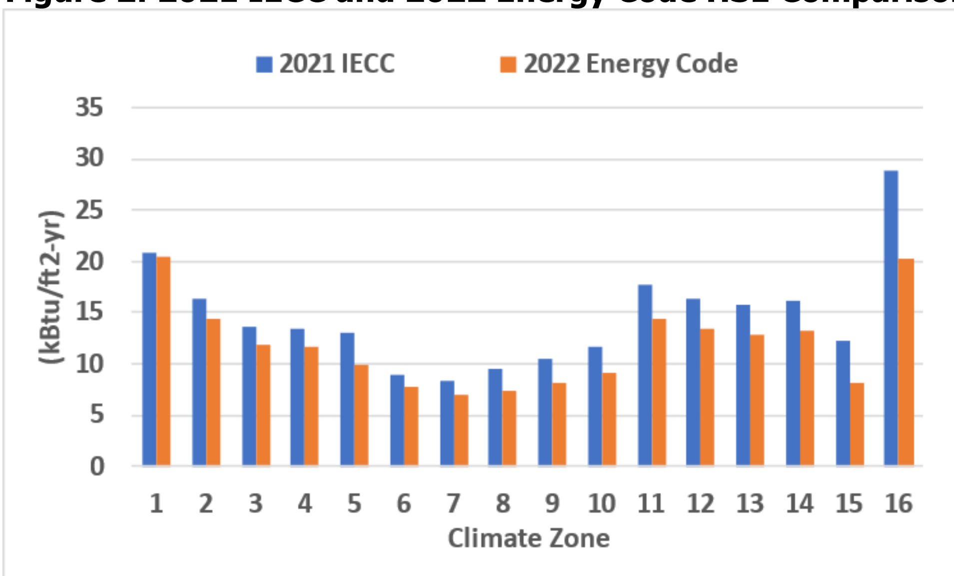


Figure 2: 2021 IECC and 2022 Energy Code HSE Comparison



APPENDIX C: Detailed Impacts Results

Table 27 through Table 30 provide detailed results by the construction forecast building category.

Table 27: Nonresidential statewide new construction savings by forecast building category

Forecasted Building Type	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Forecasted Building Type	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
Small Office	192	44.55	0.25	0.19	1,094	74.02	4,530
Large Office	616	149.35	0.48	3.90	3,652	226.45	13,909
Restaurant	101	36.75	(0.24)	1.65	816	35.77	2,222
Retail	545	128.22	0.93	(0.80)	3,078	197.14	12,049
Non-Refrigerated Warehouse	122	47.65	(0.47)	0.51	959	15.99	1,030
School	169	25.28	0.74	(3.87)	791	93.63	5,694
College	79	15.93	0.19	0.49	446	37.89	2,389
Hospital	85	7.05	0.61	1.17	377	73.51	4,461
Hotel/Motel	29	8.52	(0.00)	0.37	206	11.09	684
Miscellaneous	140	47.76	(0.28)	1.92	1,094	37.07	2,310
Total	**2,078**	**511.04**	**2.21**	**5.52**	**12,513**	**802.57**	**49,277**

Table 28: Residential Statewide New Construction Savings by Forecast Building Category

Forecasted Building Type	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Forecasted Building Type	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
Single-family Residential	361	(48.54)	5.27	(2.71)	657	325.91	22,667
Low-rise Residential	23	(0.41)	0.25	0.41	75	17.18	1,173

Forecasted Building Type	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Forecasted Building Type	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
High-rise Residential	801	116.77	3.81	0.81	3,973	441.37	29,059
Total	**1,185**	**67.82**	**9.33**	**(1.49)**	**4,705**	**784.46**	**52,899**

Table 29: Nonresidential Statewide Alterations Savings by Forecast Building Category

Forecasted Building Type	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Forecasted Building Type	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
Small Office	90	28.36	(0.07)	3.09	798	63.50	3,943
Large Office	250	52.23	0.71	5.80	1,861	188.94	11,588
Restaurant	61	33.87	(0.55)	3.61	822	43.62	2,756
Retail	221	59.65	0.17	5.50	1,775	141.67	8,718
Non-Refrigerated Warehouse	209	89.13	(0.95)	0.92	1,847	44.45	2,830
School	110	32.60	(0.01)	5.79	951	71.99	4,435
College	58	16.77	0.01	1.89	499	40.24	2,486
Hospital	220	20.71	1.50	3.41	1,031	189.98	11,540
Hotel/Motel	19	5.68	(0.00)	0.82	188	15.87	980
Miscellaneous	145	59.35	(0.58)	4.66	1,548	55.61	3,486
Total	**1,383**	**398.35**	**0.23**	**35.49**	**11,320**	**854.87**	**52,762**

Table 30: Residential Statewide Alterations Savings by Forecast Building Category

Forecasted Building Type	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Forecasted Building Type	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
Single-Family	392	91.2	0.81	43.33	4599	226.81	14,271
Low-rise Residential	120	30.3	0.16	11.09	1275	58.19	29,407
High-rise Residential	457	126.94	0.24	13.20	3,657	300.94	18,647
Total	**969**	**248.44**	**1.21**	**67.62**	**9,531**	**585.94**	**62,325**

Table 31 through Table 34 separate efficiency only and efficiency plus PV savings from the total savings of all measures previously shown. Since the PV and battery standard was only applicable to nonresidential and high-rise multifamily buildings, the tables summarize the impact on those building sectors only. Table 32 contains values of zero for Electric Demand in climate zones 1, 10, and 14 because even though there was a slight increase in demand when rounding to two significant digits, the reported value become zero since this table contains the savings of several measures, demand could theoretically increase, decrease, or stay the same. Ultimately, it is likely that demand did not significantly change.

Table 31: Statewide Savings for Nonresidential New Construction by Climate Zone (Efficiency Only Measures)

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
1	2.35	0.39	0.01	0.18	12	2	102
2	15.31	2.40	0.07	1.12	98	10	606
3	64.60	12.10	0.23	5.31	448	43	2,633
4	32.73	6.31	0.11	3.27	242	21	1,305
5	6.08	1.30	0.02	0.51	38	4	226
6	47.44	11.30	0.09	4.53	358	30	1,868
7	31.41	7.75	0.05	3.49	232	20	1,244
8	68.67	17.76	0.08	6.84	567	42	2,573

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	[GBtu]	[GWh]	[MTherms]	[MW]	[GTDV]	[GBtu]	[tonnes CO2-e]
9	115.56	28.15	0.19	11.61	974	73	4,494
10	65.85	16.34	0.10	7.54	505	38	2,363
11	18.06	3.03	0.08	1.64	133	12	719
12	116.24	17.60	0.56	6.69	734	82	5,003
13	48.98	7.74	0.23	3.56	331	36	2,173
14	22.15	4.08	0.08	1.62	161	15	900
15	13.85	3.21	0.03	1.56	108	9	549
16	5.21	1.62	(0.00)	0.49	43	3	216
Total	**674.48**	**141.08**	**1.93**	**59.96**	**4,986**	**440**	**26,974**

Table 32: Statewide Savings for High-rise Multifamily New Construction (Efficiency Only Measures)

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	[GBtu]	[GWh]	[MTherms]	[MW]	[GTDV]	[GBtu]	[tonnes CO2-e]
1	2.67	(0.02)	0.03	0.00	9	2	162
2	14.42	0.22	0.14	0.02	59	13	846
3	62.77	(0.22)	0.64	(0.17)	228	56	3,739
4	31.71	0.12	0.31	(0.05)	121	28	1,871
5	5.73	(0.03)	0.06	(0.02)	20	5	341
6	25.52	0.39	0.24	0.01	100	22	1,496
7	27.21	0.48	0.26	0.06	105	24	1,596
8	35.66	0.88	0.33	0.06	147	31	2,063
9	84.50	1.93	0.78	0.09	353	73	4,896
10	26.45	0.69	0.24	(0.00)	111	23	1,513
11	9.90	0.37	0.09	0.02	45	8	558
12	50.92	1.48	0.46	0.10	224	44	2,928
13	14.79	0.70	0.12	0.06	69	13	833

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
14	7.40	0.31	0.06	0.00	34	6	415
15	3.94	0.39	0.03	0.03	21	3	208
16	3.43	0.06	0.03	0.01	13	3	202
Total	**407.02**	**7.75**	**3.81**	**0.23**	**1,659**	**354**	**23,665**

Table 33: Statewide Savings for Nonresidential New Construction (Efficiency and PV Measures)

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	[GBtu]	[GWh]	[MTherms]	[MW]	[GTDV]	[GBtu]	[tonnes CO2-e]
1	6.27	1.39	0.01	0.08	30	2	139
2	47.97	10.44	0.07	0.45	256	16	991
3	202.96	45.41	0.26	2.22	1,031	69	4,228
4	118.79	27.12	0.11	1.57	671	37	2,297
5	20.76	4.78	0.02	0.23	103	7	422
6	167.96	40.56	0.09	2.63	933	53	3,274
7	112.81	27.67	0.05	2.06	604	36	2,205
8	234.20	58.89	0.09	3.89	1,474	73	4,531
9	417.41	101.97	0.20	6.61	2,521	132	8,150
10	201.70	50.80	0.09	4.24	1,207	65	4,003
11	44.29	9.71	0.07	0.84	241	16	995
12	250.83	56.19	0.33	2.82	1,334	82	4,997
13	87.73	19.85	0.13	1.74	486	31	1,893
14	55.08	12.76	0.06	0.80	320	19	1,139
15	34.01	8.75	0.01	0.97	204	11	673
16	12.49	3.62	(0.01)	0.26	77	4	230
Total	**2,015.27**	**479.92**	**1.57**	**31.39**	**11,493**	**654**	**40,166**

Table 34: Statewide Savings for High-rise Multifamily New Construction (Efficiency and PV Measures)

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	[GBtu]	[GWh]	[MTherms]	[MW]	[GTDV]	[GBtu]	[tonnes CO2-e]
1	4.12	0.33	0.03	0.00	16	3	175
2	26.42	2.96	0.14	0.03	116	15	955
3	112.82	12.05	0.64	(0.14)	470	64	4,224

Climate Zone	Site Energy	Electric Energy	Gas Energy	Electric Demand	TDV Energy	HSE	GHG
Climate Zone	**[GBtu]**	**[GWh]**	**[MTherms]**	**[MW]**	**[GTDV]**	**[GBtu]**	**[tonnes CO2-e]**
4	63.85	7.45	0.31	(0.03)	282	33	2,174
5	10.63	1.18	0.06	(0.01)	44	6	394
6	54.18	7.08	0.24	0.06	239	27	1,807
7	55.92	7.28	0.26	0.13	242	29	1,923
8	74.19	10.47	0.33	0.13	364	38	2,493
9	178.94	24.75	0.78	0.23	850	89	5,921
10	59.72	8.93	0.24	0.06	284	29	1,883
11	18.46	2.48	0.09	0.03	88	10	638
12	100.57	13.19	0.46	0.14	464	51	3,368
13	29.35	4.31	0.12	0.07	143	15	968
14	15.11	2.09	0.06	0.02	72	8	496
15	9.72	1.72	0.03	0.04	48	4	269
16	5.71	0.61	0.03	0.01	24	3	225
Total	**819.69**	**106.88**	**3.81**	**0.76**	**3,746**	**423**	**27,912**

APPENDIX D: Floor Area Forecast, Prototype Mapping, and Conversion Factors

Table 35: 2023 projected nonresidential new construction floor area by building category, million square feet (SF)

Climate Zone	Small Office	Large Office	Restau-rant	Retail	Grocery Store	Non-Refrig. Wareh-ouse	Refrig. Wareh-ouse	School	College	Hospital	Hotel/ Motel	Miscell-aneous
1	0.035	0.115	0.015	0.106	0.028	0.077	0.006	0.049	0.027	0.036	0.042	0.142
2	0.209	0.682	0.091	0.629	0.169	0.459	0.037	0.289	0.158	0.215	0.248	0.841
3	0.744	3.842	0.375	2.875	0.708	2.382	0.189	1.181	0.687	0.927	1.138	3.902
4	0.372	2.016	0.191	1.473	0.359	1.223	0.096	0.599	0.352	0.472	0.588	2.006
5	0.081	0.353	0.039	0.298	0.076	0.227	0.019	0.124	0.071	0.098	0.114	0.398
6	0.558	2.756	0.380	2.101	0.531	1.880	0.067	0.665	0.372	0.494	0.697	2.275
7	0.773	1.550	0.248	1.482	0.445	1.108	0.013	0.713	0.328	0.540	0.750	1.720
8	0.732	4.127	0.548	3.016	0.749	2.702	0.096	0.912	0.525	0.724	0.965	3.298
9	1.178	7.679	0.922	4.716	1.152	4.322	0.142	1.229	1.002	1.317	1.488	5.295
10	0.986	1.508	0.651	2.823	0.780	3.441	0.086	1.249	0.494	0.702	0.815	3.535
11	0.269	0.322	0.088	0.582	0.193	0.637	0.072	0.333	0.138	0.220	0.164	0.732
12	1.409	3.216	0.412	3.170	0.824	3.187	0.243	1.400	0.641	1.035	0.972	3.757
13	0.575	0.495	0.191	1.218	0.410	1.087	0.187	0.725	0.274	0.457	0.307	1.518
14	0.193	0.519	0.143	0.668	0.176	0.740	0.030	0.258	0.107	0.152	0.179	0.804
15	0.189	0.158	0.071	0.384	0.129	0.540	0.017	0.181	0.047	0.087	0.134	0.466

Climate Zone	Small Office	Large Office	Restau-rant	Retail	Grocery Store	Non-Refrig. Wareh-ouse	Refrig. Wareh-ouse	School	College	Hospital	Hotel/ Motel	Miscell-aneous
16	0.078	0.133	0.041	0.212	0.062	0.225	0.019	0.099	0.040	0.060	0.055	0.262
TOTAL	**8.381**	**29.471**	**4.409**	**25.755**	**6.791**	**24.238**	**1.319**	**10.006**	**5.263**	**7.537**	**8.656**	**30.950**

Table 36: 2023 projected nonresidential alterations floor area by building category, million square feet (SF)

Climate Zone	Small Office	Large Office	Restau rant	Retail	Grocery Store	Non-Refrig. Wareh-ouse	Refrig. Wareh-ouse	Schools	Colleges	Hospitals	Hotel/ Motels	Miscell-aneous
1	1.6	5.6	0.6	4.6	1.2	3.3	0.3	2.6	1.5	1.9	1.7	5.9
2	9.8	33.4	3.7	27.5	7.4	19.9	1.6	15.7	8.6	11.0	10.2	34.8
3	35.4	182.8	14.9	123.1	30.4	101.3	8.0	64.8	37.3	47.4	46.6	159.9
4	17.7	95.5	7.6	62.8	15.3	51.7	4.1	32.9	19.1	24.1	24.0	82.1
5	3.9	17.4	1.6	13.0	3.3	9.9	0.8	6.8	3.9	5.0	4.8	16.5
6	26.1	123.3	16.7	99.2	25.2	90.2	3.4	43.9	23.9	28.6	30.1	120.2
7	35.7	82.3	10.9	73.2	21.8	52.5	0.7	35.5	19.7	26.9	33.3	78.5
8	34.1	182.1	24.0	141.1	35.2	128.0	4.9	61.0	33.4	41.5	41.2	173.8
9	54.6	327.3	40.4	221.1	54.4	204.2	7.3	92.3	62.1	71.6	65.2	257.6
10	48.4	81.5	32.6	153.6	41.6	183.8	4.4	70.8	30.5	37.2	36.5	181.7
11	12.2	16.0	3.6	27.4	9.1	30.9	3.3	17.6	7.7	11.2	6.7	31.4
12	59.9	149.7	17.5	143.5	37.6	136.4	11.1	74.8	34.9	52.8	39.5	155.3
13	26.4	22.9	8.0	57.0	19.1	50.3	8.4	39.8	15.1	23.0	12.6	68.1

Climate Zone	Small Office	Large Office	Restau rant	Retail	Grocery Store	Non-Refrig. Wareh-ouse	Refrig. Wareh-ouse	Schools	Colleges	Hospitals	Hotel/ Motels	Miscell-aneous
14	9.4	24.6	6.9	34.7	9.1	38.4	1.5	15.9	6.8	8.5	7.8	42.7
15	9.3	8.0	3.5	21.1	7.0	28.5	0.9	9.9	2.9	4.6	5.6	23.0
16	3.7	6.3	1.9	10.7	3.1	11.4	0.9	5.9	2.4	3.2	2.4	13.0
TOTAL	**388.5**	**1,358.7**	**194.3**	**1,213.6**	**320.9**	**1,140.7**	**61.6**	**590.2**	**309.7**	**398.4**	**368.3**	**1,444.2**

Table 37: Multifamily New Construction Housing Unit Projections by Climate Zone

CZ	Low-Rise Garden Style	Low-Rise Loaded Corridor	Mid-Rise Mixed Use	High-Rise Mixed Use
1	11	87	154	13
2	63	519	912	79
3	305	2518	4425	382
4	159	1312	2306	199
5	28	233	409	35
6	135	1112	1955	169
7	145	1196	2101	181
8	190	1564	2748	237
9	445	3671	6452	556
10	157	1297	2279	197
11	45	370	651	56
12	253	2091	3674	317
13	74	610	1072	92
14	34	277	487	42
15	22	181	317	27
16	14	112	197	17
TOTAL	**2,079**	**17,149**	**30,140**	**2,598**

Table 38: Multifamily Existing Building Stock Estimates by Climate Zone

CZ	Low-Rise Garden Style	Low-Rise Loaded Corridor	Mid-Rise Mixed Use	High-Rise Mixed Use
1	6,850	3,083	3,083	4,110
2	40,688	18,310	18,310	24,413
3	212,036	95,416	95,416	127,221
4	111,414	50,136	50,136	66,848
5	17,926	8,067	8,067	10,756
6	126,314	56,841	56,841	75,788
7	116,722	52,525	52,525	70,033
8	195,735	88,081	88,081	117,441
9	434,680	195,606	195,606	260,808
10	126,554	56,949	56,949	75,932
11	32,728	14,728	14,728	19,637
12	182,106	81,948	81,948	109,264
13	61,619	27,729	27,729	36,972
14	31,657	14,246	14,246	18,994
15	16,013	7,206	7,206	9,608
16	11,002	4,951	4,951	6,601
TOTAL	**1,724,043**	**775,819**	**775,819**	**1,034,426**

Table 39: Single Family Building Data by Climate Zone

CZ	New Construction	Existing Buildings
1	266	43,798
2	1,579	260,224
3	6,072	963,408
4	3,056	489,254
5	613	95,423
6	3,227	589,387
7	2,584	488,748
8	4,813	913,789
9	6,643	1,237,621
10	8,676	1,043,549
11	2,509	317,948
12	9,717	1,275,153
13	4,286	612,938
14	1,658	236,635
15	1,653	168,190
16	699	92,126
TOTAL	**58,052**	**8,828,191**

Table 37 and Table 38 represent the new construction projections and existing building estimates for multifamily. Total multifamily estimates by climate zone were provided by the CEC. The distribution across the four multifamily prototypes is based on the analysis presented in the 2022 Multifamily Restructuring Case Report (Statewide CASE Team 2020b).Table 39 presents estimates for single-family homes provided by the CEC. Regarding single-family and low-rise multifamily alterations, the percentage of the existing building stock impacted for each measure is based on the 2022 CASE Report Residential Energy Savings and Process Improvements for Additions and Alterations (Statewide CASE Team 2020a).

Miscellaneous Building Category Floor Area

The Miscellaneous category of the forecasted construction is intended to account for the remaining buildings in the forecasted construction that do not fall into the other categories. There is also no prototype for this category. To account for the savings, the CASE team assumed that the floor-area-weighted distribution of savings in the Miscellaneous category corresponded to the floor-area-weighted distribution of savings in the other categories. A detailed discussion of their approach is typically found in Appendix A of each CASE report.

The Impact Analysis team used a different approach. They examined the original data from Dodge, a construction data and analytics company, that contained the building types in the Miscellaneous category. Certain groups of building characteristics that affect energy use were found to be common. These common characteristics also seemed to be available in some of the prototypes. Table 40 lists these characteristics, the count of buildings within Dodge's Miscellaneous category with these characteristics, a general description of the type of Dodge buildings, and the proposed prototype correspondence for the building type. The characterizations, aside from space volume, represent the energy density of the feature. For example, the "People" characteristic is a combination of the number of people and the activity level of the people within the space, and "Interior Equipment" characterizes not just the power output of equipment, but their assumed usage schedules. Only the top four most frequent building types were assigned proposed prototypes.

The building count multiplied by the prototype floor area was assumed to represent the portion of the statewide floor area for a given prototype within the Miscellaneous category in the Dodge data. This is a rough approximation but was considered the best alternative. In future work, other existing prototypes or modifications of existing prototypes can be considered for mapping into this category.

Table 40: Dodge Miscellaneous Category Building Types

Volume	People	Lights	Equipment	OA	Count	Type	Proposed Prototype
Large	High	Average	Low	High	7	Audience/viewing/ gathering	Public Assembly
Large	Average	High	Low	High	4	Vehicle servicing	Warehouse
Medium	Low	Average	Average	Average	3	Government/Public	Medium Office
Large	Average	Average	Low	High	3	Transportation terminals	Public Assembly

Volume	People	Lights	Equipment	OA	Count	Type	Proposed Prototype
Large	Low	Average	Low	Average	2	-	-
Large	High	Average	High	Average	1	-	-
Large	Low	Low	High	Average	1	-	-
Large	High	Average	Low	Average	1	-	-
Large	Low	Low	Low	Average	1	-	-
Large	Average	Average	Low	Average	1	-	-
Medium	Low	High	High	High	1	-	-

Table 41: Mapping of Construction Forecast Building Types to Prototype Models

Forecast Building Category	Applicability	Prototype Model
Small Office	100%	Small Office
Large Office	50%	Medium Office
	50%	Large Office
Restaurant	100%	Fast Food Restaurant
Retail	10%	Stand-Alone Retail
	75%	Large Retail
	5%	Strip Mall Retail
	10%	Mixed-Use Retail
Grocery Store	100%	Grocery
Non-Refrigerated Warehouse	100%	Warehouse
Refrigerated Warehouse	N/A	Refrigerated Warehouse
Schools	60%	Small School
	40%	Large School
College	5%	Small Office
	15%	Medium Office
	20%	Medium Office Lab
	5%	Assembly
	30%	Large School

Forecast Building Category	Applicability	Prototype Model
	25%	High-Rise Apartment
Hospital	100%	Hospital
Hotel/Motel	100%	Small Hotel
Misc.	61%	Assembly
	36%	Warehouse
	3%	Medium Office
High-rise Residential	58%	Mid-Rise Apartment
	5%	High-Rise Apartment