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2025 California Energy Code

Technical Measure Report

Photovoltaic and Battery Storage System Update and Expansion

NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, AND HOTEL AND MOTEL BUILDINGS

Prepared by the California Energy Commission February 2024

California Energy Commission

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Executive Summary

Introduction

This report proposes specific actions that will result in reductions of wasteful, uneconomic, inefficient, or unnecessary consumption of energy in the state of California. The code change proposal, or "measure," described in this report is provided to the California Energy Commission (CEC) for consideration and possible inclusion in the California Energy Code (also known as the Energy Code, or Building Energy Efficiency Standards, or Title 24 Part 6). This measure will be considered, may be modified, and could be assembled as part of a comprehensive regulatory package proposed and adopted by the CEC. The Energy Code must be found to be technically feasible and cost-effective as a whole.

For the purposes of this document, the term "nonresidential" refers to nonresidential, high-rise residential, and hotel and motel building categories.

Code Change Description

This measure proposes to expand the photovoltaic (PV) and battery system requirements in Section 140.10, 170.2(g), and 170.2(h) of the 2022 Energy Code. New building types, and updates to current system capacities are proposed for the 2025 Energy Code.

Scope of Work

The Photovoltaic and Battery Update and Expansion will modify the following Energy Code sections, reference appendices and supporting documents listed in Table 1.

Table 1: Code Change Scope of Work

Energy Code Section(s)	Regulation Type(s): M, Ps, or Pm	Reference Appendices	Modeling Tools	Forms	Other Supporting Documents
Section 100.1	Ps				
Section 140.10	Ps			Add new building types	
Section 170.2(g)	Ps			Add new building types	
Section 170.2(h)	Ps			Add new building types	
Nonresidential ACM	Pm		Add PV by building and space type to CBECC		

An (M) indicates mandatory requirements, (Ps) Prescriptive, (Pm) Performance.

Compliance and Enforcement

This measure is an extension of nonresidential photovoltaic (PV) system and battery storage system requirements currently in the 2022 Energy Code. The most substantive proposed changes are the addition of new building types to the PV and battery requirements, these include "exhibits and events", "religious worship", and "sports and recreation" buildings. In addition, the current system capacity requirements for "hotel/motel", "restaurants", and "medical office" building/"clinic" are proposed to be changed. the "auditorium", "convention center", and "theater" building types from the 2022 Energy Code are now included in the "exhibits and events" building type and their capacities are proposed to be changed as well. Code officials will have to ensure that these new and revised requirements are met.

Market Assessment

The market for both PV and battery storage systems is well established. The extension of PV requirements to additional building types will have a significant impact on the solar industry in the state. An analysis that correlates additional project revenue with construction jobs has determined that over 1,700 new jobs will be required in the construction industry to support the new requirements. The measure will also generate approximately 53 jobs in design and consulting to support the additional project scope.

Cost-effectiveness

Table 2 summarizes the estimated Long-term System Cost (LSC) benefits, measure costs, and resulting Benefit-Cost Ratios (BCRs) by California climate zone for the proposed measures. The total LSC savings and total incremental cost are for all prototypes, extrapolated to the forecasted statewide floor area, considering the sizing selected for the proposed 2025 code. Measures are cost-effective when LSC benefits meet or exceed measure costs, indicated in the chart below where BCRs are 1.0 or greater.

Table 2: Cost-effectiveness Summary

Climate Zone	Benefit: Total Incremental LSC Savings (Millions of NPV $)	Cost: Total Incremental First Costs and Maintenance Costs (Millions of NPV $)	Benefit-Cost Ratio (BCR)
1	1.01	0.61	1.66
2	12.05	6.78	1.78
3	43.58	23.74	1.84
4	27.13	12.03	2.26
5	3.30	1.67	1.98
6	35.56	17.90	1.99
7	27.25	15.19	1.79
8	78.77	35.49	2.22
9	110.35	47.93	2.30
10	68.67	28.92	2.37
11	11.17	5.40	2.07
12	54.60	26.97	2.02
13	21.63	9.93	2.18
14	15.67	6.36	2.46
15	10.26	4.33	2.37
16	3.56	1.67	2.13

Statewide Energy Impacts

Tables 3 and 4 summarize the estimated statewide energy and greenhouse gas (GHG) emissions savings for the first year that the proposed measure is implemented.

Table 3: Estimated Statewide Energy Savings

	First Year Statewide Electricity Savings (GWh)	First Year Statewide Power Demand Reduction (MW)	First Year Statewide Natural Gas Savings (Million Therms)	First Year Statewide Electricity LSC Savings (Millions of NPV $)	First Year Statewide Natural Gas LSC Savings (NPV $)
Photovoltaic and Battery Update and Expansion	151.9	0.44	0.00	524.6	0.00
TOTAL	**151.9**	**0.44**	**0.00**	**524.6**	**0.00**

Table 4: Estimated Statewide Greenhouse Gas Emission Savings

	First Year Statewide GHG Emission Savings (MT CO_2e/year)	First Year Statewide Source Savings (Billions of Btus)
Photovoltaic and Battery Update and Expansion	3,797	71.8
TOTAL	**3,797**	**71.8**

ACRONYMS

Acronym	Definition
ACM	Alternate Calculation Method
BCR	Benefit-Cost Ratio
BCZ	Building Climate Zone. BCZ is one of 16 climate zones used in the California Energy Code. It is referred to as CZ in Code documents and compliance materials.
BEM	Building Energy Modeling
Btu	British Thermal Units
CBECC	California Building Energy Code Compliance software used for all building types except single family buildings
CBECC-Res	California Building Energy Code Compliance software used for single-family buildings
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CPUC	California Public Utilities Commission
FCZ	Forecast Climate Zone
GHG	Greenhouse Gas. Commonly used as GHG emissions.
GWh	Gigawatt-Hour
ITC	Investment Tax Credit (federal)
KBtu	Thousands of British Thermal Units
kWh	Kilowatt-Hour
MT CO2e	Metric Tons of Carbon Dioxide Equivalent
MW	Megawatt
NREL	National Renewable Energy Laboratory

LSC	Long-term System Cost (30-year NPV$)
PV	Photovoltaic system
NBT	CPUC adopted Net Billing Tariff that replaced previous net energy metering tariffs (NEM and NEM2).
NPV	Net Present Value
NEM	Net Energy Metering
sf	Square foot

1. INTRODUCTION

This report proposes specific actions that could result in further reductions of wasteful, uneconomic, inefficient, or unnecessary consumption of energy in the state of California. The code change proposal, or "measure," described in this report is provided by the California Energy Commission (CEC) for consideration and possible inclusion in the California Energy Code (also known as the Energy Code, or Building Energy Efficiency Standards, or Title 24 Part 6). This measure will be considered and may be modified as part of a comprehensive regulatory package proposed and adopted by the CEC. The Energy Code must be found to be cost-effective and technically feasible when taken as a whole.

Consistent with California Law (Public Resources Code 25402(b)(3)), a measure is cost-effective if the Benefit-Cost Ratio (BCR) is 1.0 or greater, when amortized over the economic life of the structure. BCR is calculated by dividing the total dollar benefit of the measure by the total dollar cost of the measure, over a period of analysis of 30 years.

To calculate the benefit, Long-term System Cost (LSC) is used to determine the dollar value of measures in the Energy Code. LSC hourly factors help the state account for long-term benefits associated with policies needed to meet the statewide climate actions goals – such as 100 percent renewable energy generation, proliferation of electric transportation, and reductions in building-related emissions. Today's energy costs do not adequately account for these long-term values to California's energy system. LSC hourly factors weigh the long-term value of each hour differently, where times of peak demand are more valuable, and times off-peak demand are less valuable. LSC hourly factors are not utility rates or energy rate forecasts. LSC is not a predicted utility bill.

LSC hourly conversion factors are developed and published by the CEC for each code cycle. These LSC hourly factors are used to convert predicted site energy use – an output common to building energy modeling (BEM) software – to 30-year present value to California's energy system.

Energy savings for proposed measures are estimated using both LSC hourly factors and CEC-established model prototypes. Large sets of survey data are used to create prototypes that act as averaged representations of common building types in California. These prototypes are created for use in BEM software to provide accuracy and consistency amongst energy models that are used to determine energy savings for the state. CEC-developed prototypes and LSC hourly factors are published by the CEC ahead of each code cycle for use in the CEC's reference California Building Energy Code compliance software (CBECC-Res used for single family buildings and CBECC used for all other building types). For this reason, CBECC-Res and CBECC are the CEC-recommended BEM software tool for use when assessing the energy savings of proposed measures.

To calculate cost, first costs and ongoing maintenance costs must be assessed for proposed measures and accounted for over a period of analysis of 30 years. In the BCR, both the benefits and the costs are assessed incrementally, meaning in comparison to the latest adopted version of the Energy Code.

Similar to LSC hourly factors, the CEC develops and publishes conversion factors for Source Energy, Weighted Peak Demand, and for GHG Emissions for each code cycle. These four sets of hourly factors are published on CEC's website and formatted to be accessible and usable in combination with broadly available BEM tools.

For the purposes of this document, the term 'nonresidential' refers to nonresidential, high-rise residential, and hotel and motel building categories.

2. MEASURE DESCRIPTION

This code measure revises the requirements for onsite photovoltaic (PV) generation and battery storage systems for nonresidential buildings. The proposed measure extends PV and battery requirements to additional building types and adjusts the requirements to account for changes to weather, LSC, California Public Utility Commission's (CPUC's) Net Billing Tariff (NBT) valuation of PV generation exports to the grid, system costs, and the 2022 Energy Code's required building energy efficiency measures.

The measure will base battery storage system requirements on conditioned floor area and will base battery storage power capacity on a 4-hour charge-discharge cycle.

The measure will add new building type definitions for events & exhibits buildings; religious worship buildings; and sports & recreation buildings to Section 100.1. It will also add new PV and battery requirements to Section 140.10, 170.2(g) and 170.2(h). The requirements will be applicable in all climate zones and to all nonresidential newly constructed buildings, except hospitals, laboratories, transportation terminals, parking garages, and other miscellaneous building types.

2.1 Measure Modifications to Energy Code Documents

This section provides descriptions of how the proposed measure will affect each Energy Code document. See *Section 6.Proposed* Code Language of this report for detailed revisions to code language.

2.1.1 Energy Code Change Summary

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

Subsection 100.1(b): Additional building type definitions are added.

140.10, 170.2(g) and 170.2(h) – PRESCRIPTIVE REQUIREMENTS FOR PHOTOVOLTAIC AND BATTERY STORAGE SYSTEMS

Equation 140.10-B and 170.2-E- Battery Storage Rated Energy Capacity: The equation is now based on conditioned floor area square footage, similar to PV.

Equation 140.10-C and 170.2-G- Battery Storage Rated Power Capacity: The power capacity equation is now based on a 4-hour charging and discharging time. The battery storage exception is removed. In lieu of the battery storage exception, the battery capacity factor in the code language tables is listed as "NR" where there is no requirement for a battery.

Table 140.10-A and 170.2-U – PV Capacity Factors: The table now has a column for each climate zone and has additional building types.

Table 140.10-B and 170.2-V– Battery Storage Capacity Factors: The table now has a column for each climate zone and has additional building types.

2.1.2 Reference Appendices Change Summary

There are no proposed changes to the Reference Appendices. The requirements listed in this section are not affected by the changes made to the Energy Code.

2.1.3 Compliance Manuals Change Summary

The Compliance Manuals will list the new building types that require PV and battery storage systems.

2.1.4 ACM Reference Manuals Change Summary

The table listing PV and battery sizing factors by building type will be updated with new factors and new building types.

2.1.5 Compliance Forms Change Summary

The prescriptive and performance certificates of compliance ruleset will be modified to include new building types and apply updated PV and battery capacity factors for the plans examiner’s verification.

2.2 Measure Context

2.2.1 Comparable Model Code or Standard

While other jurisdictions have some incentives and requirements for onsite renewable generation with PV systems in their codes and reach codes, the Energy Code in 2022 developed a distinct approach for PV and battery storage requirements for nonresidential buildings. The proposed revisions to the PV and battery storage system requirements account for changes to weather, LSC, NBT valuation of PV exports to the grid, system costs and the 2022 Energy Code’s required building energy efficiency measures. The PV system for each building type and climate zone was sized to limit exported energy to no more than 20 percent of onsite PV energy generation. The battery storage system is sized to further limit exports to no more than 10 percent of onsite PV generation.

2.2.2 Conflicts with Other Regulations or Certifications

Battery storage systems also must comply with the California Electrical Code (Title 24, Part 3) and the California Fire Code (Title 24, Part 9). A fire suppression system, a battery management system that continuously monitors performance, and proper spacing between battery cells are among the safety measures required.

2.3 Compliance and Enforcement

Compliance and enforcement will be the same as for previous code cycles but because the building types have been expanded, there will be more buildings that will require industry compliance and enforcement agency actions.

3. Market and Economic Analysis

For the proposed measure, this section provides the author's assessment of product availability, incremental cost, potential market size, and potential economic and fiscal impacts to the state – including potential impacts on the creation or elimination of jobs in the state.

3.1 Market Structure and Availability

The nonresidential PV market is a mature market in California and the United States, with consistent annual growth. Once the impact of the CPUC's NBT decision has taken effect, the rate of growth is forecasted to decline slightly, from 13 percent in 2024 to 11 percent in 2027 (Wood Mackenzie 2023). The Investment Tax Credit (ITC) is expected to stabilize the market, which has faced challenges with supply chain issues over the last two years.

3.2 Design and Construction Practices

This measure will modify the PV and battery storage system requirements for buildings where PV is already required and will extend the requirements to additional building types. Designers must account for adequate Solar Access Roof Area (SARA) of PV panels and must allow for the significant additional first cost to project budgets. For buildings already subject to PV and battery storage requirements the proposed change in the 2025 Energy Code is only a limited revision to the 2022 Energy Code requirements accounting for revised system costs, utility costs, and NBT export valuation without altering design and construction practice significantly.

3.3 Impacts on Market Actors

This measure will help ensure the onsite deployment of PV panels and battery storage systems for several nonresidential building types. The measure identifies an appropriate capacity PV system that will help meet the building's energy demand while limiting exports. This helps not only the grid but the consumer, ensuring a good return on investment for the system. Since the 2025 Energy Code requirement extends to new building types, the measure will expand the nonresidential solar industry in California and its workforce. Although newly constructed building projects will incur first cost on planning these new projects, the proposed measures are still cost effective over the 30-year period of analysis.

3.4 Impacts on Jobs and Businesses

The proposed measure impact on jobs and businesses was evaluated with the aid of the IMPLAN economic forecasting software. Project inputs of incremental first cost and affected square footage were used to generate estimates of newly constructed buildings construction activity and added jobs to the construction industry sector.

For the nonresidential PV and battery storage system estimate, the impact of the PV measure was determined by multiplying the affected newly constructed building forecast by the difference in required PV system capacity under the 2025 Energy Code compared to the 2022 Energy Code for each affected building type and climate zone, and applying an average newly--constructed--building, capacity-weighted, first cost of $2 per Watt for the PV system before the federal ITC. As shown in Table 5, the measure has a significant positive impact on solar industry employment and business.

Table 5: Nonresidential PV Measure Economic Impacts

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	880.6	$68,408,876	$79,059,149	$134,654,196
Indirect Effect	215.4	$18,635,011	$29,241,775	$53,850,648
Induced Effect	366.3	$24,994,384	$44,750,393	$71,225,750
Total Effect	**1,462.3**	**$112,038,271**	**$153,051,316**	**$259,730,594**

The building design and energy consultant community will experience an impact because out of the annual 107 million square feet from newly constructed building activity, approximately 10 million square feet or 400 newly constructed buildings will be built that will require PV for the first time.

The impact of the battery storage system was calculated similarly to the PV system. The newly constructed building forecast was multiplied by the change in battery storage system capacity, comparing the 2025 Energy Code requirements to the 2022 Energy Code. That result was then multiplied by the weighted-average first costs for energy storage systems across all building types and climate zones. The cost of $/Wh of battery storage was multiplied by the battery storage capacity requirement for each building type (Wh/sf), to derive a weighted average newly constructed building cost of $0.40/sf to estimate the impact on economic activity in the state. The battery storage system requirement of the proposed code change also has a significant impact on design and construction in the state. Together, the code change requirements for nonresidential PV and battery storage systems will result in an estimated 1,711 jobs added to the state. Table 6 shows the economic impacts from the nonresidential battery storage requirement.

Table 6: Nonresidential Battery Storage Measure Economic Impacts

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	149.8	$11,637,628	$13,449,670	$22,907,588
Indirect Effect	36.7	$3,170,218	$4,974,658	$9,161,159
Induced Effect	62.3	$4,252,085	$7,613,009	$12,117,039
Total Effect	**248.8**	**$19,060,131**	**$26,037,336**	**$44,185,786**

The labor estimate applies assumptions of 110 hours average of design time for the PV system design, and 30 hours for the battery storage system. This would include structural calculations, racking design[1], siting panels, and other tasks. The battery storage design time

[1] A hybrid ballast system is common for flat commercial roofs, as it minimizes the number of penetrations.

includes battery specification, location and siting, and electrical system details. The result is a modest impact to the building design workforce, as shown in Table 7.

Table 7: Building Designers / Energy Consultants PV and Battery Economic Impacts

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	27.3	$2,990,114	$2,960,177	$4,678,839
Indirect Effect	10.9	$890,307	$1,237,350	$1,991,879
Induced Effect	16.4	$1,115,800	$1,998,161	$3,180,363
Total Effect	**54.6**	**$4,996,222**	**$6,195,688**	**$9,851,081**

To estimate the impact on the workforce of building inspectors, the newly constructed building stock estimate that is required to install PV for the first time is assumed to add a burden of 6 hours labor for each new project. Note that there could be a number of projects claiming exceptions, which could add to building inspector time as well. The resulting impact on building inspectors is shown in Table 8.

Table 8: Building Inspectors Economic Impacts

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	0.6	$64,651	$76,668	$93,167
Indirect Effect	0.1	$5,987	$9,325	$16,242
Induced Effect	0.3	$20,335	$36,426	$57,978
Total Effect	**0.9**	**$90,973**	**$122,419**	**$167,386**

3.5 Economic and Fiscal Impacts

This measure will directly benefit the California solar and storage industry and installation contractors. A small secondary benefit will be to engineering design firms that support the design and installation of rooftop PV systems. These impacts are detailed in Section 3.4 Impacts on Jobs and Businesses of this report. It is important to note that without this supporting measure, the growth of installations of nonresidential PV systems would likely slow, due to the expected impact of the CPUC's NBT recent decrease on the valuation of exports (CPUC(b) 2022).

While this measure has additional first costs, the significant energy savings over the 30-year period of analysis will enable nonresidential businesses to divert funds normally used for utilities towards business development, which may result in additional jobs created. Finally, there are synergies between the PV and battery storage measures and other measures that support electrification of end uses, and with grid-level renewables. Taken together, these measures will diminish the need for new electrical generation for decades into the future.

3.6 Cost of Compliance and Enforcement

The additional cost of compliance and enforcement will be modest, as the need is primarily to the building types that have the PV and battery storage system requirements for the first time under the proposed 2025 Energy Code. The design constraints with PV are well understood and can be handled by the industry. The questions that may arise concerning siting, structural or attachment methods, and system costs, can be readily addressed. Since PV and battery storage systems are required in the current code, the proposed measure is not expected to require substantial new compliance or enforcement processes or training. The effect of the measure is a limited increase in the number of projects with PV and storage systems that require permit review by local building departments.

4. Energy Savings and Cost-effectiveness

This section provides a summary of energy savings estimates, costs, and overall cost-effectiveness analysis for the proposed measure. Energy savings, costs, and cost-effectiveness of proposed measures are assessed incrementally, meaning in comparison to the latest adopted version of the Energy Code. Best available data is used and references to those data sources are provided to clearly substantiate energy savings, costs, and cost-effectiveness.

4.1 Energy Savings Methodology

For this measure, all nonresidential and high-rise multifamily CEC prototypes were analyzed except for the Hospital, Laboratory, Parking Garage, and the Transportation Terminal portion of Assembly. Hospitals and Laboratories were not included because of their strict design needs. Parking Garages were excluded because they generally are not a conditioned building. The Transportation Terminal was not analyzed because of airplane sensitivity to glare at airport terminals, and lack of time to address considerations for other transportation terminals. The Small Office, Small School, and high-rise multifamily prototypes were modeled as having single-zone air-conditioners with gas furnaces.

CBECC 2025.0.4 RV was used to generate the basic models, then EnergyPlus v9.4 was used to further refine the models. LSC, Source Energy, GHG Emissions, and Weighted Peak Demand factors were then applied to the energy model results.[2] Table 9 provides a summary of the prototypes used in the analysis and their key features.

[2] See Section 1, Introduction, for an explanation of these factors.

Table 9: Prototype(s) Used for Energy, Cost, and Environmental Analysis

Prototype ID	Occupancy Type (Residential, Retail, Office, etc.)	Floor Area (ft²)	Number of Stories	Statewide Newly Constructed Building Floor Area (Million ft²)[3]
AssemblyExhibit	Assembly	8,892	1	3.7
AssemblyLibrary	Assembly	12,996	1	0.9
AssemblyReligious	Assembly	6,889	1	2.15
AssemblySports	Assembly	3,493	1	3.51
HotelSmall	Hotel	42,554	1	7.02
OfficeLarge	Office	498,589	13	13.31
OfficeMedium	Office	53,628	3	15.47
OfficeSmall-gas-htg	Office	5,502	1	3.22
RestaurantSmall	Restaurant	2,501	1	3.59
RetailLarge	Retail	240,000	1	8.34
RetailMedium	Retail	24,563	1	7.29
RetailStripMall	Retail	9,375	1	6.81
SchoolLarge	School	210,886	2	7.32
SchoolSmall-gas-htg	School	24,413	1	4.5
Warehouse	Warehouse	52,045	1	17.44
MultiFamily88Unit-5Story	Residential	95,028	5	33.36
MultiFamily117Unit-10Story	Residential	9,504	10	2.64

Two sets of PV and battery sizing analyses were performed: a "20/10" export set, and a 2022 Energy Code set. For the 20/10 export analysis a computer program was used to analyze the EnergyPlus electric load results for each prototype. This program sized the PV systems such that 20 percent of the annual generated electricity was exported. Batteries were then sized using the same program to further reduce exports to 10 percent. For the 2022 Energy Code analysis, PV and battery storage systems were sized using Equations 140.10-A, 140.10-B, 140.10-C, 170.2-D, 170.2-E, and 170.2-Fin the 2022 Energy Code.

Battery capacity was limited to 40 percent of full capacity for both the 20/10 and 2022 Energy Code cases to calculate the final results. The rationale for this utilized capacity is discussed in Appendix D: Selection of Utilized Battery Capacity.

[3] The proportion of each building type within the Assembly prototype was applied to the construction forecast for the Assembly prototype. For example, Exhibits & Events account for 33.8 percent of the Assembly prototype's floor area. Multiplying by Assembly's 10.92 Msf newly constructed building forecast by 33.8 percent results in 3.7 Msf. The Multifamily prototypes used the CEC dwelling unit forecasts, forecast prototype proportions, and average dwelling unit size. For example, 53,268 dwelling units are forecasted. 5 percent are applicable to the 10-story prototype. The 10-story dwelling units average 990.5 square feet. This results in 2.64 Msf.

Selecting the final PV and battery sizes for the proposed code language followed a process that evaluated and compared the 20/10 export results and 2022 Energy Code results. Specifically, this process was:

1. If, under the 20/10 export case, a PV with battery storage combination was found to be cost-effective for a given prototype, then those results were selected for that prototype.
2. If the 20/10 export PV with battery storage combination was not cost-effective, then either the 20/10 export's PV-only results, or the 2022 Energy Code results were selected for the prototype, whichever had lower exports to the grid and was cost-effective.
3. Prototypes with similar occupancies were grouped (such as all sizes of offices). After step 2, whichever prototype had the smallest PV size by square foot within the group was selected as the PV size requirement for that group.
4. The minimum, cost-effective battery size for the selected PV size was selected as the battery size for the occupancy group.

4.2 Energy Savings Results

Table 10 lists the LSC savings for the PV and battery size determined through the process described in Section 4.1 for each building prototype. There are no gas savings associated with this measure. So, the LSC savings are both the electricity and total savings. Table 11 lists the Source Energy savings.

Savings are determined for the proposed PV and battery storage sizes with respect to the 2022 Energy Code requirements for each building category that had PV and battery storage system requirements in the 2022 Energy Code.

There were no PV and battery storage system requirements for the AssemblyReligious and AssemblySports building prototypes. So, the LSC savings for these building prototypes were determined with respect to the building's total electricity usage without any PV generation or battery storage.

Wherever the existing Energy Code requirements were selected from the process described in Section 4.1, the proposed PV and battery storage requirements are the same as for the 2022 Energy Code. Therefore, there are no savings shown in the tables in those cases.

Table 10: LSC Savings Over 30-Year Period of Analysis [NPV$/sf]

	Climat e Zone	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**	**Climat e Zone**
Prototype	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
AssemblyExhibit	14.21	20.37	18.28	22.43	19.95	21.96	21.19	25.43	25.19	26.03	23.89	21.27	23.97	25.42	29.15	17.54
AssemblyLibrary	0.00	15.14	12.46	16.46	12.49	14.08	14.47	17.77	17.42	19.58	17.78	15.54	18.30	19.33	23.85	14.51
AssemblyReligious	19.92	25.19	19.91	26.62	22.41	26.69	25.99	34.59	32.40	34.41	31.03	27.02	31.21	30.64	45.83	23.38
AssemblySports	11.59	10.71	8.79	11.96	9.62	11.43	11.10	15.46	15.08	15.78	14.52	11.93	14.70	14.23	24.45	10.87
HotelSmall	5.82	7.50	6.90	8.62	7.43	8.40	8.04	10.04	9.64	10.24	9.45	8.32	9.68	10.02	12.44	7.66
OfficeLarge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OfficeMedium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OfficeSmall-gas-htg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RestaurantSmall	37.96	47.58	43.97	53.82	46.58	50.92	47.92	56.86	56.40	59.18	54.57	49.88	55.06	61.09	70.31	47.93
RetailLarge	1.41	1.62	1.05	2.33	1.29	0.93	1.47	3.42	2.68	3.43	4.40	2.34	4.02	3.40	4.29	2.09
RetailMedium	1.62	2.06	1.27	2.83	1.52	1.17	1.90	3.44	3.16	3.48	4.65	2.89	4.38	3.86	4.29	2.20
RetailStripMall	2.64	3.38	2.37	4.42	2.77	2.32	3.07	5.88	4.85	5.87	6.72	4.24	6.28	5.64	6.87	3.79
SchoolLarge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SchoolSmall-gas-htg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF88Unit_ResOnly	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF117Unit_ResOnly	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 11: Source Energy Savings Over 30-Year Period of Analysis [kBtu/sf]

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
AssemblyExhibit	2.02	2.65	2.52	3.05	2.86	3.05	3.14	3.40	3.36	3.45	3.01	2.65	3.02	3.47	3.74	2.33
AssemblyLibrary	0.00	1.95	1.68	2.21	1.72	1.86	2.08	2.32	2.27	2.55	2.23	1.90	2.28	2.64	3.25	1.86
AssemblyReligious	2.79	3.21	2.70	3.53	3.18	3.67	3.80	4.47	4.21	4.43	3.83	3.31	3.85	4.09	5.72	3.05
AssemblySports	1.64	1.39	1.21	1.63	1.37	1.59	1.63	2.01	1.96	2.03	1.83	1.49	1.85	1.96	2.99	1.44
HotelSmall	0.86	1.03	1.00	1.25	1.12	1.25	1.27	1.43	1.37	1.44	1.25	1.10	1.28	1.46	1.70	1.08
OfficeLarge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OfficeMedium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OfficeSmall-gas-htg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RestaurantSmall	5.39	6.32	6.16	7.54	6.78	7.27	7.44	7.92	7.79	8.10	7.05	6.39	7.10	8.68	9.59	6.46
RetailLarge	0.27	0.28	0.21	0.38	0.25	0.12	0.22	0.51	0.40	0.48	0.70	0.39	0.63	0.46	0.41	0.37
RetailMedium	0.30	0.37	0.24	0.51	0.29	0.19	0.31	0.56	0.51	0.51	0.77	0.48	0.69	0.61	0.41	0.40
RetailStripMall	0.34	0.40	0.30	0.57	0.36	0.27	0.42	0.73	0.59	0.74	0.82	0.49	0.76	0.77	0.93	0.46
SchoolLarge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SchoolSmall-gas-htg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Warehouse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF88Unit_ResOnly	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF117Unit_ResOnly	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4.3 Incremental First Cost

4.3.1 PV System First Cost

PV costs for nonresidential projects were estimated using several sources. The California Public Utilities Commission's (CPUC's) Distributed Generation Interconnection Program Data, including NEM/NBT PV datasets for PV systems interconnected in IOU territories in 2022, was used to determine median system first cost as a function of installed capacity (CPUC(c) 2023). The following approach was used to determine PV system costs:

- The PV System first cost was determined based on cost data from the CPUC NEM dataset mentioned above.
- Component replacement costs for inverters were developed using published studies of NREL cost data.
- Price forecast data was also developed using NREL cost studies.

The CPUC Distributed Generation Interconnection Program dataset is very large, consisting of tens of thousands of entries. The following projects or entries were filtered out to produce a data set usable for the analysis in this report:

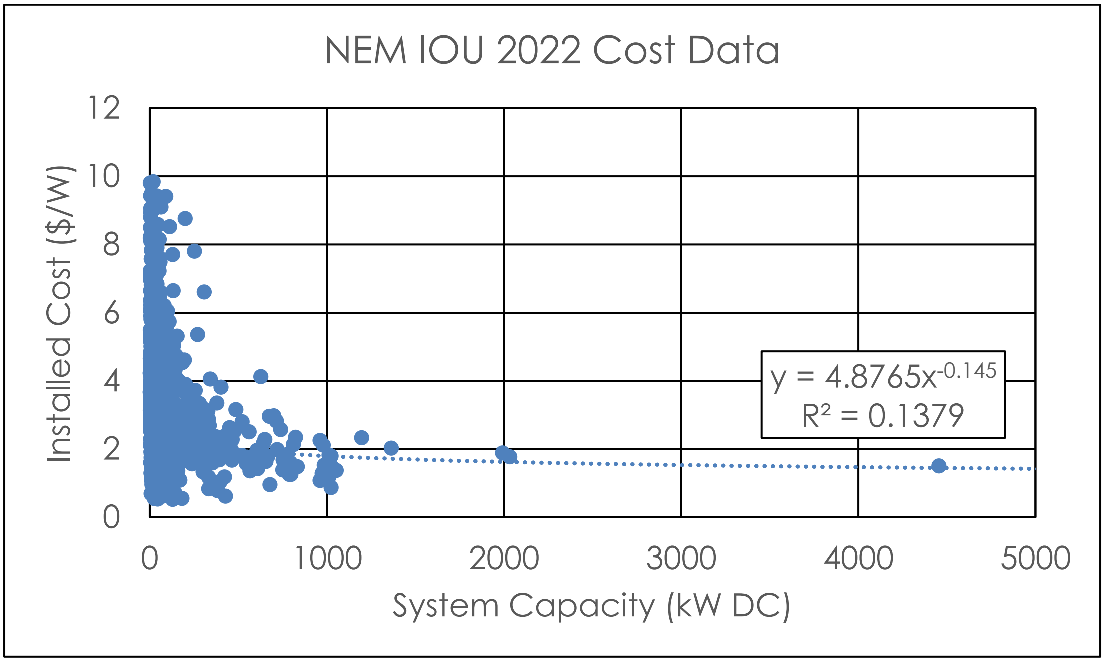
- Projects with single or dual-axis tracking
- Projects with mounting other than roof-mounted
- Projects with non-profit or government customer sector
- Entries too low (<$0.50/sf) or too high to be practical (>$10/W).

This resulted in a filtered dataset of nearly 2,000 project entries from year 2022. An exponential regression of installed cost ($/W) as a function of system capacity was developed and used to generate the base PV system cost. **Error! Reference source not found.** shows the cost data and the corresponding regression equation linking PV installed cost to system capacity. The base PV system cost was modified further to account for inflation, changes to labor costs, forecasted reduction in PV cost by 2026, and a combined PV and battery system discount. These adjustments are described below.

The following adjustments were applied to the base PV system cost developed using the NEM IOU Interconnected PV system dataset:

- **Inflation Adjustment:** An annual inflation rate to convert the estimate from 2022 dollars to 2026 dollars.
- **Customer Acquisition Cost Reduction:** A reduction that accounts for avoided customer acquisition costs for newly constructed building projects that are required by the Energy Code.
- **Forecasted Price Reduction:** A conservative projected forecast decline in PV system costs over the 4-year period from 2022 through 2026, prior to the January 2026 effective date of the 2025 Energy Code.

Figure 1: NEM IOU Interconnected 2022 PV System Cost Data



- **Prevailing Wage Adjustment:** A prerequisite for eligibility for the ITC, prevailing wage was estimated to increase PV labor installation costs by 50 percent.
- **Combined PV/Battery Discount:** An adjustment for reduction in total system cost, based on reduced labor and balance-of-system costs when PV is installed together with battery storage. This reduction is based on a recent study estimating a 20 percent reduction in system costs. This report uses a slightly more conservative assumption of a 15 percent reduction in total system costs, due to reduced labor, permitting and other soft costs.
- **ITC credit:** A reduction in project costs, as specified by the ITC program guidelines. This adjustment applies a reduction to system first costs.

After the base PV installation cost was adjusted using the parameters described above, replacement costs and maintenance costs were added to arrive at the present value cost of the system over the 30-year period of analysis.

- **Inverter 10-year Replacement Cost:** Applies the discount rate to inverter equipment, labor, overhead, and profit costs, and sales tax, applied through year 10.
- **Inverter 20-year Replacement Cost:** Applies the discount rate to inverter equipment, labor, overhead, and profit costs, and sales tax, applied through year 20.
- **Annual PV Maintenance Cost:** Accounts for periodic cleaning of PV panels.

Table 12 shows the economic and system cost parameter values used in the lifecycle cost analysis and their sources.

Table 12: PV System Cost Input Parameter Values

Input Parameter	Value	Source
Period of Analysis	30 years	Energy Commission
Inflation Rate 2022-2026	3.0%	Energy Commission
Discount Rate	3.0%	Energy Commission
Customer Acquisition Cost Reduction	$0.18/W	(Chung 2015)
Forecasted Price Reduction	10%	(Cole 2020)
Prevailing Wage Adjustment	$0.10/W	(RS Means 2022)
Combined Discount	15%	(Ramasamy, et al. 2022, 41)
Investment Tax Credit	30%	(Solar Energy Technologies Office 2023)
Inverter Equipment	$0.07/W	(Ramasamy, et al. 2022)
Annual PV Maintenance Cost	$15	Assumes cleaning once in 5 years
Inverter Replacement Labor	$0.03/W	(Cole 2020)
Inverter 10-yr Replacement Cost	$0.105/W	(Cole 2020)
Inverter 20-yr Replacement Cost	$0.077/W	(Cole 2020)

Table 13 shows the base and adjusted PV system first cost when it is standalone and when it is coupled with battery-storage. Note that the cost in the battery-coupled column reflects the cost of only the PV system. The following describes the columns in Table 13:

- **Base Cost** is the estimated first cost of a nonresidential PV system, in 2022 dollars per Watt (DC), derived from the regression of project costs with system capacity for 2022 NEM IOU reported data.
- **PV Standalone Cost** shows the adjusted PV system first cost for a newly constructed building standalone PV project with no battery storage. This includes the adjustment factors defined in Table 12 for Customer Acquisition Cost Reduction, Forecasted Price Reduction, the Prevailing Wage Adjustment, and Inflation Adjustment. After these adjustments were applied, the ITC discount was applied.
- **PV Cost with Battery Storage** is the adjusted PV Standalone Cost, after applying the Combined PV/battery discount. To get the full cost of a system that includes both PV and battery, this PV Cost with Battery Storage was added to the battery storage costs discussed in 4.3.2.

Table 13: Nonresidential PV System First Cost Estimate ($/W)

Capacity (kW)	Base Cost	Adjusted PV System Standalone Cost	Adjusted PV Cost with Battery Storage
	2022 (2022 $)	**2026 (2026 $)**	**2026 (2026 $)**
5	3.86	2.69	2.29
10	3.49	2.43	2.07
25	3.06	2.12	1.80
50	2.77	1.91	1.62
75	2.61	1.80	1.53
100	2.50	1.72	1.46
200	2.26	1.55	1.32
500	1.98	1.36	1.16
1000	1.79	1.22	1.04
5000	1.42	0.96	0.81

Table 14 shows the total incremental cost of a standalone PV system, including 10-year and 20-year inverter replacement costs and the annual PV maintenance cost as described in Table 12. Since the maintenance cost is fixed, the cost per Watt is lower for larger PV systems than for smaller PV systems. The present value of all system costs over the project's 30-year period of analysis is shown in the last column. Table 15 shows the total incremental cost of only the PV system when it is coupled with a battery storage system, incorporating the Combined Discount as described in Table 12.

Table 14: Nonresidential PV Standalone System Costs Including Replacement and Maintenance Costs

Capacity (kW)	PV Standalone Cost	Replacement and Maintenance Costs ($/W) Inverter	Replacement and Maintenance Costs ($/W) Maintenance	NPV of PV Standalone ($/W)
	(2026 $)	**(2026 $)**	**(2026 $)**	**(2026 $)**
5	2.69	0.18	0.059	2.93
10	2.43	0.18	0.029	2.64
25	2.12	0.18	0.012	2.31
50	1.91	0.18	0.006	2.10
75	1.80	0.18	0.004	1.99
100	1.72	0.18	0.003	1.91
200	1.55	0.18	0.001	1.74
500	1.36	0.18	0.001	1.54
1000	1.22	0.18	0.000	1.40
5000	0.96	0.18	0.000	1.14

Table 15: Costs of only the Nonresidential PV System when it is coupled with Battery Storage, Including Replacement and Maintenance Costs (2026 $)

Capacity (kW)	PV Cost with Battery Storage	Replacement and Maintenance Costs ($/W) Inverter	Replacement and Maintenance Costs ($/W) Maintenance	NPV of PV Cost with Battery Storage ($/W)
5	2.29	0.18	0.059	2.53
10	2.07	0.18	0.029	2.27
25	1.80	0.18	0.012	1.99
50	1.62	0.18	0.006	1.81
75	1.53	0.18	0.004	1.72
100	1.46	0.18	0.003	1.65
200	1.32	0.18	0.001	1.50
500	1.16	0.18	0.001	1.34
1000	1.04	0.18	0.000	1.22
5000	0.81	0.18	0.000	0.99

4.3.2 Battery Storage System Costs

The nonresidential battery storage systems assume a 4--hour battery discharge cycle, in line with standard CPUC assumptions for PV--storage resource reliability (Carden 2021). The parameters used for the battery storage costs are similar to those used in the development of PV system costs, described in the previous section (4.3.1). Table 16 lists economic and cost parameters used to develop the battery storage cost where they differ from the PV system cost development. These parameters are described below:

- **Customer Acquisition Adjustment** is a fixed incremental value for overhead and marketing expenses for systems ≤ 100 kWh. For systems > 100 kWh, a discount is applied to permitting, interconnection, and inspection fees (PII), contingency, and engineering, procurement, and construction (EPC) overhead costs.
- **Forecasted Cost Reduction** is based on a conservative forecast for batteries developed by NREL.
- **Prevailing Wage Adjustment** an estimated 50 percent increase in labor costs due to prevailing wage differences.

Table 16: Economic and Cost Parameters for Battery Cost Development

Input Parameter	Value	Source
Customer Acquisition Cost Reduction	$3851 (<100 kWh) 30% (>100 kWh)	(Ramasamy, et al. 2022, 33) (Ramasamy, et al. 2022, 41)
Forecasted Cost Reduction	10.9%	(Cole 2020)
Prevailing Wage Adjustment	$43.40/kWh	(RS Means 2022)

Table 17 shows the incremental battery first costs. The base cost for Tesla Powerwall storage systems or equivalent was used for nonresidential installations with loads up to 100 kWh. For these smaller systems, cost was determined through distributor estimates. For capacity step increases in required battery size for these smaller systems, the analysis uses the smallest available multiple of Tesla Powerwall systems to achieve that capacity step. For larger battery systems (>100 kWh), battery storage system costs were derived from NREL source data (Ramasamy, et al. 2022) (Cole 2020), and from manufacturer and distributor surveys. The Combined PV/Battery Discount is always included because the proposal requires batteries only when coupled with PV.

Table 17: Nonresidential Battery Storage First Cost ($/kWh)

Capacity (kWh)[1]	Base Cost 2022 (2022 $)	Battery Storage First Cost 2026 (2026 $)
13.5	1340	658
27	1206	664
40.5	1206	692
54	1206	706
100	945	551
200	857	498
500	754	437
1,000	685	396
5,000	551	316
10,000	503	287

Table 18 shows the net present value of the battery storage system after including two replacements over the period of analysis: one after ten years and a second after twenty years. The battery system has an expected useful life of 10 years (Augustine 2023) with little maintenance. Replacement costs for batteries were discounted at 10 and 20 years and adjusted further to account for a forecasted reduction in battery system costs (Cole 2020), and a reduction in system costs due to reduced balance-of-system costs. Battery replacements were determined to be ineligible for the ITC, which expires prior to when the replacements would be made.

Table 18: Nonresidential Battery Storage Life-Cycle Costs (2026 $)

Capacity (kWh)	Battery Storage First Cost	Replacement Cost, Year 10 ($/kWh)	Replacement Cost, Year 20 ($/kWh)	NPV of Battery Storage Cost ($/kWh)
13.5	658	537	254	1,449
27	664	541	256	1,460
40.5	692	565	267	1,524
54	706	577	273	1,556
100	551	445	210	1,206
200	498	400	189	1,088
500	417	348	164	949
1,000	396	313	148	857
5,000	316	245	116	676

10,000	287	220	104	611

4.4 Incremental Maintenance Costs

The Section 4.3.2 discussion of battery storage system first costs above includes a detailed description of maintenance and replacement costs over the 30--year period of analysis. Maintenance costs are very low for PV systems, consisting only of occasional cleaning of PV panels. The PV system also includes replacement of the inverters every ten years. For nonresidential battery storage, while there are no maintenance costs, there are two battery system replacements that occur over the 30--year period of analysis. Each of these factors is included in the life-cycle cost estimates in the first cost section.

The estimate of PV system performance assumes a level of performance degradation over time, and that only minimal maintenance is performed. The cost estimate includes a $75 cleaning fee, performed once every five years. This is translated into a fixed maintenance cost.

The nonresidential batteries do not require maintenance, and have an expected service life of 10 years, given the depth-of-charge and expected rate of cycling. Incremental maintenance costs are included in the cost analysis described in Section 4.3.2.

4.5 Cost-Effectiveness

The BCR results are presented in Table 19 by California climate zone for the designed building category. BCR values that are shown as N/A are cost-effective because they have both LSC savings and incremental cost savings. Values with a dash are the same requirements as the current code and so cost-effectiveness is unchanged.

Table 19: Cost-effectiveness BCR Summary

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
AssemblyExhibit	1.57	1.92	1.98	2.05	2.05	2.10	1.91	2.09	2.11	2.09	1.82	1.89	1.85	2.13	2.00	1.96
AssemblyLibrary	-	1.03	1.03	1.16	1.09	1.14	1.11	1.18	1.17	1.23	1.13	1.07	1.19	1.33	1.38	1.10
AssemblyReligious	1.50	1.78	1.82	1.88	1.87	1.88	1.71	1.89	1.92	1.92	1.64	1.74	1.66	1.96	1.89	1.82
AssemblySports	1.34	1.52	1.56	1.61	1.62	1.62	1.49	1.62	1.66	1.64	1.42	1.48	1.44	1.69	1.63	1.57
HotelSmall	1.74	2.17	2.21	2.29	2.30	2.39	2.19	2.32	2.35	2.29	2.23	2.11	2.26	2.62	2.53	2.25
OfficeLarge	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OfficeMedium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OfficeSmall-gas-htg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RestaurantSmall	1.50	1.81	1.86	1.97	1.95	2.04	1.85	1.99	2.03	2.02	1.76	1.81	1.80	2.11	2.01	1.94
RetailLarge	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15.99	82.75	11.39	5.54	588.69	6.43	8.68	8.93	38.58
RetailMedium	2.95	18.39	90.82	8.99	15.36	N/A	N/A	3.95	N/A	13.79	4.91	4.82	6.17	9.39	9.27	3.14
RetailStripMall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8.46	N/A	12.14	29.97	19.26	N/A
SchoolLarge	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SchoolSmall-gas-htg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warehouse	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF88Unit_ResOnly	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF117Unit_ResOnly	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

5. Statewide Energy Impacts

This section provides the first-year statewide savings of the proposed measure. This analysis is to help determine overall value of the proposed measure to the State of California and is not used to determine cost-effectiveness of the proposed measure. To assist with this analysis, a statewide newly constructed building forecast was developed by the CEC for 2026, which is presented in more detail in *Appendix A: Statewide Savings Methodology*. The first-year energy impacts represent the first-year annual savings from all buildings forecasted to be completed in 2026.

5.1 Statewide Energy and Energy Cost Savings[4]

The statewide annual energy savings were estimated based on the forecasted floor area developed by the CEC. The results are presented in Table 20.

Table 20: Estimated Statewide Annual Energy Savings

	First Year Statewide Electricity Savings (GWh)	First Year Statewide Power Demand Reduction (MW)	First Year Statewide Natural Gas Savings (Million Therms)	First Year Statewide Electricity LSC Savings (Millions of NPV$)	First Year Statewide Natural Gas LSC Savings (Millions of NPV$)
Photovoltaic and Battery Update and Expansion	156.2	0.45	0.00	534.8	0.00
TOTAL	**156.2**	**0.45**	**0.00**	**534.8**	**0.00**

5.2 Statewide Greenhouse Gas Emissions Savings

The GHG emissions were estimated based on hourly factors developed by the CEC. The results are presented in Table 21.

Table 21: Estimated Statewide Greenhouse Gas Emissions Savings

	First Year Statewide GHG Emission Savings (MT CO_2e/year)	First Year Statewide Source Energy Savings (Billions of Btus)
Photovoltaic and Battery Update and Expansion	3,878.7	73.3
TOTAL	**3,878.7**	**73.3**

[4] Electricity savings from the PV and battery storage system measure are reductions in building electricity consumption that does not have to be served by the grid.

5.3 Statewide Water Savings

There are no expected water impacts for this measure.

5.4 Other Non-Energy Impacts

Both PV and battery storage systems work together to reduce peak system demand. These systems have the direct benefit of limiting aggregate demand, reducing the state's reliance on combustion power plants, dramatically reducing pollution emissions and improving air quality.

Energy storage systems also provide an increase in resilience during times of peak grid demand. While the systems are primarily designed to reduce grid energy consumption during the late afternoon and early evening peak hours, they can also be used to provide for power in emergency conditions.

PV and battery storage systems use materials that must be disposed of or recycled at the end of their useful life. PV panels have been recently reclassified as products not requiring special handling, which facilitates both recycling, disposal, and transport.

Commercial energy storage systems use lithium, cobalt, and nickel, and some require small amounts of manganese. Battery manufacturers are developing cathode materials to eliminate the use of cobalt. Many of the metals in batteries can be recycled and reused, when treated at appropriate facilities. Battery storage materials can also be recycled in specialized processing facilities that can purify and reconstitute the materials for use in batteries. There are facilities with the capability to repurpose very large quantities of batteries, including electric vehicle batteries (Ohnsman 2023).

Commercial battery recycling facilities have developed the ability to recycle, refine and remanufacture battery materials from expended batteries. The scale of the electric vehicle market provides synergies for batteries used for commercial energy storage in buildings.

6. PROPOSED CODE LANGUAGE

6.1 Energy Code (Title 24, Part 6)

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

NONRESIDENTIAL BUILDING OCCUPANCY TYPES are building types in which a minimum of 90 percent of the building floor area functions as one of the following, which do not qualify as any other Building Occupancy Types more specifically defined in Section 100.1, and which do not have a combined total of more than 10 percent of the area functioning of any Nonresidential Function Areas specifically defined in Section 100.1:

Events & Exhibits Building is a Museum Building, Motion Picture or Performance Arts Theater Building, or other building in which 80% of the building floor area is comprised of any combination of Auditorium Area, Convention, Conference, Multipurpose and Meeting Area, or Civic Meeting Place Area.

Religious Worship Building is a building in which 80% of the building floor area is comprised of Religious Worship Area.

Sports & Recreation Building is a building in which 80% of the building floor area is comprised of Exercise/Fitness Center and Gymnasium Area, or other area where recreational sports are practiced.

SECTION 140.10 – PRESCRIPTIVE REQUIREMENTS FOR PHOTOVOLTAIC AND BATTERY ENERGY STORAGE SYSTEMS

(a) **Photovoltaic Requirements.** All newly constructed building types specified in Table 140.10-A, or mixed occupancy buildings where one or more of these building types constitute at least 80 percent of the floor area of the building, shall have a newly installed photovoltaic (PV) system meeting the minimum qualification requirements of Reference Joint Appendix JA11. The PV ~~size~~ capacity in kW_{dc} shall be not less than the smaller of the PV minimum rated PV system capacity ~~system size~~ determined by Equation 140.10-A, or the total of all available Solar Access Roof Areas (SARA) multiplied by 18 for steep-sloped roofs or SARA multiplied by 14 for low-sloped roofs. In mixed occupancy buildings, the minimum rated PV system capacity for the building shall be determined by applying Equation 140.10-A to the conditioned floor area of each of the listed building types and summing the capacities determined for each.

1. SARA include the area of the building's roof space capable of structurally supporting a PV system, and the area of all roof space on covered parking areas, carports, and all other newly constructed structures on the site that are compatible with supporting a PV system per Title 24, Part 2, Section 1511.2.

2. SARA does NOT include:

   A. Any area that has less than 70 percent annual solar access. Annual solar access is determined by dividing the total annual solar insolation (accounting for shading obstructions) by the total annual solar insolation if the same areas were unshaded by those obstructions. For all roofs, all obstructions including those that are external to the building, and obstructions that are part of the building design and elevation features may be considered for the annual solar access calculations.

B. Occupied roofs as specified by CBC Section 503.1.4.

C. Roof area that is otherwise not available due to compliance with other state building code requirements or with local building code requirements if the local building code requirements are confirmed by the Executive Director ~~Roof space that is otherwise not available due to compliance with other building code requirements if confirmed by the Executive Director~~.

EQUATION 140.10-A PHOTOVOLTAIC DIRECT CURRENT SIZE

kW_{PVdc} = (CFA x A)/1000

where:

kW_{PVdc} = Minimum rated PV system capacity in kW ~~Size of the PV system in kW.~~

CFA = Conditioned floor area in square feet

A = PV capacity factor in W/square foot as specified in Table 140.10-A for the building type

~~Where the building includes more than one of the space types listed in Table 140.10-A, the total PV system capacity for the building shall be determined by applying Equation 140.10-A to each of the listed space types and summing the capacities determined for each.~~

Exception 1 to Section 140.10(a). No PV system is required where the total of all available SARA is less than three percent of the conditioned floor area.

Exception 2 to Section 140.10(a). No PV system is required where the required PV system size is less than 4 kW_{dc}.

Exception 3 to Section 140.10(a). No PV system is required if the SARA contains less than 80 contiguous square feet.

Exception 4 to Section 140.10(a). Buildings with enforcement-authority-approved roof designs, where the enforcement authority determines it is not possible for the PV system, including panels, modules, components, supports, and attachments to the roof structure, to meet ASCE 7-16, Chapter 7, Snow Loads.

~~**Exception 5 to Section 140.10(a).** Multi-tenant buildings in areas where a load-serving entity does not provide either a virtual net metering (VNEM), virtual net billing tariff (VNBT) or community solar program.~~

Exception 5 to Section 140.10(a): For nonresidential and hotel/motel multitenant buildings, the PV capacity determined by Equation 140.10-A shall be calculated without including tenant spaces meeting all of the following:

i. The tenant space is less than or equal to 2,000 square feet of conditioned space;
ii. The tenant space is served by an individual HVAC system that does not serve other spaces in the building; and
iii. The tenant space has an individual utility meter to track electricity consumption that does not include the electricity consumption of other spaces in the building.

This exception does not apply where the Commission has approved a community solar program for showing compliance as specified in Title 24, Part 1, Section 10-115, or where a load-serving entity provides a program where PV generation is compensated through virtual energy bill credits for occupants of nonresidential and hotel/motel tenant spaces to receive energy bill benefits from netting of energy generation and consumption.

(b) **Battery** Energy storage system (BESS) **Requirements.** All buildings that are required by Section 140.10(a) to have a PV system shall also have a battery storage system BESS meeting the minimum qualification requirements of Reference Joint Appendix JA12. The rated energy capacity and the rated power capacity shall be not less than the Minimum Rated Useable Energy Capacity values determined using Equation 140.10-B, or Equation 140.10-C if SARA was used to determine the PV capacity in Section 140.4(a). The rated power capacity shall be not less than the Minimum Rated Power Capacity determined by Equation 140.10-DC. Where the building includes more than one of the space types listed in Table 140.10-B In mixed occupancy buildings, the total battery system capacity for the building shall be determined by applying the Minimum Rated Useable Energy Capacity Equations 140.10-B and 140.10-C to each of the listed space building types and summing the capacities determined for each space type and equation.

EQUATION 140.10-B - BATTERY STORAGE RATED ENERGY CAPACITY

$kWh_{batt} = kW_{PVdc} \times B / D^{0.5}$

$$kWh_{batt} = \frac{CFA \times B}{1000 \times C^{0.5}}$$

EQUATION 140.10-C - BATTERY ENERGY STORAGE SYSTEM RATED ENERGY CAPACITY, SARA-ADJUSTED

where:

kWh_{batt}	=	Minimum Rated Useable Energy Capacity of the battery storage system BESS in kWh
CFA	=	Conditioned floor area that is subject to the PV system requirements of Section 140.10(a) in square feet
kW_{PVdc}	=	Size of the PV system Minimum Rated PV System Capacity in kW from Equation 140.10-A
kW_{PVdc}	=	PV system capacity required by section 140.10(a) in kWdc
$kW_{PVdc, SARA}$	=	Minimum Rated PV System Capacity in kW from the SARA calculation.
B	=	Battery Energy BESS cCapacity fFactor in Wh/square foot as specified in Table 140.10-B for the building-type

~~D~~<u>C</u> = Rated single charge-discharge cycle AC to AC (round-trip) efficiency of the ~~battery storage system~~ <u>BESS</u>

EQUATION 140.10-<u>D</u>~~C~~ - ~~BATTERY STORAGE~~ <u>BESS</u> RATED POWER CAPACITY

~~$kW_{batt} = kWh_{batt, min} / 4\ kW_{PVdc} \times C$~~

WHERE:

kW_{batt} = <u>Minimum Rated Power</u> Capacity of the battery storage system in kWdc

<u>kWh_{batt} = Minimum Rated Useable Energy Capacity of the BESS in kWh</u>

~~kW_{PVdc} = PV system capacity required by section 140.10(a) in kWdc~~

~~C = Battery power capacity factor specified in Table 140.10-B for the building type~~

EXCEPTION 1 to Section 140.10(b). No ~~battery storage system~~ <u>BESS</u> is required if the installed PV system size is less than 15 percent of the size determined by Equation 140.10-A.

EXCEPTION 2 to Section 140.10(b). No ~~battery storage system~~ <u>BESS</u> is required in buildings with ~~battery storage~~ <u>BESS</u> system requirements with less than 10 kWh rated capacity.

EXCEPTION 3 to Section 140.10(b). For multi-tenant buildings, the energy capacity ~~and power capacity~~ of the ~~battery storage system~~ <u>BESS</u> shall be based on the tenant spaces with more than 5,000 square feet of conditioned floor area. For single-tenant buildings with less than 5,000 square feet of conditioned floor area, no ~~battery storage system~~ <u>BESS</u> is required.

~~**EXCEPTION 4 to Section 140.10(b).** In climate zone 1, no battery storage system is required for offices, schools, and warehouses.~~

TABLE 140.10-A – PV Capacity Factors (W/ft² of conditioned floor area)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Events & Exhibits	3.48	4.28	3.66	4.32	3.77	4.05	4.28	4.83	4.63	4.80	5.04	4.44	4.95	4.36	5.48	3.38
Library	0.39	3.23	2.59	3.25	2.48	2.74	3.04	3.49	3.32	3.69	3.79	3.32	3.79	3.37	4.49	2.84
Hotel/Motel	1.69	1.90	1.66	1.97	1.69	1.87	1.94	2.22	2.09	2.20	2.30	2.05	2.30	2.02	2.72	1.73
Office, Financial Institution, Unleased Tenant Space, Medical Office Building/Clinic	2.59	3.13	2.59	3.13	2.59	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.80	2.59
Restaurants	8.55	9.32	8.16	9.65	8.21	8.73	9.11	10.18	9.75	10.28	10.85	9.73	10.69	9.73	12.25	8.47
Retail, Grocery	3.14	3.49	3.01	3.61	3.05	3.27	3.45	3.83	3.65	3.81	4.09	3.64	3.99	3.71	4.60	3.21
School	1.27	1.63	1.27	1.63	1.27	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	2.46	1.27
Warehouse	0.39	0.44	0.39	0.44	0.39	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.58	0.39
Religious Worship	4.25	4.65	3.49	4.52	3.72	4.29	4.64	5.89	5.30	5.67	5.89	4.99	5.78	4.63	7.57	3.90
Sports & Recreation	2.47	1.97	1.54	2.03	1.60	1.84	1.98	2.63	2.47	2.60	2.75	2.20	2.72	2.15	4.03	1.81
Multifamily > 3 stories	1.82	2.21	1.82	2.21	1.82	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.77	1.82

TABLE 140.10-B – BESS Capacity Factors (Wh/ft² of conditioned floor area)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Events & Exhibits	1.82	1.95	1.74	2.12	1.91	2.13	2.24	2.30	2.36	2.47	2.62	2.16	2.64	2.68	3.22	1.89
Library	0.37	7.17	5.97	6.75	5.64	6.08	6.19	7.13	7.18	7.56	7.17	6.93	6.88	6.81	7.93	6.40
Hotel/Motel	0.86	0.84	0.77	0.92	0.81	0.89	0.90	1.01	1.00	1.11	1.14	0.96	1.18	1.18	1.49	0.85
Office, Financial Institution, Unleased Tenant Space, Medical Office Building/Clinic	NR	5.26	4.35	5.26	4.35	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	6.39	4.35
Restaurants	4.36	4.11	3.78	4.37	3.89	4.02	4.11	4.49	4.47	4.82	5.05	4.43	5.05	5.24	6.23	4.11
Retail, Grocery	1.89	1.82	1.71	1.82	1.72	1.80	1.76	1.92	1.97	2.05	2.22	1.95	2.16	2.29	2.66	1.91
School	NR	3.05	2.38	3.05	2.38	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	4.60	2.38
Warehouse	NR	0.41	0.37	0.41	0.37	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.54	0.37
Religious Worship	2.21	2.25	1.74	2.42	2.08	2.75	2.94	3.37	3.17	3.37	3.58	2.72	3.62	3.21	4.89	2.37
Sports & Recreation	1.26	0.98	0.76	1.14	0.86	1.20	1.23	1.57	1.53	1.65	1.83	1.27	1.86	1.57	3.02	1.13
Multifamily > 3 stories	1.88	2.27	1.88	2.27	1.88	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.85	1.88

~~Table 140.10-A – PV Capacity Factors~~

	~~Factor A – Minimum PV Capacity (W/ft^2 of conditioned floor area)~~		
~~Climate Zone~~	**~~1, 3, 5, 16~~**	**~~2, 4, 6-14~~**	**~~15~~**
~~Grocery~~	~~2.62~~	~~2.91~~	~~3.53~~
~~High-Rise Multifamily~~	~~1.82~~	~~2.21~~	~~2.77~~
~~Office, Financial Institutions, Unleased Tenant Space~~	~~2.59~~	~~3.13~~	~~3.80~~
~~Retail~~	~~2.62~~	~~2.91~~	~~3.53~~
~~School~~	~~1.27~~	~~1.63~~	~~2.46~~
~~Warehouse~~	~~0.39~~	~~0.44~~	~~0.58~~
~~Auditorium, Convention Center, Hotel/Motel, Library, Medical Office Building/Clinic, Restaurant, Theater~~	~~0.39~~	~~0.44~~	~~0.58~~

~~*Table 140.10-B – Battery Storage Capacity Factors*~~

-	~~**Factor B – Energy Capacity**~~	~~**Factor C – Power Capacity**~~
~~**Storage-to-PV Ratio**~~	~~**Wh/W**~~	~~**W/W**~~
~~Grocery~~	~~1.03~~	~~0.26~~
~~High-Rise Multifamily~~	~~1.03~~	~~0.26~~
~~Office, Financial Institutions, Unleased Tenant Space~~	~~1.68~~	~~0.42~~
~~Retail~~	~~1.03~~	~~0.26~~
~~School~~	~~1.87~~	~~0.46~~
~~Warehouse~~	~~0.93~~	~~0.23~~
~~Auditorium, Convention Center, Hotel/Motel, Library, Medical Office Building/Clinic, Restaurant, Theater~~	~~0.93~~	~~0.23~~

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, and 25943, Public Resources Code.

SECTION 170.2 – PRESCRIPTIVE APPROACH

(g) **Photovoltaic Requirements – More than Three Habitable Stories.** All newly constructed building types specified in Table 170.2-U, or mixed occupancy buildings where one or more of these building types constitute at least 80 percent of the floor area of the building, shall have a newly installed photovoltaic (PV) system meeting the minimum qualification requirements of Reference Joint Appendix JA11. The PV capacity in kW_{dc} shall be not less than the smaller of the PV minimum rated PV system capacity determined by Equation 170.2-D, or the total of all available Solar Access Roof Areas (SARA) multiplied by 18 for steep-sloped roofs or multiplied by 14 for low-sloped roofs. ~~size in kWdc shall be not less than the smaller of the PV system size determined by Equation 170.2-D, or .the total of all available Solar Access Roof Areas (SARA) multiplied by 14 W/ft².~~ In mixed occupancy buildings, the Minimum Rated PV System Capacity for the building shall be determined by applying Equation 170.2-D to the conditioned floor area of each of the listed building types and summing the capacities determined for each.

1. SARA include the area of the building's roof space capable of structurally supporting a PV system, and the area of all roof space on covered parking areas, carports, and all other newly constructed structures on the site that are compatible with supporting a PV system per Title 24, Part 2, Section 1511.2.

2. SARA does NOT include:
    A. Any area that has less than 70 percent annual solar access. Annual solar access is determined by dividing the total annual solar insolation (accounting for shading obstructions) by the total annual solar insolation if the same areas were unshaded by those obstructions. For all roofs, all obstructions including those that are external to the building, and obstructions that are part of the building design and elevation features may be considered for the annual solar access calculations.
    B. Occupied roofs as specified by CBC Section 503.1.4.
    C. Roof area that is otherwise not available due to compliance with other state building code requirements and local building code requirements if the local building code requirements are confirmed by the Executive Director. ~~Roof space that is otherwise not available due to compliance with other building code requirements if confirmed by the Executive Director.~~

EQUATION 170.2-D PHOTOVOLTAIC DIRECT CURRENT SIZE

$kW_{PVdc,min}$ ~~kW_{PVdc}~~ = (CFA x A)/1000

where:

$kW_{PVdc,\ min}$ ~~kW_{PVdc}~~ = Minimum Rated PV System Capacity in kW. ~~Size of the PV system~~

CFA = Conditioned floor area in square feet.

A = PV capacity factor in W/square foot as specified in Table 170.2-U for the building type.

~~Where the building includes more than one of the space types listed in Table 170.2-U, the total PV system capacity for the building shall be determined by applying Equation 170.2-D to each of the listed space types and summing the capacities determined for each.~~

EXCEPTION 1 to Section 170.2(g). No PV system is required where the total of all available SARA is less than 3 percent of the conditioned floor area.

EXCEPTION 2 to Section 170.2(g). No PV system is required where the required PV system size is less than 4 kW_{dc}.

EXCEPTION 3 to Section 170.2(g). No PV system is required if the SARA contains less than 80 contiguous square feet.

EXCEPTION 4 to Section 170.2(g). Buildings with enforcement-authority-approved roof designs, where the enforcement authority determines it is not possible for the PV system, including panels, modules, components, supports, and attachments to the roof structure, to meet ASCE 7-16, Chapter 7, Snow Loads.

EXCEPTION 5 to Section 170.2(g). ~~Multi-tenant~~ High-rise multifamily buildings in areas where a load serving entity does not provide either a ~~Virtual Net Metering (VNEM)~~ program where PV generation is compensated through virtual energy bill credits ~~or a community solar program~~. This exception does not apply where the Commission has approved a community solar program for showing compliance as specified in Title 24, Part 1, Section 10-115, or where a load-serving entity provides a program where PV generation is compensated through virtual energy bill credits for occupants of nonresidential and hotel/motel tenant spaces to receive energy bill benefits from netting of energy generation and consumption.

TABLE 170.2-U – PV CAPACITY FACTORS (W/ft² of conditioned floor area)

Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
	Climate Zone															
Events & Exhibits	3.48	4.28	3.66	4.32	3.77	4.05	4.28	4.83	4.63	4.80	5.04	4.44	4.95	4.36	5.48	3.38
Library	0.39	3.23	2.59	3.25	2.48	2.74	3.04	3.49	3.32	3.69	3.79	3.32	3.79	3.37	4.49	2.84
Hotel/Motel	1.69	1.90	1.66	1.97	1.69	1.87	1.94	2.22	2.09	2.20	2.30	2.05	2.30	2.02	2.72	1.73
Office, Financial Institution, Unleased Tenant Space, Medical Office Building/Clinic	2.59	3.13	2.59	3.13	2.59	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.80	2.59
Restaurants	8.55	9.32	8.16	9.65	8.21	8.73	9.11	10.18	9.75	10.28	10.85	9.73	10.69	9.73	12.25	8.47
Retail, Grocery	3.14	3.49	3.01	3.61	3.05	3.27	3.45	3.83	3.65	3.81	4.09	3.64	3.99	3.71	4.60	3.21
School	1.27	1.63	1.27	1.63	1.27	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	2.46	1.27
Warehouse	0.39	0.44	0.39	0.44	0.39	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.58	0.39
Religious Worship	4.25	4.65	3.49	4.52	3.72	4.29	4.64	5.89	5.30	5.67	5.89	4.99	5.78	4.63	7.57	3.90
Sports & Recreation	2.47	1.97	1.54	2.03	1.60	1.84	1.98	2.63	2.47	2.60	2.75	2.20	2.72	2.15	4.03	1.81
Multifamily > 3 stories	1.82	2.21	1.82	2.21	1.82	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.77	1.82

~~*Table 170.2-U – PV Capacity Factors*~~

~~**Building Type**~~	~~**Factor A – Minimum PV Capacity (W/ft² of conditioned floor area) Climate Zones 1, 3, 5, 16**~~	~~**Factor A – Minimum PV Capacity (W/ft² of conditioned floor area) Climate Zones 2, 4, 6-14**~~	~~**Factor A – Minimum PV Capacity (W/ft² of conditioned floor area) Climate Zone 15**~~
~~**Climate Zone**~~	~~**1, 3, 5, 16**~~	~~**2, 4, 6-14**~~	~~**15**~~
~~Grocery~~	~~2.62~~	~~2.91~~	~~3.53~~
~~High-Rise Multifamily~~	~~1.82~~	~~2.21~~	~~2.77~~
~~Office, Financial Institutions, Unleased Tenant Space~~	~~2.59~~	~~3.13~~	~~3.80~~
~~Retail~~	~~2.62~~	~~2.91~~	~~3.53~~
~~School~~	~~1.27~~	~~1.63~~	~~2.46~~
~~Warehouse~~	~~0.39~~	~~0.44~~	~~0.58~~
~~Auditorium, Convention Center, Hotel/Motel, Library, Medical Office Building/Clinic, Restaurant, Theater~~	~~0.39~~	~~0.44~~	~~0.58~~

(h) Battery Energy ~~s~~Storage S~~s~~ystem (BESS) requirements— **More Than Three Habitable Stories.** All buildings that are required by Section 170.2(g) to have a PV system shall also have a ~~battery storage system~~BESS meeting the minimum qualification requirements of Reference Joint Appendix JA12. The rated energy capacity shall be not less than the Minimum Rated Useable Energy Capacity determined by Equation 170.2-E, or by Equation 170.2-F if SARA was used to determine the PV capacity in Section 170.2-D. and the rated power capacity shall be not less than the Minimum Power Capacity determined by Equation 170.2-G. ~~The rated energy capacity and the rated power capacity shall be not less than the~~

~~values determined by Equation 170.2-E and Equation 170.2-F. Where the building includes more than one of the space types listed in Table 170.2-V, the total battery system capacity for the building shall be determined by applying Equations 170.2-E and 170.2-F to each of the listed space types and summing the capacities determined for each space type and equation.~~ In mixed occupancy buildings, the total battery system capacity for the building shall be determined by applying the Minimum Rated Usable Energy Capacity to each of the listed building types and summing the capacities determined for each.

EQUATION 170.2-E - BATTERY ENERGY STORAGE SYSTEM RATED ENERGY CAPACITY

~~$kWh_{batt} = kW_{PVdc} \times B / D^{0.5}$~~ $kWh_{batt} = ((CFA \times B)/(1000 \times C^{0.5}))$

EQUATION 170.2-F - BATTERY ENERGY STORAGE SYSTEM RATED ENERGY CAPACITY, SARA-ADJUSTED

$kWh_{batt} = ((CFA \times B)/(1000 \times C^{0.5})) \times (kW_{PVdc,SARA}/kW_{PVdc})$

WHERE:

kWh_{batt} ~~kWh_{batt}~~ = Minimum Rated U~~u~~seable E~~e~~nergy C~~c~~apacity of the ~~battery storage system~~ ESS in kWh.

kW_{PVdc} = Minimum Rated PV System Capacity in kW from Equation 170.2-D

$kW_{PVdc, SARA}$ = Minimum Rated PV System Capacity in kW from the SARA calculation.

CFA = Conditioned floor area that is subject to the PV system requirements of Section 170.2(g) in square feet

~~PV system capacity required by Section 170.2(g) in kWdc.~~

B = ~~Battery energy Energy Storage~~BESS C~~c~~apacity F~~f~~actor in Wh/square foot as specified in Table 170.2-V for the building type.

~~kW_{PVdc} = PV system capacity required by Section 170.2(g) in kWdc~~

~~D~~C = Rated single charge-discharge cycle AC to AC (round-trip) efficiency of the ~~battery storage system~~ BESS.

EQUATION 170.2-G~~F~~ - BATTERY ENERGY STORAGE SYSTEM RATED POWER CAPACITY

$kW_{batt} = kWh_{batt}$ ~~, min~~ $/ 4$ ~~$kW_{PVdc} \times C$~~

WHERE:

kW_{batt} = Minimum Rated Power Capacity of the ~~battery storage system~~ BESS in kWdc

kWh_{batt} = Minimum Rated Useable Energy Capacity of the ~~battery storage system~~ BESS in kWh

~~kW_{PVdc} = PV system capacity required by Section 170.2(g) in kWdc~~

~~C = Battery power capacity factor specified in Table 170.2-V for the building type~~

EXCEPTION 1 to Section 170.2(h). No ~~battery storage system~~ BESS is required if the installed PV system size is less than 15 percent of the size determined by Equation 170.2-D.

EXCEPTION 2 to Section 170.2(h). No ~~battery storage system~~ BESS is required in buildings with ~~battery storage system~~ BESS requirements with less than 10 kWh rated capacity.

TABLE 170.2-V – BESS CAPACITY FACTORS (Wh/ft² of conditioned floor area)

	Climate Zone															
Building Type	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Events & Exhibits	1.82	1.95	1.74	2.12	1.91	2.13	2.24	2.30	2.36	2.47	2.62	2.16	2.64	2.68	3.22	1.89
Library	0.37	7.17	5.97	6.75	5.64	6.08	6.19	7.13	7.18	7.56	7.17	6.93	6.88	6.81	7.93	6.40
Hotel/Motel	0.86	0.84	0.77	0.92	0.81	0.89	0.90	1.01	1.00	1.11	1.14	0.96	1.18	1.18	1.49	0.85
Office, Financial Institution, Unleased Tenant Space, Medical Office Building/Clinic	NR	5.26	4.35	5.26	4.35	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	6.39	4.35
Restaurants	4.36	4.11	3.78	4.37	3.89	4.02	4.11	4.49	4.47	4.82	5.05	4.43	5.05	5.24	6.23	4.11
Retail, Grocery	1.89	1.82	1.71	1.82	1.72	1.80	1.76	1.92	1.97	2.05	2.22	1.95	2.16	2.29	2.66	1.91
School	NR	3.05	2.38	3.05	2.38	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	4.60	2.38
Warehouse	NR	0.41	0.37	0.41	0.37	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.54	0.37
Religious Worship	2.21	2.25	1.74	2.42	2.08	2.75	2.94	3.37	3.17	3.37	3.58	2.72	3.62	3.21	4.89	2.37
Sports & Recreation	1.26	0.98	0.76	1.14	0.86	1.20	1.23	1.57	1.53	1.65	1.83	1.27	1.86	1.57	3.02	1.13
Multifamily > 3 stories	1.88	2.27	1.88	2.27	1.88	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.85	1.88

~~*Table 170.2-V – Battery Storage Capacity Factors*~~

:	~~**Factor B – Energy Capacity**~~	~~**Factor C – Power Capacity**~~
~~**Storage-to-PV Ratio**~~	~~**Wh/W**~~	~~**W/W**~~
~~Grocery~~	~~1.03~~	~~0.26~~
~~High-Rise Multifamily~~	~~1.03~~	~~0.26~~
~~Office, Financial Institutions, Unleased Tenant Space~~	~~1.68~~	~~0.42~~
~~Retail~~	~~1.03~~	~~0.26~~
~~School~~	~~1.87~~	~~0.46~~
~~Warehouse~~	~~0.93~~	~~0.23~~
~~Auditorium, Convention Center, Hotel/Motel, Library, Medical Office Building/Clinic, Restaurant, Theater~~	~~0.93~~	~~0.23~~

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, and 25943, Public Resources Code.

6.2 Reference Appendices

There are no proposed changes to the Reference Appendices

6.3 Compliance Manuals

Additional building types will be added to the Compliance Manuals and any capacities that have changed for building types already in the manual will be updated.

6.4 ACM Reference Manuals

5.10 Onsite Energy Generation and Storage

5.10.1 Onsite Photovoltaic Energy Generation

PV RATED CAPACITY

Applicability: All buildings that have onsite photovoltaic energy generation.

Definition: The rated DC capacity of the system in kilowatts.

Units: kW.

Input Restrictions: Non-negative value.

Standard Design: ~~Requirement in 2022 Title 24 Part 6, Table 140.10(a), where required PV capacity is specified for each space function.~~ The mapping of space function to building type is documented in Appendix ~~C~~5.4A.[5] The PV capacity is calculated as:

$$\mathrm{kW_{PVdc}} = \frac{\sum_{1}^{n} \mathrm{CFA_i} * \mathrm{A_i}}{1000}$$

Where:

$\mathrm{kW_{PVdc}}$ = Capacity of the building's PV system in kW

$\mathrm{CFA_i}$ = Conditioned floor area in square feet of the i^th space

$\mathrm{A_i}$ = PV capacity factor for the i^th space's space function given the mapping of space function to building type from Appendix 5.4A and the building type PV requirement from Table 140.10-A in the Standard.

5.10.2 Battery Storage

BATTERY ENERGY STORAGE CAPACITY

Applicability: All buildings that have onsite battery storage.

Definition: The storage capacity of all onsite battery storage, in kWh.

Units: kWh.

Input Restrictions: Positive number.

Standard Design: ~~The battery storage matches requirements in 2022 Title 24, Part 6 Section 140.10(b), where required storage capacity is specified for individual space functions.~~ The mapping of space function to building type is documented in Appendix ~~C~~5.4A. The battery storage capacity is calculated as:

$$\mathrm{kWh}_{batt} = \frac{\sum_{1}^{n} \mathrm{CFA_i} * B_{\mathrm{i}}}{1000 * \sqrt{\mathrm{C}}}$$

[5] Appendix 5.4A is a spreadsheet that is provided with compliance software that provides information used in the software to account for allocation of data parameters to space types. This includes mapping of building types for PV and battery for buildings that contain more than one building type.

Where:

kWh_{batt} = Capacity of the building's battery storage system in kWh

CFA_i = Conditioned floor area in square feet of the i^{th} space

B_i = Battery Energy Capacity Factor for the i^{th} space's space function given the mapping of space function to building type from Appendix 5.4A and the building type battery requirement from Table 140.10-B in the Standard.

C = Rated single charge-discharge cycle AC to AC (round-trip) efficiency of the battery storage system

BATTERY CHARGING/DISCHARGING RATES (POWER) CAPACITY

Applicability: All buildings that have onsite battery storage.

Definition: This is the rate at which a battery can store energy from electricity supplied to it or provide energy for systems it feeds. Typical batteries have rated power storage for 2 to 4 hours of discharge capacity.

Units: kW.

Input Restrictions: Positive number.

Standard Design: ~~The battery storage charge and discharge rates (power) match requirements in 2022 Title 24, Part 6 Section 140.10(b), where required battery capacity is determined by individual space function.~~ The capacity is calculated using EQUATION 140.10-C.

6.5 Compliance Forms

The prescriptive certificates of compliance (NRCC and LMCC-SAB) ruleset will be modified to include new building types and apply updated PV and battery capacity factors. The plans examiner will need to verify that the proposed building type in the NRCC/LMCC matches the designed building type in the plan set. The performance certificate of compliance (NRCC and LMCC-PRF) ruleset will need to be modified to adjust the baseline system type as needed. The layout of both the prescriptive and performance certificates of compliance will not need modification. The certificates of installation (NRCI and LMCI-MCH) will not need modification to the ruleset or the layout. There will be no HERS or acceptance testing required as a part of this proposal, so no changes will be made to the certificates of acceptance (NRCA) or verification (NRCV & LMCV).

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APPENDICES

Appendix A: Statewide Savings Methodology

Estimated statewide energy savings for the first year that the Energy Code goes into effect (2026) is determined by multiplying the proposed measure's per unit savings by the statewide construction forecasts provided in this appendix.

The CEC has provided residential and nonresidential newly constructed building forecasts for 2026, broken out by building type and forecast climate zones (FCZ). This data is converted from FCZ to building climate zones (BCZ) using the conversion factors shown in Table 22. The CEC provided prototypes for all forecasted building types except for Controlled Environmental Horticulture, Grocery, Refrigerated Warehouse, Vehicle Service, Manufacturing and Miscellaneous. The Enclosed Parking Garage is included in the high-rise multifamily prototypes. Mid-Rise Mixed-Use accounts for 58 percent and High-Rise Mixed-Use accounts for 5 percent of the multifamily dwelling units in Table 23. These percentages are developed by the CEC, derived from CoStar Realty data. Table 24 provides more complete definitions of the building types used in the nonresidential construction forecast.

Table 25 shows the nonresidential newly constructed floor area forecast for 2026.

Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Large Office	0	0	3.234	1.578	0	1.422	0.825	2.288	4.152	0.3916	0.1088	0.5747	0	0.2002	0.01303	0.04995
Medium Office	0.1302	0.4761	1.372	0.7442	0.3705	1.201	0.8046	1.646	3.184	1.174	0.2685	2.799	0.5859	0.3482	0.2629	0.102
Small Office	0.01306	0.4369	0.1869	0.02019	0.06423	0.1481	0.2339	0.1594	0.36	0.4167	0.0933	0.5443	0.3852	0.04404	0.1051	0.03313
Large Retail	0	0	1.097	0.5497	0.1491	0.6978	0.3746	0.8316	1.664	0.6327	0.2997	1.303	0.3564	0.1442	0.1803	0.05547
Medium Retail	0.08421	0.348	0.7947	0.4459	0.08574	0.6027	0.2856	0.8641	1.424	0.8224	0.142	0.6274	0.379	0.18	0.1242	0.08122
Strip Mall	0.001146	0.1543	0.504	0.2256	0.007439	0.5629	0.4878	0.9855	1.065	1.345	0.07164	0.5928	0.3253	0.3206	0.1001	0.0602
Large School	0.006476	0.1273	0.8761	0.4418	0.03636	0.5941	0.6084	0.9052	1.421	0.8535	0.3545	1.152	0.6149	0.1661	0.08573	0.0681
Small School	0.0665	0.2698	0.4566	0.2294	0.1395	0.3155	0.2944	0.3516	0.6581	0.3481	0.09881	0.7763	0.3025	0.107	0.03728	0.04489
Non-refrigerated Warehouse	0.06177	0.3672	2.16	1.118	0.1776	1.363	0.7108	1.948	3.01	1.36	0.6315	2.844	0.8203	0.3618	0.3673	0.1381
Hotel	0.03627	0.2154	1.033	0.5306	0.1095	0.5527	0.4822	0.7835	1.183	0.5716	0.1534	0.8029	0.2557	0.1375	0.1248	0.04395
Assembly	0.01028	0.3935	1.583	0.5574	0.05869	0.7868	0.7991	1.431	1.824	1.144	0.1669	1.414	0.3043	0.2453	0.118	0.08429
Hospital	0.02939	0.1746	0.8416	0.4358	0.07972	0.3285	0.549	0.4412	0.7894	0.8128	0.1459	0.8253	0.2729	0.1417	0.115	0.04813
Laboratory	0.000819	0.0531	0.6313	0.3632	0.02078	0.07327	0.05265	0.1017	0.1214	0.06227	0.008372	0.04996	0.009723	0.01063	0.006101	0.003518
Restaurant	0.0139	0.08256	0.3269	0.1667	0.03403	0.3365	0.2036	0.4933	0.8189	0.4129	0.07099	0.3135	0.1414	0.1015	0.04739	0.0296
Enclosed Parking Garage	0.000176	0.009137	1.83	1.245	0.004558	2.585	0.7059	2.265	1.527	0.05053	0.001585	0.04116	0.002972	0.0152	0.003691	0.007247
Open Parking Garage	0.002272	0.1182	2.474	1.682	0.05894	3.648	1.201	3.197	2.155	0.6535	0.0205	0.5323	0.03843	0.1965	0.04773	0.09372

Table 22: FCZ to BCZ Conversion Factors

Forecast zones (FCZ) along X-axis, building climate zones (BCZ) along Y-axis

Climate Zone	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	17.90%	0.00%	13.51%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2	0.00%	0.00%	80.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3	0.00%	52.43%	6.28%	0.00%	3.64%	0.00%	52.26%	0.00%	0.00%	0.00%	0.00%
4	0.00%	30.39%	0.00%	0.00%	0.00%	0.00%	15.39%	0.00%	0.00%	0.00%	0.00%
5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	32.33%	0.00%	0.18%	0.00%	0.00%
6	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	18.89%	61.19%	0.00%	0.00%
7	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	43.99%	0.00%	0.00%	0.00%
9	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	32.29%	37.22%	0.00%	0.00%
10	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	71.19%
11	0.42%	0.00%	0.00%	84.77%	22.07%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
12	0.00%	17.18%	0.00%	0.00%	72.61%	4.55%	0.00%	0.00%	0.00%	0.00%	0.00%
13	0.00%	0.00%	0.00%	0.00%	0.00%	94.81%	0.00%	0.00%	0.00%	78.49%	0.00%
14	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.51%	0.00%	12.10%	24.17%
15	3.18%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%
16	78.50%	0.00%	0.01%	15.23%	1.68%	0.64%	0.00%	0.33%	1.41%	9.41%	4.55%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Table 22 (continued)

Climate Zone	11	12	13	14	15	16	17	18	19	20
1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2	0.00%	0.00%	0.00%	0.00%	0.19%	0.00%	0.00%	0.00%	0.00%	0.00%
3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6	0.00%	6.60%	0.00%	0.00%	0.00%	17.18%	0.00%	0.00%	0.00%	0.00%
7	0.00%	62.81%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8	0.00%	1.94%	0.00%	0.00%	0.00%	27.90%	0.00%	0.00%	0.00%	0.00%
9	0.00%	0.00%	0.00%	0.00%	0.00%	54.92%	99.35%	100.00%	0.00%	0.00%
10	86.11%	27.88%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11	0.00%	0.00%	0.42%	0.00%	44.55%	0.00%	0.00%	0.00%	0.00%	0.00%
12	0.00%	0.00%	99.58%	100.00%	52.65%	0.00%	0.00%	0.00%	0.00%	0.00%
13	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
14	0.00%	0.66%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%
15	13.33%	0.12%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	99.98%	0.00%
16	0.56%	0.00%	0.00%	0.00%	2.61%	0.00%	0.65%	0.00%	0.00%	100.00%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Table 23: Statewide Residential Newly Constructed Buildings (2026)

Climate Zone	Single-Family Units	Multifamily Units
1	359	144
2	1,861	1,391
3	3,035	7,699
4	2,689	3,417
5	616	285
6	1,719	2,243
7	1,869	5,156
8	4,163	8,600
9	4,286	10,302
10	7,950	4,306
11	5,840	1,173
12	14,542	5,537
13	7,257	1,009
14	3,739	1,446
15	3,160	373
16	1,937	187
Total	**65,022**	**53,268**

Table 24: Statewide Nonresidential Newly Constructed Building Types

Forecast Building Types	Uses	Number of Stories	Floor Area (sf)
Assembly	Gatherings including, but not limited to: Arenas, Coliseums, Auditoriums, Transportation Terminals, Clubs and Lodges, Exhibition Halls, Funeral or Internment Facilities, Religious Buildings, Libraries, Museums, Theaters, Recreational and Exercise Facilities.	Any	Any
Controlled-environment Horticulture	Buildings with indoor conditioned spaces used for agriculture.	Any	Any
Hospital	Hospitals, Clinics, and Nursing Convalescent Facilities	Any	Any
Hotel	Hotels and Motels	Any	Any
Laboratory	Laboratories	Any	Any
Large Office	Offices, Banks and Financial Institutions, Government Services Buildings, Post Offices	≥ 5	Any
Medium Office	Offices, Banks and Financial Institutions, Government Services Buildings, Post Offices	2 - 4	Any
Small Office	Offices, Banks and Financial Institutions, Government Services Buildings, Post Offices	1	Any
Restaurant	Food and/or Beverage Service	Any	Any
Large Retail	Stores and Other Mercantile Buildings	Any	≥ 50k
Medium Retail	Stores and Other Mercantile Buildings	Any	< 50k

Forecast Building Types	Uses	Number of Stories	Floor Area (sf)
Grocery	Stores and Other Mercantile Buildings used for the sale of food items	Any	Any
Strip Mall Retail	Shopping Centers	Any	Any
Large School	Schools and Educational Facilities	Any	≥ 50k
Small School	Schools and Educational Facilities	Any	< 50k
Warehouse	Warehouses and Freight Terminals	Any	Any
Refrigerated Warehouse	Refrigerated Warehouses	Any	Any
Vehicle Service	Auto, Aircraft, Bus, Truck, Railroad, Boat, or any other Vehicle Servicing Facility	Any	Any
Manufacturing	Manufacturing Facilities	Any	Any
Enclosed Parking Garage	Parking Garages enclosed by walls and a roof with rooftop parking.	Any	Any
Open Parking Garage	Parking Garages that are open to the ambient environment. Parking lots with canopies are not considered Parking Garages.	Any	Any
Miscellaneous	Miscellaneous Non-Residential Buildings.	Any	Any

Table 25: Statewide Nonresidential Newly Constructed Building Activity (2026 in Million ft²)

Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Large Office	0	0	3.234	1.578	0	1.422	0.825	2.288	4.152	0.3916	0.1088	0.5747	0	0.2002	0.01303	0.04995
Medium Office	0.1302	0.4761	1.372	0.7442	0.3705	1.201	0.8046	1.646	3.184	1.174	0.2685	2.799	0.5859	0.3482	0.2629	0.102
Small Office	0.01306	0.4369	0.1869	0.02019	0.06423	0.1481	0.2339	0.1594	0.36	0.4167	0.0933	0.5443	0.3852	0.04404	0.1051	0.03313
Large Retail	0	0	1.097	0.5497	0.1491	0.6978	0.3746	0.8316	1.664	0.6327	0.2997	1.303	0.3564	0.1442	0.1803	0.05547
Medium Retail	0.08421	0.348	0.7947	0.4459	0.08574	0.6027	0.2856	0.8641	1.424	0.8224	0.142	0.6274	0.379	0.18	0.1242	0.08122
Strip Mall	0.001146	0.1543	0.504	0.2256	0.007439	0.5629	0.4878	0.9855	1.065	1.345	0.07164	0.5928	0.3253	0.3206	0.1001	0.0602
Large School	0.006476	0.1273	0.8761	0.4418	0.03636	0.5941	0.6084	0.9052	1.421	0.8535	0.3545	1.152	0.6149	0.1661	0.08573	0.0681
Small School	0.0665	0.2698	0.4566	0.2294	0.1395	0.3155	0.2944	0.3516	0.6581	0.3481	0.09881	0.7763	0.3025	0.107	0.03728	0.04489
Non-refrigerated Warehouse	0.06177	0.3672	2.16	1.118	0.1776	1.363	0.7108	1.948	3.01	1.36	0.6315	2.844	0.8203	0.3618	0.3673	0.1381
Hotel	0.03627	0.2154	1.033	0.5306	0.1095	0.5527	0.4822	0.7835	1.183	0.5716	0.1534	0.8029	0.2557	0.1375	0.1248	0.04395
Assembly	0.01028	0.3935	1.583	0.5574	0.05869	0.7868	0.7991	1.431	1.824	1.144	0.1669	1.414	0.3043	0.2453	0.118	0.08429
Hospital	0.02939	0.1746	0.8416	0.4358	0.07972	0.3285	0.549	0.4412	0.7894	0.8128	0.1459	0.8253	0.2729	0.1417	0.115	0.04813
Laboratory	0.000819	0.0531	0.6313	0.3632	0.02078	0.07327	0.05265	0.1017	0.1214	0.06227	0.008372	0.04996	0.009723	0.01063	0.006101	0.003518
Restaurant	0.0139	0.08256	0.3269	0.1667	0.03403	0.3365	0.2036	0.4933	0.8189	0.4129	0.07099	0.3135	0.1414	0.1015	0.04739	0.0296
Enclosed Parking Garage	0.000176	0.009137	1.83	1.245	0.004558	2.585	0.7059	2.265	1.527	0.05053	0.001585	0.04116	0.002972	0.0152	0.003691	0.007247
Open Parking Garage	0.002272	0.1182	2.474	1.682	0.05894	3.648	1.201	3.197	2.155	0.6535	0.0205	0.5323	0.03843	0.1965	0.04773	0.09372

Source: CEC

Appendix B: Environmental Impact Analysis

Greenhouse Gas Emissions Impacts Methodology

GHG emissions are calculated assuming the latest applicable hourly GHG Emissions factors published by the CEC and used by the CEC's reference code compliance software (CBECC-Res and CBECC).

Water Use and Water Quality Impacts Methodology

There are no direct water savings from this measure at buildings. The measure will result in water savings at natural gas power plants that use water for energy production.

Potential Significant Environmental Effect of Proposal

The CEC is the lead agency under the California Environmental Quality Act (CEQA) for the 2025 Energy Code and must evaluate any potential significant environmental effects resulting from the proposed Energy Code. A "significant effect on the environment" is "a substantial adverse change in the physical conditions which exist in the area affected by the proposed project." (Cal. Code Regs., tit. 14, § 15002(g).)

Direct Environmental Impacts

Direct Environmental Benefits

There are several environmental benefits from the requirements for PV and battery storage systems. First, onsite generation reduces reliance on fossil fuels and the dependence on combustion power plants for energy production during times of peak demand. Combustion power plants generate high rates of pollution and are sometimes located near disadvantaged communities (PSE 2020). Onsite PV generation with energy storage avoids the inefficiencies of meeting building load through combustion powerplants and transmission and distribution systems.

Nonresidential battery storage systems enable building load shifting during peak load periods that occur in the late afternoon to early evening. They enable PV generation exports to the grid to occur during utility peak generation periods instead of during off-peak periods when the demand for energy is lower and utility scale renewable energy is readily available. Also, stored energy that is not exported to the grid can be available for use by the building when PV generation is low or zero (such as at nighttime). In the future, energy storage will cost less to operate than the combustion power plants, allowing for retirement of the plants (Filatoff 2021).

Onsite generation also aligns with the state's long-term goals for decarbonization. The requirements for onsite PV generation also can mitigate wintertime electricity use for space heating.

Direct Adverse Environmental Impacts

PV systems require significant amounts of glass, metal, and silicon for production. The increase in material requirements due to this proposal occurs simultaneously with major increases in utility-scale PV systems in the state and throughout the country. The marginal incremental increase is not expected to have a significant environmental impact.

The other potential environmental impact is the end-of-life treatment of the used PV panels. The life cycle of the systems are typically 30 years. Previously, the materials were classified as hazardous waste and required special handling, with limitations on material transport. However, California passed a law in 2021 (California Code of Regulations, Title 20, Section 66273.7.1) to reclassify used solar PV panels as universal waste. This change has made it easier to store, transport and recycle used PV panels.

Up to 80% of the material in PV panels can be recycled. However, separating materials can be difficult. Some manufacturers, such as First Solar, have established recycling programs.

Nonresidential battery systems consist of lithium, cobalt, and nickel, and some require small amounts of manganese. Most of the cobalt in batteries can be reused; manufacturers are developing new batteries with a lithium-ion phosphate cathode that does not require cobalt.

While the measure results in a slight increase in the use of lithium, the effect is not significant in the context of societal lithium consumption. The sharp increase and projected continued rate of increase in demand for electric vehicles drives the lithium market.

Indirect Environmental Impacts

Indirect Environmental Benefits

The indirect environmental benefit, which minimizes the effects of material use, is the ability to recycle and reuse nonresidential PV system and battery storage system materials. PV and battery recycling facilities have developed the ability to recycle, refine, and manufacture battery materials from expended batteries. For example, Redwood Materials has developed broad capabilities to recycle materials, and to remanufacture anode and cathode battery components. The steadily increasing demand for electric vehicle batteries is a strong driving force for recycling companies.

Indirect Adverse Environmental Impacts

Battery systems must be located properly and have safeguard measures such as temperature monitoring for fire protection.

Mitigation Measures

No mitigation measures are required, because it has been determined that the measure has no significant environmental impacts.

Appendix C: CBECC Software Specification

The inputs, rules, and reports that are needed for this measure already exist in CBECC. Currently Appendix 5.4A maps space functions to the building types in Section 140.10(b) of the Standard. The area of each space function multiplied by the PV and battery requirement for the corresponding building type determines the Standard Design's PV and battery capacities. This procedure currently provides PV and battery capacity factors for all building types and will only be updated to include new building types where the proposal establishes PV and battery storage requirements for the first time.

Appendix D: Selection of Utilized Battery Capacity

Batteries were sized for 10% exports as discussed in section 4.1. However, analysis of real-world data showed that batteries may only utilize 40 percent of their total capacity (Verdant 2023). This real-world reduction in utilized capacity could be from oversized batteries, undersized PV systems, or user preference, for example maintaining a battery reserve for power outage events, or to minimize the impact on battery life of discharging to zero percent or charging to 100 percent. Whatever the cause, there is evidence that the full capacity of batteries is not utilized.

In addition, degradation over the useful life of batteries reduces their capacity. A major manufacturer of home batteries warranties their capacity to be at least 70 percent of the initial capacity after 10 years from their installation date (Tesla Corporation 2024), with some sources documenting 60 to 70 percent as typical (EnergySage 2024) (CNET 2024) (Solar.com 2024).

To understand the effect of utilizing less than the full capacity, an analysis of the cost-effectiveness for different utilization capacities was performed. The results showed that decreasing battery capacity utilization down to 40 percent of the full capacity lowered the BCRs below 1.0 for only a couple of prototypes in a handful of climate zones. This result was unexpected, so the phenomenon was investigated to understand the cause.

Table 26 shows that the building's utilization of the stored battery energy (building self-utilization) does not drop drastically as utilized battery capacity is decreased. This explains why the effect of decreasing a battery's utilized capacity does not change its cost-effectiveness- drastically. With a mild effect on building self-utilization, the effect on energy savings benefits is also mild. But the cause for this less-than-expected effect still required further investigation.

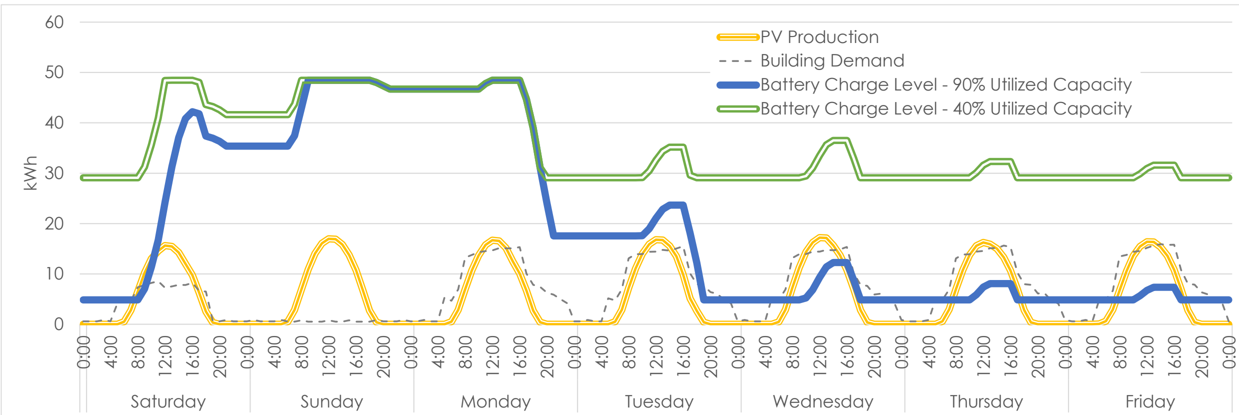
Table 26: Effect of Battery Utilized Capacity

Battery Utilized Capacity	Building Self-Utilization of PV and Battery Energy
100%	90.0%
90%	89.3%
80%	88.5%
70%	87.6%
60%	86.7%
50%	85.8%
40%	84.8%

Error! Reference source not found. shows a sample week of PV production, battery storage, and building electricity demands. These demands are the building's needs for electricity due to all modeled electricity loads. PV production occurs periodically throughout the week, peaking at mid-day. When the PV production is above the dashed line of building demand, the PV charges the battery, and the battery charge level increases. When the battery is within the 4 – 9 pm utility time-of-use period, the battery discharges to help meet the on-peak building demand and the battery charge level decreases. The 40 percent battery utilized capacity case goes down to 60 percent capacity, and the 90 percent case goes down to 10 percent capacity.

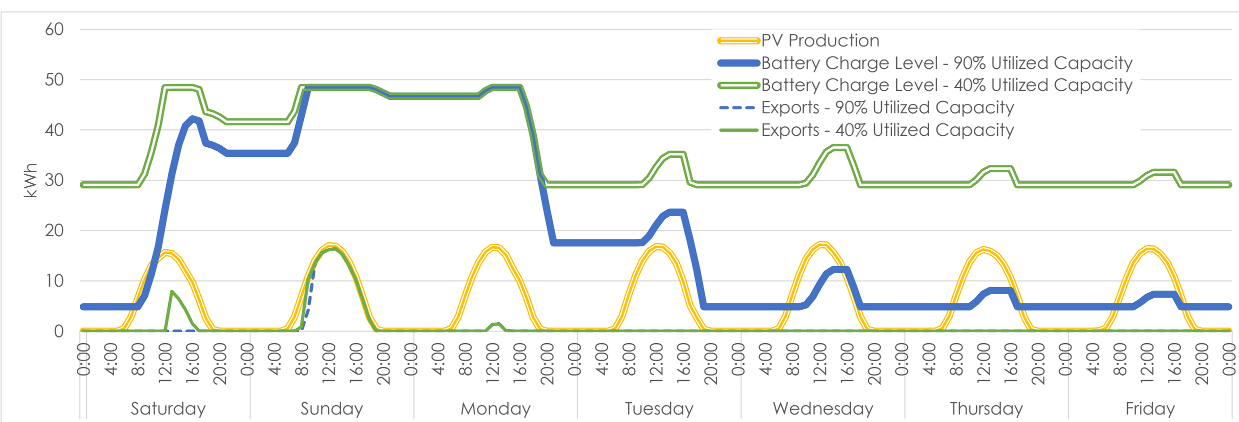
On weekdays there are a few bumps up in battery charge level, but the bulk of battery charging occurs on the weekend when building demands are low. The flattening of the battery charge levels during these weekend times represent times when the PV production surpasses both the building demand and the maximum battery capacity, 48 kWh in the example. Since PV production continues, the excess PV production is exported to the utility grid. This occurs during weekend periods when avoided cost compensation is at the lowest marginal cost value.

Figure 2: Sample Week PV Production and Battery Charge Level



Error! Reference source not found. shows the same week, but with the magnitude of exports for the two battery charge level cases included. This shows that the exports are very similar between the two cases. On Monday through Friday, because there are no exports, they track exactly and therefore lie on top of each other in the figure. On the weekend, the 40 percent case does export while the 90 percent case does not, but the exports are different only for a few hours on Saturday and for an hour on Sunday with very low marginal cost compensation values.

Figure 3: Sample Week PV Production and Exports



The net effect is that exports, as a percentage of total PV production, changed very little between the 90 percent and 40 percent cases. Any energy that is not exported is utilized by the building. So, the change in building self-utilization is equal to the change in exports. This explains the small change in building self-utilization energy in Table 26. This small change in building self-utilization occurring on the weekend, when avoided cost compensation is low, explains why cost-effectiveness was not dramatically different between the two cases. Building self-utilization did not change much; therefore, cost-effectiveness did not change enough to lower BCRs below the 1.0 threshold for proving cost--effectiveness.

Although batteries were sized to mitigate the negative impact of exports on the grid, given the evidence from real world installations, manufacturer degradation warranties, and the low impact on cost-effectiveness of decreasing utilized battery capacity, a utilized capacity of 40 percent was selected as a conservative approach to evaluate cost-effectiveness.