DOCKETED	
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Project Title:	2028 Energy Code Pre-Rulemaking.
TN #:	270994
Document Title:	Presentations - June 23, 2026 (Day 1) - 2028 Energy Code Staff Pre-Rulemaking Workshop
Description:	Presentations from the June 23, 2026, 2028 Energy Code staff pre-rulemaking workshop.
Filer:	Michael Shewmaker
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	6/25/2026 10:46:36 AM
Docketed Date:	6/25/2026

2028 Energy Code, Pre-Rulemaking

Presenter: Payam Bozorgchami P.E., Building Standards Branch

Date: June 23, 2026

Housekeeping Rules

Public Comments

Zoom App/Online

- Click “raise hand”

Telephone

- Press *9 to raise hand
- Press *6 to Mute/Unmute

When called upon

- CEC will open your line
- Unmute on your end
- Spell name and state affiliation, if any
- 2 minutes or less per speaker, 1 speaker per entity

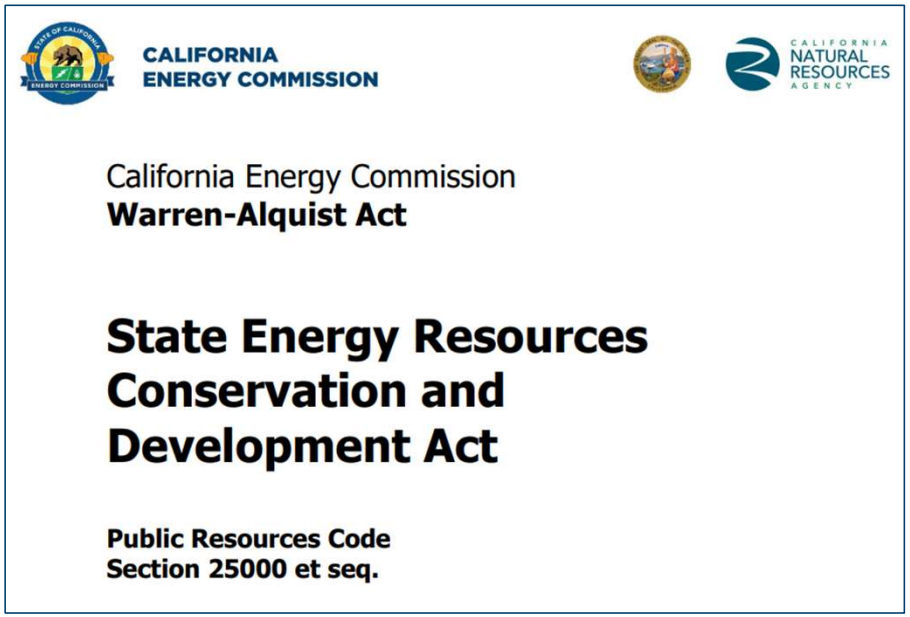
Agenda for Today's Workshop

	Topics	Presenter
1	Introduction & 2028 Overview	Payam Bozorgchami
2	Construction Forecast	Payam Bozorgchami; NORESCO
4	Updates to Solar (PV) and Battery Energy Storage Systems (BESS)	Muhammad Saeed; NORESCO
5	Nonresidential Existing Building Performance Foundations	Hab Tewelde; NORESCO
6	Nonresidential AC to Heat Pump (5 to 20 tons)	Hab Tewelde; NORESCO
7	Adjourn	- - - -

California Energy Commission's Authority & Process

Public Resources Code (PRC 25402): Reduction of wasteful, uneconomic, inefficient, or unnecessary consumption of energy

- Warren Alquist Act Signed into law in 1974
- Mandates updates to Building Efficiency Standards and requires the building departments to enforce them through the permit process



Assembly Bill 130 (2025)

Limits updates to building standards affecting residential units before 2031 code cycle (effective date no sooner than Jan 1, 2032)

- All 2028 Energy Code updates will exclude buildings of Group R Occupancy including its common or public use areas
  - Residential Group R is defined Part 2 of Title 24
- Residential energy metrics will remain unchanged until 2031 Energy Code, including compliance metrics and weather files
- September 2025, CA Building Standards Commission Information Bulletin 25-03:
  - https://www.dgs.ca.gov/BSC/News/Page-Content/Building-Standards-Commission-News-List-Folder/IB-25-03-AB-130

Proposed Definition for Group R Occupancies

Will provided exceptions through the Energy Code

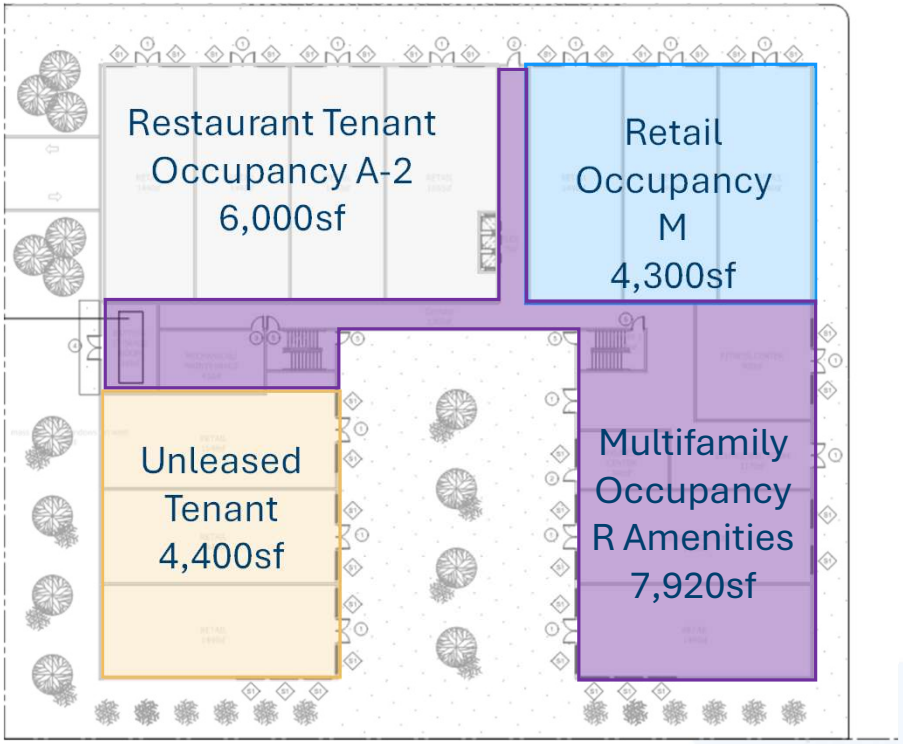
- **GROUP R OCCUPANCIES** residential Group R and common and public use areas as defined in Chapter 2 of the CBC, serving residential units, and structures accessory to residential units designated and constructed in accordance with the CRC, are also subject to Assembly Bill 130-2025.

Proposed Definition for Group R Occupancies

Our understanding of Multifamily Occupancy in a Mixed Occupancy Building.

R-Occupancy
(2025 Energy Code Stringency)

- 1st floor Amenities (A-2 lobby, R-2 corridors and stairs to multifamily occupancy, B leasing office). 2-5 floors supporting dwelling units and circulation to those dwelling units

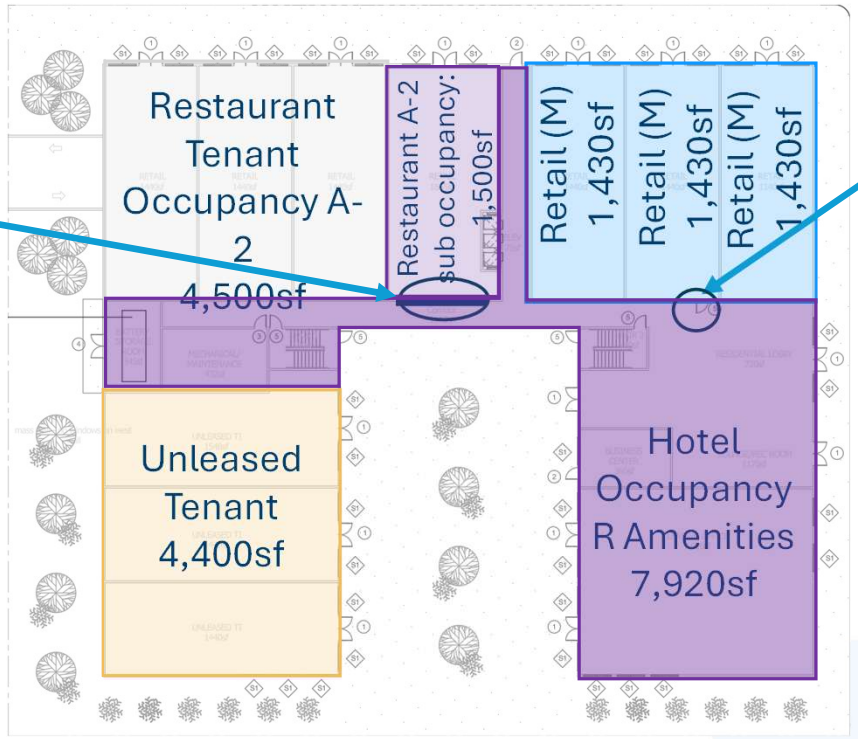


All of the non-R Occupancies that are not a sub occupancy nor share common areas with the R Occupancy *and will be subject to 2028 stringency.*

Proposed Definition for Group R Occupancies

Our understanding of Hotel/Motel in a Mixed Occupancy Building.

There is access to the restaurant from the hotel as sub-occupancy



One of the non-R Occupancies that is not a sub occupancy to the R Occupancy has access to common area of the R occupancy via a fire rated door *and will be subject to 2028 stringency.*

2028 Energy Code Drivers and Themes

State Goals

- Contribute to the state's GHG reduction goals
- Increase building energy efficiency cost-effectively

2028 Energy Code Areas of Interest – Nonresidential Buildings

- Continue to encourage efficient building decarbonization where possible
- Promote demand flexibility
- Covered process loads
- Existing buildings
- Compliance improvements

2025 Restructured Standards

To Be The New Structure for the 2028 Energy Code

Restructured 2025 Energy Code – California Code of Regulations – Title 24, Part 6 (For Information Only)

FIND IT: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Organized by Building System

Chapter	Section	Subsect.	Title
1	100.0-100.2	(a)(b)(c) 1.2.3. A.B.C. i.ii.iii a.b.c.	**General Provisions** All building types
2	110.0-110.12		**Mandatory** All building types
3	120.0-120.10		**Mandatory** Nonresidential, Covered Process
4	130.0-130.5		**Mandatory Lighting & Electrical** Nonresidential, Covered Process
5	140.0-140.10		**Prescriptive and Performance** Nonresidential, Covered Process
6	141.0-141.1		**Additions, Alterations and Repairs** Nonresidential, Covered Process
7	150.0		**Mandatory** Single-family
8	150.1		**Prescriptive and Performance** Single-family
9	150.2		**Additions, Alterations and Repairs** Single-family
10	160.0-160.9		**Mandatory** Multifamily
11	170.0-170.2		**Prescriptive and Performance** Multifamily
12	180.0-180.4		**Additions, Alterations and Repairs** Multifamily

CURRENT 2025 STRUCTURE

Chapter	Section	Subsect.	Title
1	100-102	1.2.3... 1.2.3... 1.2.3... 1.2.3... 1.2.3...	**General Provisions** All building types
2	200		**Definitions** All building types
3	300-303		**Envelope** All building types, Nonresidential, Single-family, Multifamily
4	400-403		**HVAC and Ventilation** All building types, Nonresidential, Single-family, Multifamily
5	500-503		**Plumbing** All building types, Nonresidential, Single-family, Multifamily
6	600-603		**Electrical and Lighting** All building types, Nonresidential, Single-family, Multifamily
7	700-703		**Renewables and Storage** All building types, Nonresidential, Single-family, Multifamily
8	800-803		**Pool and Spa** All building types, Nonresidential, Single-family, Multifamily
9	900-911		**Process Systems and Equipment** Covered Process
10	1000-10001		**Design Review and Commissioning** Nonresidential

NEW 2028 STRUCTURE

Restructured Energy Code

- In response to industry feedback, we published the 2025 Restructured Code
  - Better aligns the Energy Code with other Parts of Title 24
  - Improves usability and navigation
  - Will be used as the basis for the 2028 Energy Code

Current Code Format

(a) **Roof deck, ceiling and rafter roof insulation.** The opaque portions of roof decks separating attic spaces from ambient air, and ceilings or rafter roofs separating conditioned spaces from unconditioned spaces or ambient air, shall meet the requirements of Items 1 through 4 below:

1. In Climate Zones 4 and 8 through 16, roof decks in newly constructed attics that are above conditioned space shall be insulated to achieve an area-weighted average U-factor not exceeding U-0.184.

Exception 1 to Section 150.0(a)1:

i. The space-conditioning system air handler and ducts are located entirely in conditioned space below the ceiling separating the occupiable space from the attic; or

ii. The space-conditioning system air handler is located in unconditioned space and has 12 linear feet or less of supply duct, including the length of the air handler and the plenum, located in unconditioned space, with all other portions of the supply ducts located in conditioned space below the ceiling separating the occupiable space from the attic; or

iii. The space-conditioning system is a ductless system.

Exception 2 to Section 150.0(a)1: Space-conditioning duct systems buried within insulation in an attic that complies using Section 150.1(b) and is verified according to RA 3.1.4.1.

Restructured Code Format

302.2 *[Section 150.0]* **Mandatory requirements (Newly Constructed, Additions, Alterations).**

302.2.1 *[Section 150.0(a)]* **Roof deck, ceiling and rafter roof insulation.**

The opaque portions of *roof* decks separating *attic* spaces from ambient air, and ceilings or rafter *roofs* separating *conditioned spaces* from *unconditioned spaces* or ambient air, shall meet the requirements below:

302.2.1.1 *[Section 150.0(a)1]* **Attics above conditioned space.**

In *Climate Zones* 4 and 8 through 16, *roof* decks in newly constructed *attics* that are above *conditioned space* shall be insulated to achieve an area-weighted average *U-factor* not exceeding U-0.184.

Exception 1 to Section 302.2.1.1: The *space-conditioning system* air handler and ducts are located entirely in *conditioned space* below the ceiling separating the *occupiable space* from the *attic*; or

The *space-conditioning system* air handler is located in *unconditioned space* and has 12 linear feet or less of supply duct, including the length of the air handler and the plenum, located in *unconditioned space*, with all other portions of the supply ducts located in *conditioned space* below the ceiling separating the *occupiable space* from the *attic*; or

The *space-conditioning system* is a ductless system.

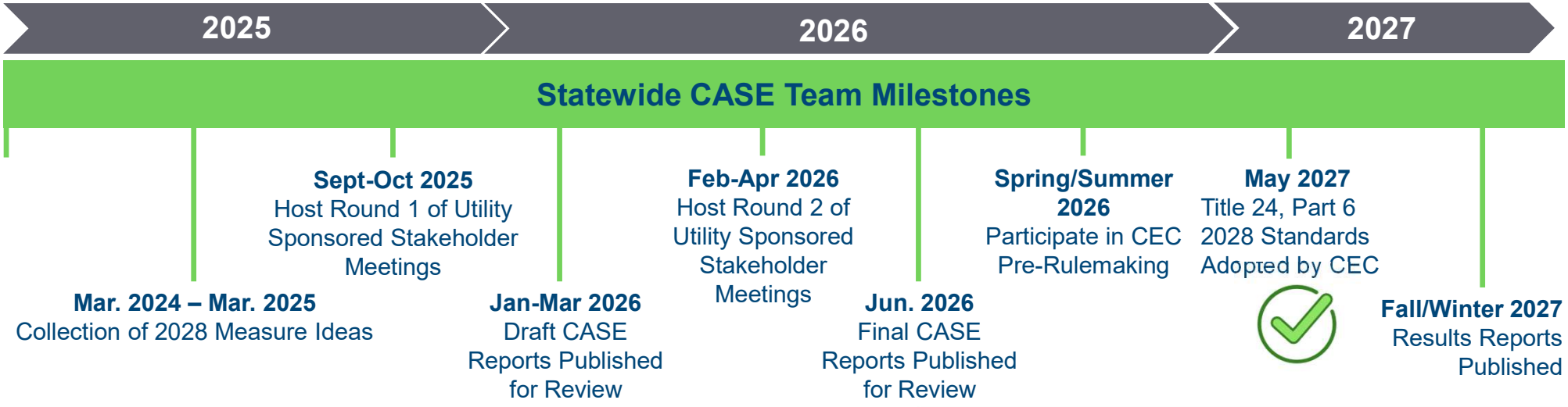
Exception 2 to Section 302.2.1.1: Space-conditioning *duct systems* buried within insulation in an *attic* that complies using Sections 102.5.2 and 102.5.5 *[Section 150.1(b)]* and is verified according to RA 3.1.4.1.

IOU CASE team and Consultants

Thank You!!

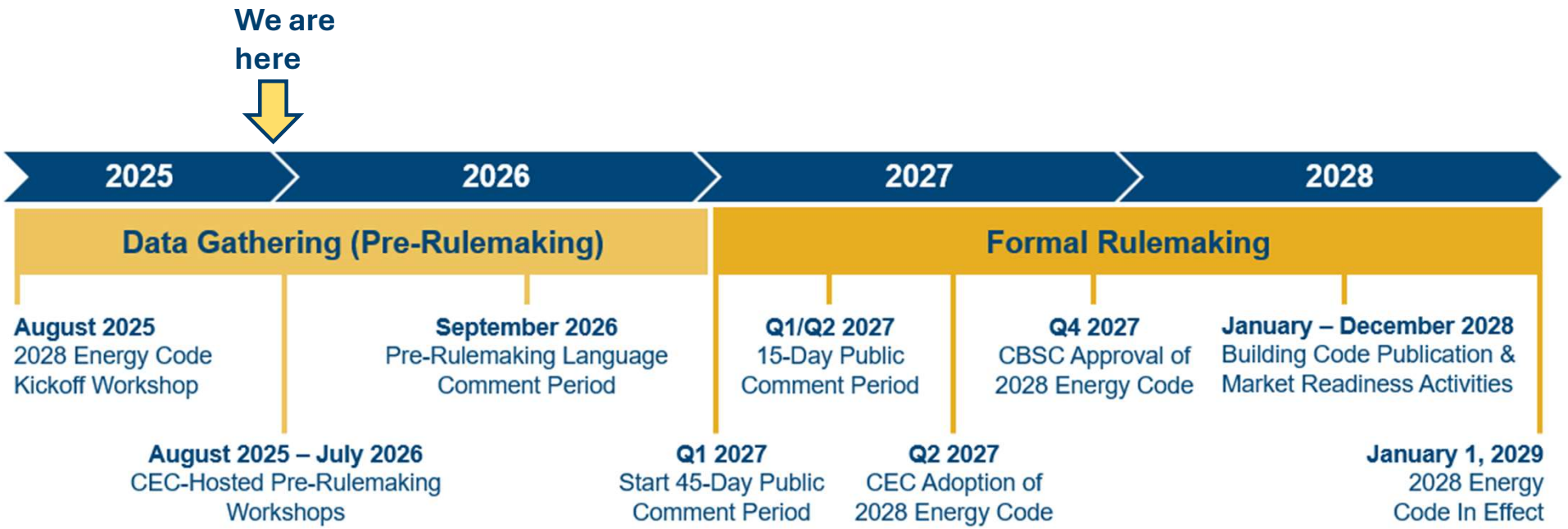
Overview Schedule for the 2028 California Energy Code

IOU CASE Team Schedule



Overview Schedule for the 2028 California Energy Code

2028 Energy Code



Comments for Today's workshop

Due Date: July 17, 2026, by 5:00 PM

Comments to be submitted to:

- https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=25-BSTD-03

- Thank you for participating!

- Contact Information: Payam.Bozorgchami@energy.ca.gov

Nonresidential Construction Forecast

Fatemeh Yousefi, NORESCO

June 23, 2026

Content

- Purpose of the Construction Forecast
- Data Sources
- Overview of the Development Process
- Methodology and Processing Steps
- Results and Key Insights

Purpose

- Construction forecast estimates the floor area of the existing and future building stock at the building type and climate zone level

- The construction forecast is used to scale prototype level results to statewide results

$$Statewide\ Savings = Prototype\ Savings\ per\ Floor\ Area \times Forecasted\ Construction\ Floor\ Area$$

- It is used during measure evaluations and cost-effectiveness analyses for the 2028 Energy Code

Data Sources

- 2025 forecast from Energy Assessments Division (EAD)
- 2025 Dodge building datasets
  - New construction starts data (CAS)
  - New construction completions data (CASC)
  - Building stock data (BSD)
  - Data Center data
- 2025 Department of General Services (DGS) state-owned building dataset
- 2022 University of California (UC)-owned building dataset
- 2020 United States (US) Census Bureau

Office of the President

Key Terms

- **Broad Building Types (12):**
  General building classification aligned with EAD/BSD

- **Detailed Building Types (24):**
  More granular classifications, generally aligned with Energy Code building prototypes

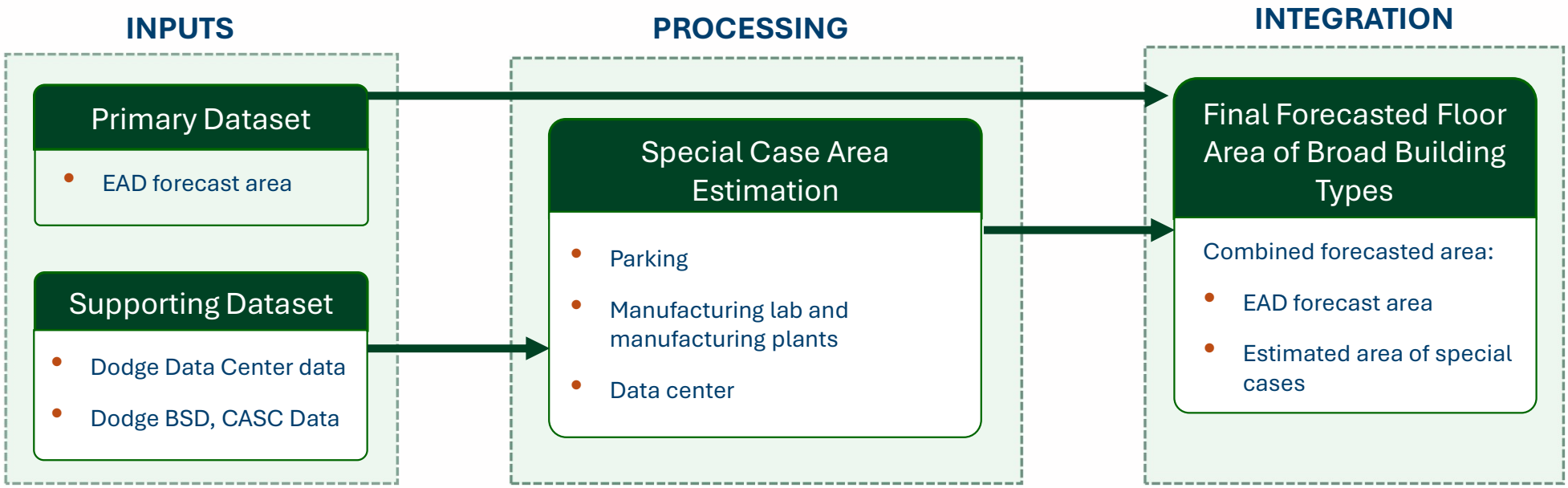
Broad Building Types (EAD/BSD)	Detailed Building Types
Office	Small Office
	Medium Office
	Large Office
Retail	Strip Mall
	Medium Retail
	Large Retail
	Grocery
School	K-8 School
	High School
	Large School
Hotel	Hotel
Hospital	Hospital
Restaurant	Restaurant
Refrigerate Warehouse	Assembly
	Vehicle Service
	CEH
Warehouse	Non-Refrigerated Warehouse
	Refrigerated Warehouse
Manufacturing Labs	Laboratory
Manufacturing Plants	Manufacturing
Parking	Enclosed Parking
	Open Parking
	Data Center
Miscellaneous	Miscellaneous

Overview of the Process

Two sets of floor area estimates for all 16 climate zones: Existing Buildings and New Construction

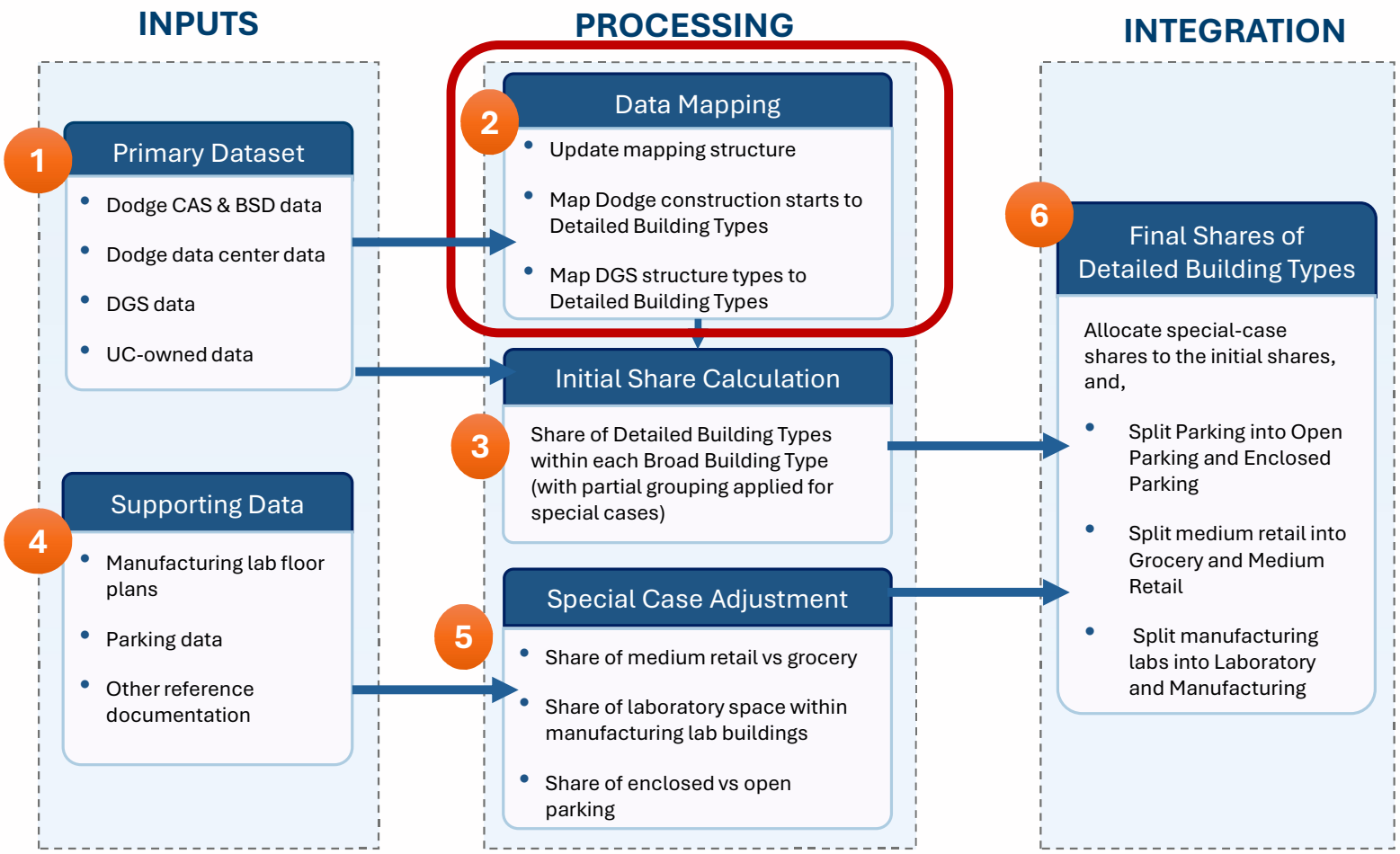
Process Steps

Construction Forecast for Broad Building Types



Process Steps

Broad-to-Detailed Building Type Shares



Major Updates from 2025 to 2028

Recent Data

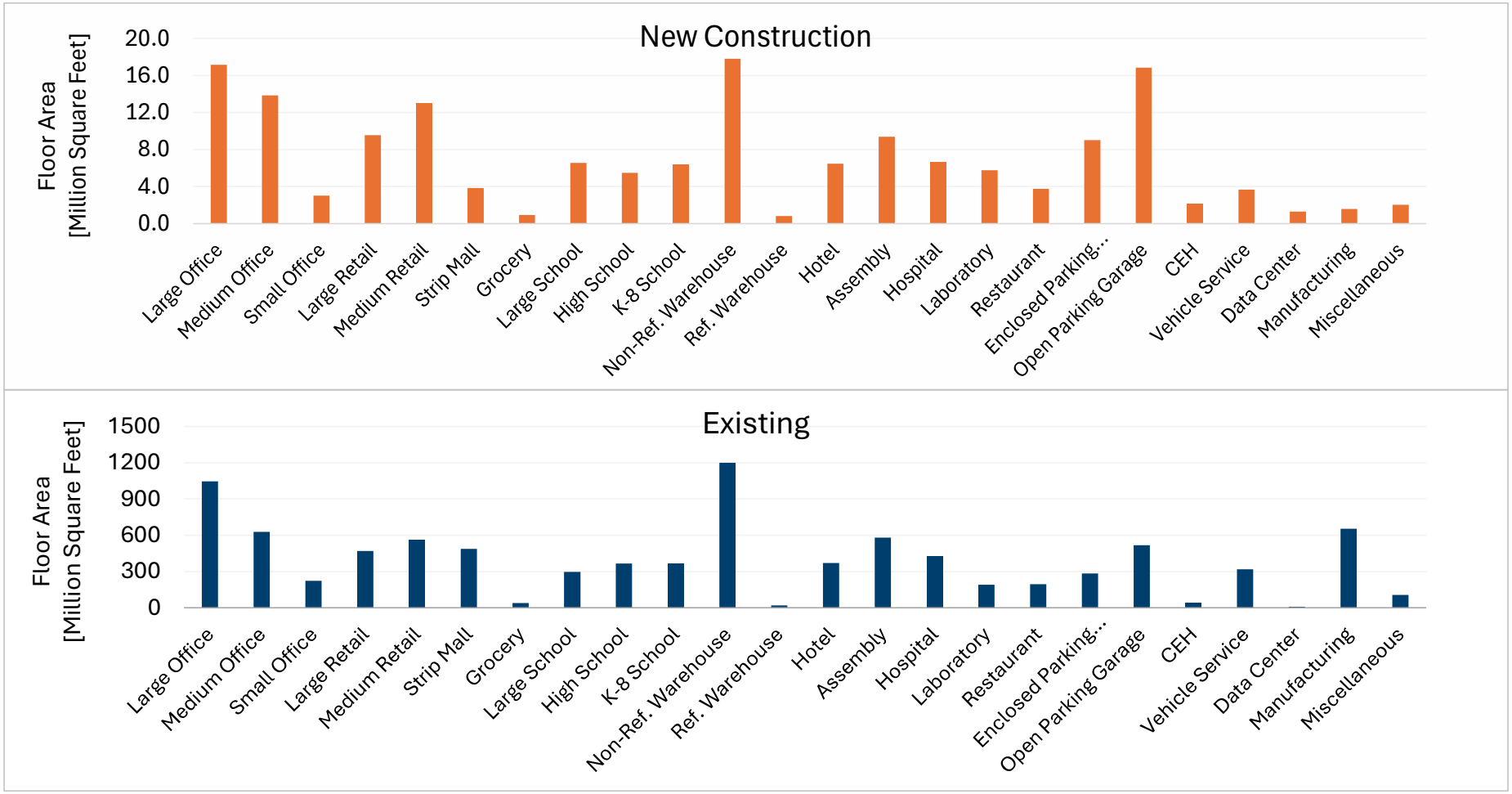
Updated Mapping

Some of the mapping updates

Schools	Dodge: Colleges/community colleges =Large Schools; primary schools and junior high schools = K–8 Schools; senior high, vocational, and special-needs schools = High school. State owned: educational buildings with facilities under CSU or UC = Large Schools; other = High school.
Warehouses	Refrigerated and non-refrigerated warehouse records were remapped; Dodge Mfg War records reclassified.
EAD Alignment	Libraries, museums, laboratories, and special schools moved from “school” to “miscellaneous”.
Miscellaneous	Dodge Animal/Fish/Plant records before 1997 included under Miscellaneous Detailed Building Type.
Laboratory	33% of Dodge BSD “Mfg Labs” floor area added to the Laboratory Detailed Building Type.

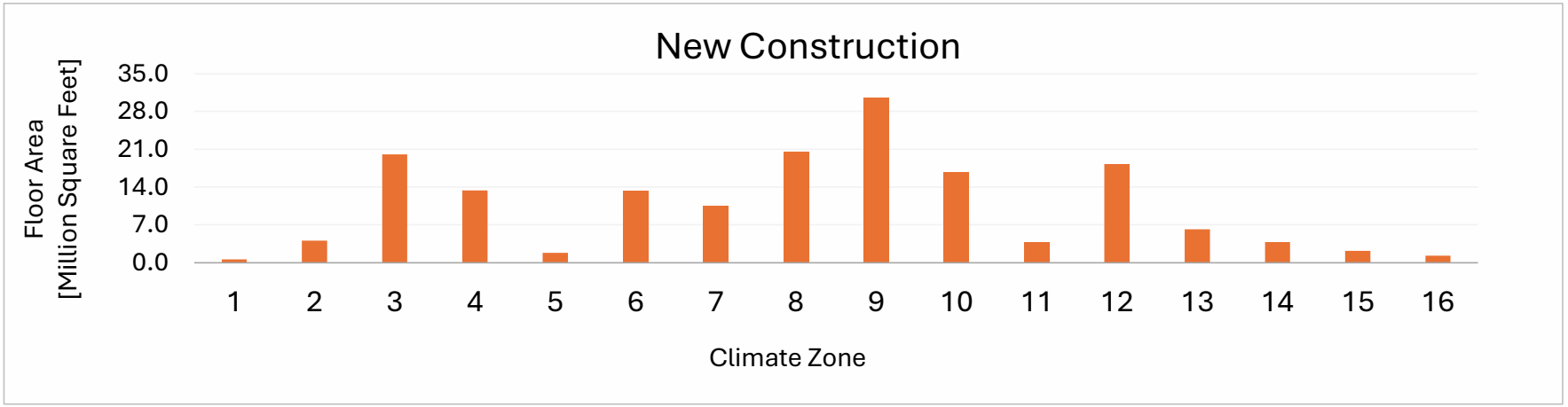
Results

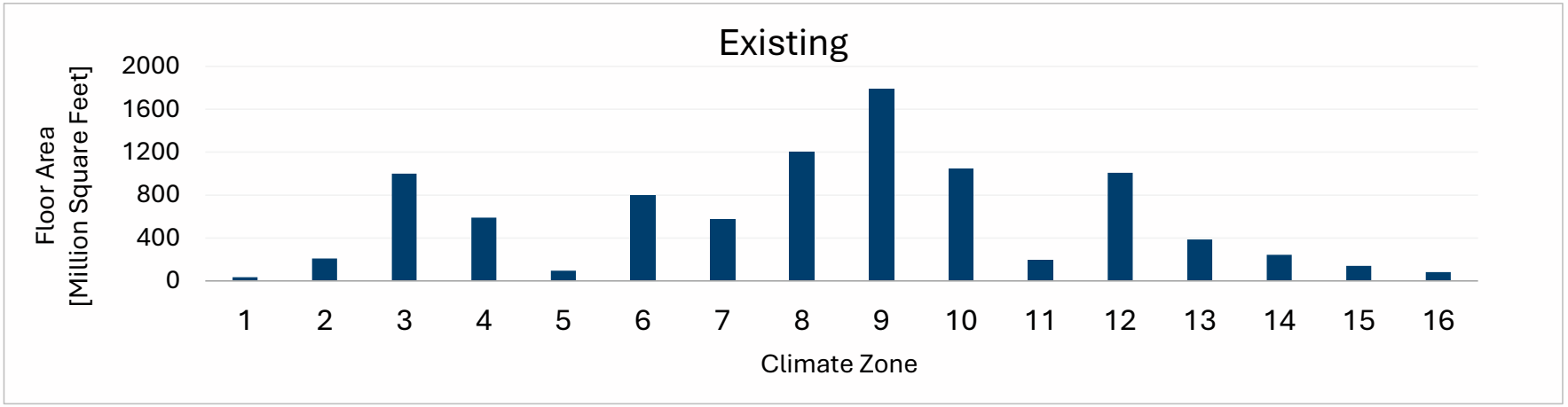
Total Building Stock Distribution by Detailed Building Type



Results

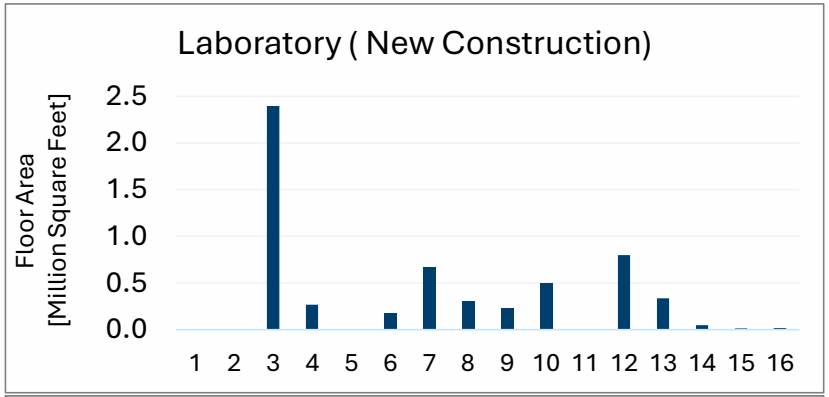
Total Building Stock Distribution by Climate Zone

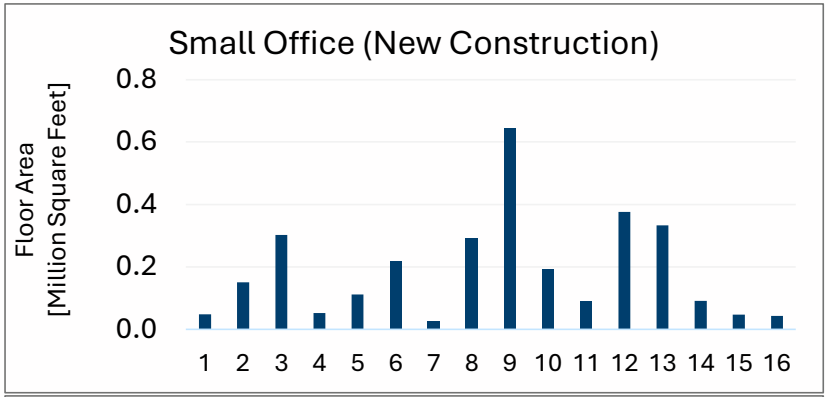


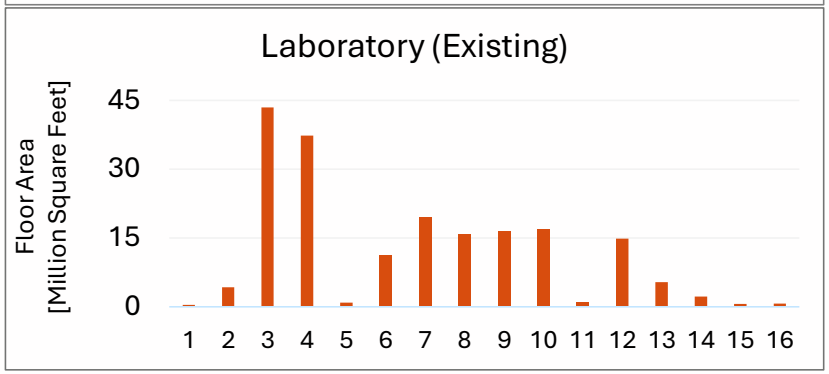


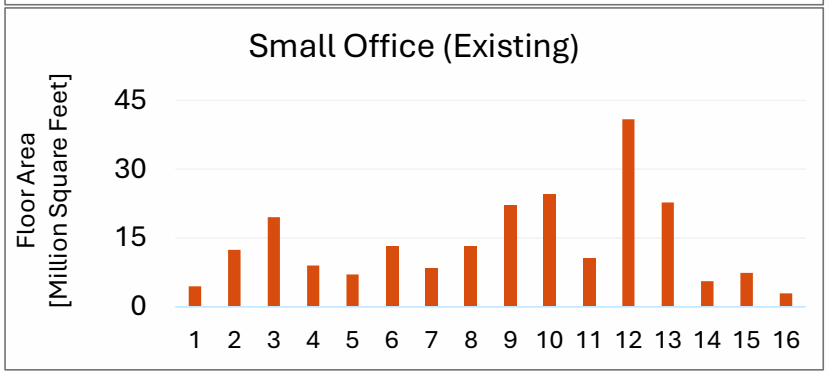
Results

New-construction trends may differ from trends in existing buildings at the climate-zone level.









Results

% Distribution of 2028 Nonresidential New Construction Floor Area

Office, Retail, Warehouse, and School represent over 55% of nonresidential new construction floor area.

	Climate Zone																
Detailed Building Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Total**
Large Office	0.0%	0.0%	1.6%	0.8%	0.0%	0.8%	0.6%	1.2%	2.8%	0.4%	0.0%	1.9%	0.0%	0.1%	0.0%	0.0%	10.3%
Medium Office	0.1%	0.4%	0.8%	0.6%	0.2%	0.9%	0.5%	1.2%	1.5%	0.9%	0.2%	0.2%	0.3%	0.2%	0.2%	0.1%	8.3%
Small Office	0.0%	0.1%	0.2%	0.0%	0.1%	0.1%	0.0%	0.2%	0.4%	0.1%	0.1%	0.2%	0.2%	0.1%	0.0%	0.0%	1.8%
Large Retail	0.0%	0.0%	1.1%	0.2%	0.0%	0.5%	0.6%	0.7%	1.1%	0.6%	0.2%	0.5%	0.0%	0.0%	0.1%	0.0%	5.7%
Medium Retail	0.1%	0.3%	0.5%	0.4%	0.1%	0.4%	0.3%	0.6%	1.2%	1.2%	0.1%	1.3%	0.7%	0.3%	0.2%	0.1%	7.8%
Strip Mall	0.0%	0.0%	0.1%	0.2%	0.1%	0.3%	0.0%	0.5%	0.4%	0.4%	0.0%	0.1%	0.0%	0.2%	0.0%	0.0%	2.3%
Large School	0.0%	0.1%	0.7%	0.3%	0.1%	0.4%	0.3%	0.6%	0.7%	0.2%	0.1%	0.2%	0.1%	0.1%	0.0%	0.0%	3.9%
High School	0.0%	0.1%	0.4%	0.3%	0.1%	0.2%	0.2%	0.2%	0.5%	0.3%	0.1%	0.4%	0.4%	0.1%	0.0%	0.0%	3.3%
K-8 School	0.0%	0.1%	0.3%	0.1%	0.0%	0.2%	0.2%	0.3%	0.7%	0.5%	0.2%	0.8%	0.2%	0.1%	0.1%	0.1%	3.8%
Non-refrigerated Warehouse	0.0%	0.3%	1.2%	0.6%	0.1%	0.9%	0.4%	1.2%	1.8%	1.3%	0.3%	1.5%	0.5%	0.3%	0.2%	0.1%	10.7%
Hotel	0.0%	0.1%	0.5%	0.3%	0.1%	0.3%	0.3%	0.5%	0.7%	0.3%	0.1%	0.4%	0.1%	0.1%	0.1%	0.0%	3.9%
Assembly	0.1%	0.3%	0.3%	0.4%	0.0%	0.5%	0.3%	0.7%	1.3%	0.5%	0.1%	0.8%	0.2%	0.1%	0.1%	0.0%	5.6%
Hospital	0.0%	0.1%	0.6%	0.3%	0.1%	0.2%	0.3%	0.3%	0.6%	0.5%	0.1%	0.6%	0.2%	0.1%	0.1%	0.0%	4.0%
Laboratory	0.0%	0.0%	1.4%	0.2%	0.0%	0.1%	0.4%	0.2%	0.1%	0.3%	0.0%	0.5%	0.2%	0.0%	0.0%	0.0%	3.5%
Restaurant	0.0%	0.0%	0.2%	0.1%	0.0%	0.2%	0.1%	0.3%	0.5%	0.3%	0.0%	0.2%	0.1%	0.1%	0.0%	0.0%	2.2%
Enclosed Parking Garage	0.0%	0.0%	0.8%	0.9%	0.0%	0.5%	0.6%	1.2%	1.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.4%
Open Parking Garage	0.0%	0.3%	1.1%	1.2%	0.1%	0.8%	1.0%	1.6%	1.6%	0.9%	0.4%	0.6%	0.1%	0.2%	0.1%	0.1%	10.1%
Grocery	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.6%
Refrigerated Warehouse	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.5%
CEH	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	1.3%
Vehicle Service	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	0.0%	0.4%	0.3%	0.2%	0.2%	0.3%	0.1%	0.0%	0.0%	0.0%	2.2%
Data Center	0.0%	0.0%	0.1%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.8%
Manufacturing	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%	0.1%	0.1%	0.2%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.9%
Miscellaneous	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.3%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%
Total	0.4%	2.4%	12.0%	8.0%	1.1%	7.9%	6.3%	12.3%	18.3%	10.0%	2.2%	11.0%	3.7%	2.3%	1.3%	0.8%	100.0%

64%

Results

% Distribution of 2028 Nonresidential Existing Floor Area

Office, Retail, Warehouse, and School represent 55% of nonresidential existing floor area.

	Climate Zone																
Detailed Building Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Total**
Large Office	0.0%	0.0%	1.4%	0.7%	0.0%	1.1%	0.8%	1.8%	3.2%	0.7%	0.0%	0.9%	0.1%	0.2%	0.0%	0.0%	11.1%
Medium Office	0.0%	0.3%	0.8%	0.4%	0.1%	0.5%	0.5%	0.6%	0.9%	0.7%	0.2%	1.0%	0.3%	0.1%	0.1%	0.0%	6.7%
Small Office	0.0%	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.3%	0.1%	0.4%	0.2%	0.1%	0.1%	0.0%	2.4%
Large Retail	0.0%	0.1%	0.7%	0.3%	0.0%	0.4%	0.3%	0.5%	0.7%	0.6%	0.1%	0.7%	0.3%	0.1%	0.1%	0.0%	5.0%
Medium Retail	0.0%	0.1%	0.5%	0.3%	0.1%	0.5%	0.4%	0.8%	1.2%	0.8%	0.1%	0.7%	0.3%	0.2%	0.1%	0.1%	6.0%
Strip Mall	0.0%	0.1%	0.4%	0.2%	0.1%	0.5%	0.3%	0.6%	0.9%	0.8%	0.1%	0.5%	0.3%	0.2%	0.1%	0.1%	5.2%
Large School	0.0%	0.1%	0.6%	0.2%	0.1%	0.4%	0.2%	0.3%	0.5%	0.2%	0.0%	0.4%	0.1%	0.0%	0.0%	0.0%	3.1%
High School	0.0%	0.1%	0.3%	0.2%	0.0%	0.3%	0.2%	0.5%	0.7%	0.5%	0.1%	0.4%	0.3%	0.1%	0.1%	0.0%	3.9%
K-8 School	0.0%	0.1%	0.3%	0.2%	0.0%	0.2%	0.2%	0.4%	0.6%	0.6%	0.1%	0.5%	0.3%	0.1%	0.1%	0.0%	3.9%
Non-refrigerated Warehouse	0.0%	0.2%	1.1%	0.6%	0.1%	1.0%	0.5%	1.5%	2.2%	2.1%	0.4%	1.5%	0.6%	0.4%	0.3%	0.1%	12.8%
Hotel	0.0%	0.1%	0.5%	0.2%	0.1%	0.3%	0.4%	0.5%	0.7%	0.4%	0.1%	0.4%	0.1%	0.1%	0.1%	0.0%	3.9%
Assembly	0.0%	0.2%	0.7%	0.3%	0.1%	0.5%	0.3%	0.8%	1.1%	0.8%	0.2%	0.6%	0.3%	0.2%	0.1%	0.1%	6.2%
Hospital	0.0%	0.1%	0.5%	0.3%	0.1%	0.3%	0.3%	0.5%	0.8%	0.4%	0.1%	0.6%	0.3%	0.1%	0.1%	0.0%	4.5%
Laboratory	0.0%	0.0%	0.5%	0.4%	0.0%	0.1%	0.2%	0.2%	0.2%	0.2%	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	2.0%
Restaurant	0.0%	0.0%	0.2%	0.1%	0.0%	0.2%	0.1%	0.3%	0.4%	0.4%	0.0%	0.2%	0.1%	0.1%	0.0%	0.0%	2.1%
Enclosed Parking Garage	0.0%	0.0%	0.5%	0.3%	0.0%	0.3%	0.3%	0.7%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.0%
Open Parking Garage	0.0%	0.1%	0.6%	0.5%	0.0%	0.5%	0.4%	1.0%	1.2%	0.4%	0.1%	0.5%	0.1%	0.1%	0.0%	0.1%	5.5%
Grocery	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%
Refrigerated Warehouse	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.2%
CEH	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%
Vehicle Service	0.0%	0.1%	0.2%	0.1%	0.0%	0.3%	0.2%	0.4%	0.7%	0.5%	0.1%	0.4%	0.2%	0.1%	0.1%	0.0%	3.4%
Data Center	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Manufacturing	0.0%	0.2%	0.5%	0.7%	0.0%	0.7%	0.3%	1.2%	1.7%	0.5%	0.1%	0.5%	0.2%	0.2%	0.0%	0.1%	7.0%
Miscellaneous	0.0%	0.1%	0.1%	0.1%	0.0%	0.1%	0.0%	0.1%	0.2%	0.1%	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	1.1%
Total	0.4%	2.2%	10.6%	6.3%	1.0%	8.5%	6.1%	12.8%	19.1%	11.1%	2.1%	10.7%	4.1%	2.6%	1.5%	0.9%	100.0%

64%

Comments for Today's Workshop

Due Date: July 17, 2026, by 5:00PM

Comments to be submitted to:
https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=25-BSTD-03

Thank you for participating in today's workshop!

Questions?

Broad-to-Detail Building Type mapping

Broad Building Types (EAD/BSD)	Detailed Building Types
Office	Small Office, Medium Office, Large Office
Retail	Strip Mall, Medium Retail, Large Retail, Grocery
Restaurant	Restaurant
School	K-8 School, High School, Large School
Hotel	Hotel
Hospital	Hospital
Warehouse	Non-refrigerated Warehouse
Refrigerated Warehouse	Refrigerated Warehouse, (Non-Refrigerated Warehouse)
Manufacturing Labs and Manufacturing Plants	Manufacturing, Laboratory
Parking Garage	Enclosed Parking, Open Parking
Miscellaneous	Miscellaneous, Assembly, Vehicle Service, CEH, (Small Office), (Medium Office), (Large Office), (High School), (Laboratory), (Non-refrigerated Warehouse).

Here is the order for today's presentations:

1. Introduction & 2028 Overview
2. Overview of Compliance Forums
3. Compliance Forum Proposals:
   a. Clarification of Automatic Demand Response
   b. Alternative to Verification Weather
   c. Rater Photo Verification
   d. Revision to ATTCP Quality Assurance
   e. Sampling and Installation Certificate
4. Updates to ATTCP Program Requirements
5. Commissioning with Acceptance Test Technician (ATT)

2028 PV and BESS Update

Muhammad Saeed, PE (CEC) | Eric Shadd, PE (NORESCO)

History of PV and BESS Updates

Energy Code	Non-Residential PV+BESS Requirements Buildings Covered	Non-Residential PV+BESS Requirements Sizing Methodology
2019	None	None
2022	Grocery, Office, Financial institutions, unleased tenant space, retail, school, warehouse, Auditorium, Convention Center, Hotel/Motel, Library, Medical Office Building/Clinic, Restaurant, Theater	PV Sized to limit exports to 20% and paired BESS to limit exports to 10% of annual PV production
2025	Above mentioned + Events & Exhibits, Religious Worship, Sports & Recreation	

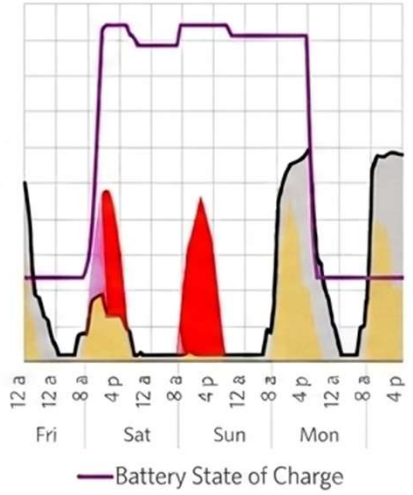
Purpose of 2028 PV and BESS Update

REVISED PROTOTYPES

CHANGES TO ENERGY ACCOUNTING

CHANGES TO PV AND BATTERY COST

SYSTEM SIZING APPROACH



Source: edited from AI images (Gemini, ChatGPT)

Standalone PV Sizing

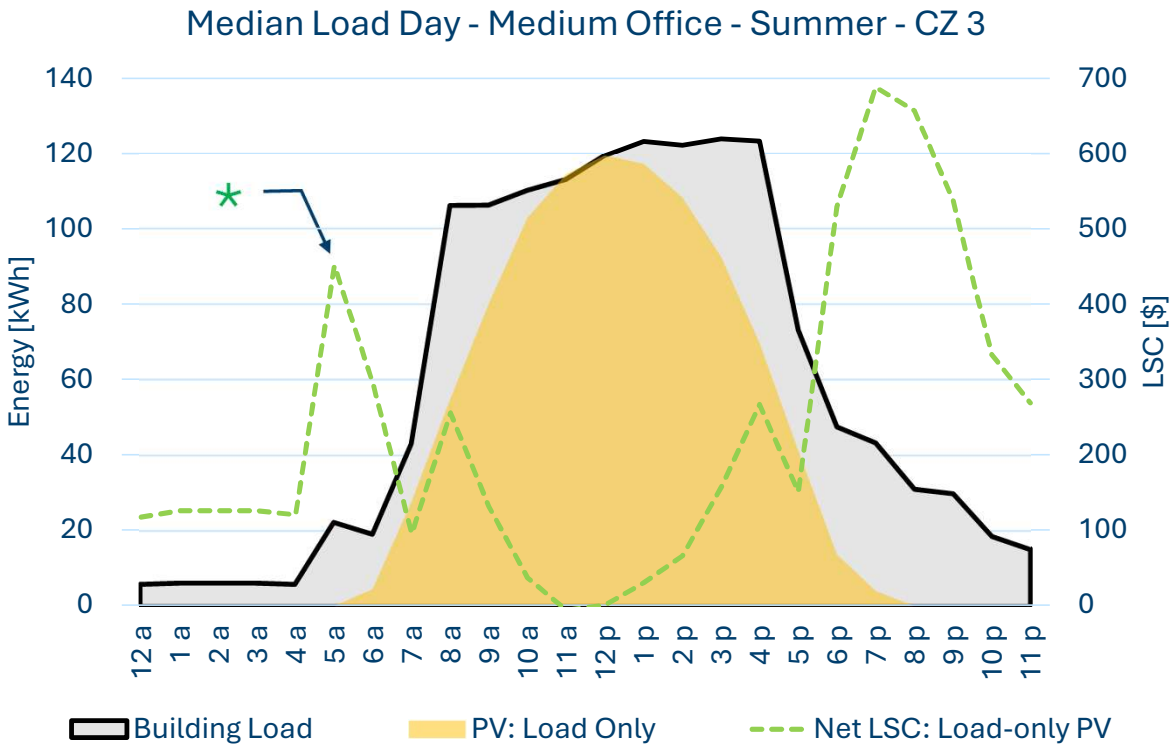
Overview of Comparison of approaches

Proposed (2028) vs. Current (2025)

	2022 & 2025	2028
PV Sizing	Target PV exports to 20% of annual generation	Sized for each season's median load day. Smallest selected.

2028 Proposed Standalone PV Sizing

*Size to the **Seasonal Median-Load-Day Minimum***



Median Load Day
- Day with median total energy use during daylight hours for the season

Fit PV
- Peak PV output matches building prototype load
- PV generation is 1 week average.

PV Size
- Select the smallest size of all the seasons

*NOTE: from 4 am to 5 am, loads quadruple, so even though it appears to be a slight bump, it quadruples the LSC at that hour.

Proposed 2028 Size & Comparison to 2025

Standalone PV [W/ft^2]

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Exhibits & Events	1.49	1.23	1.10	1.39	1.25	1.08	1.38	1.19	1.02	1.76	1.36	1.16	1.48	1.27	1.18	1.07
Library	1.77	1.98	1.91	1.97	1.79	1.93	2.16	2.75	2.35	1.92	1.87	2.21	2.18	2.08	2.25	1.96
Religious Worship	0.72	1.01	0.68	0.78	0.73	0.60	0.82	0.95	0.66	1.10	0.91	0.83	0.62	0.71	1.04	0.62
Sports & Recreation	1.23	1.20	1.10	1.44	0.99	1.67	1.39	1.05	1.73	1.42	1.22	1.15	1.52	0.94	1.21	1.41
Large Office	2.96	2.73	2.66	2.74	2.65	2.99	2.67	2.77	2.65	3.09	2.85	2.76	3.31	2.80	2.96	2.33
Medium Office	3.15	2.76	2.87	3.05	2.85	2.74	3.02	3.60	3.29	3.32	3.01	3.11	3.17	2.87	3.93	3.36
Small Office	4.00	3.22	3.38	3.86	3.56	3.38	3.37	3.70	3.36	3.95	3.57	3.61	3.96	3.47	4.05	4.34
Restaurant	4.60	4.74	5.06	5.55	4.24	4.78	5.68	5.48	5.70	5.72	5.23	4.94	5.11	5.62	6.32	5.70
Large Retail	1.79	1.93	2.05	1.94	1.73	2.06	1.91	2.17	2.07	2.24	2.47	2.03	2.40	2.21	2.70	2.11
Medium Retail	2.28	2.09	2.04	1.93	2.08	2.15	2.07	2.42	2.65	2.35	2.55	3.06	2.33	2.30	2.90	2.11
Strip Mall	3.95	3.58	3.35	3.81	3.75	3.90	3.36	3.70	3.99	4.67	3.79	3.72	3.76	4.29	4.02	4.12
High School	0.72	0.50	0.46	0.79	0.52	0.83	0.60	1.02	1.01	1.20	1.43	0.67	1.45	1.72	2.63	0.54
K - 8 School	0.12	0.46	0.50	0.58	0.50	0.42	0.51	1.02	1.17	1.13	1.38	0.57	1.50	1.74	2.33	0.18
Large School	1.59	1.42	1.36	1.40	1.35	1.59	1.27	1.52	1.33	1.62	1.61	1.60	1.39	1.41	2.02	1.15
Warehouse	1.00	0.85	0.79	0.95	0.90	0.82	0.74	1.02	0.89	0.99	0.91	0.96	1.03	0.92	1.04	0.94

$\frac{Proposed\ (2028)}{Current\ (2025)}$

≤ 10%	≤ 30%	≤ 50%	≤ 70%	≤ 90%	>100%<	≥ 110%	≥ 130%	≥ 150%	≥ 170%	≥ 190%	≥ 210%

Proposed 2028 vs. Current 2025: Exports

Standalone PV

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Exhibits & Events	(20%)	(30%)	(29%)	(27%)	(27%)	(31%)	(26%)	(32%)	(33%)	(23%)	(29%)	(31%)	(26%)	(27%)	(28%)	(26%)
Library	3%	(7%)	(2%)	(4%)	(1%)	(1%)	(2%)	0%	(1%)	(5%)	(6%)	(3%)	(6%)	(3%)	(5%)	(2%)
Religious Worship	(49%)	(44%)	(47%)	(42%)	(47%)	(49%)	(42%)	(46%)	(46%)	(38%)	(39%)	(43%)	(41%)	(36%)	(33%)	(43%)
Sports & Recreation	(20%)	(8%)	(5%)	(4%)	(8%)	2%	(4%)	(11%)	(4%)	(8%)	(11%)	(10%)	(7%)	(9%)	(14%)	(3%)
Large Office	2%	2%	4%	3%	4%	3%	2%	2%	3%	4%	3%	2%	5%	3%	1%	2%
Medium Office	3%	2%	4%	3%	4%	2%	3%	5%	4%	4%	3%	3%	4%	2%	4%	7%
Small Office	7%	4%	6%	6%	6%	4%	4%	5%	5%	7%	5%	4%	6%	5%	4%	11%
Restaurant	(16%)	(18%)	(15%)	(17%)	(16%)	(16%)	(14%)	(16%)	(15%)	(15%)	(18%)	(18%)	(17%)	(14%)	(14%)	(14%)
Large Retail	(10%)	(17%)	(8%)	(10%)	(10%)	(8%)	(9%)	(9%)	(9%)	(9%)	(9%)	(10%)	(9%)	(9%)	(9%)	(8%)
Medium Retail	(6%)	(15%)	(6%)	(10%)	(6%)	(6%)	(7%)	(8%)	(6%)	(8%)	(9%)	(2%)	(9%)	(8%)	(7%)	(7%)
Strip Mall	5%	2%	2%	2%	4%	3%	1%	1%	2%	6%	0%	2%	0%	4%	0%	5%
High School	(9%)	(18%)	(16%)	(10%)	(13%)	(9%)	(15%)	(6%)	(5%)	(2%)	2%	(13%)	2%	5%	5%	(11%)
K - 8 School	(35%)	(18%)	(12%)	(13%)	(12%)	(20%)	(17%)	(5%)	(2%)	(1%)	3%	(12%)	3%	5%	3%	(23%)
Large School	4%	3%	5%	3%	4%	5%	3%	4%	3%	4%	5%	4%	3%	3%	2%	3%
Warehouse	7%	5%	6%	7%	6%	7%	5%	9%	7%	9%	5%	6%	7%	6%	6%	7%

Less Exports | More Exports

- Value = 2028 % exports – 2025 % exports

Proposed 2028 vs. Current 2025: Electricity Savings

Standalone PV

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Exhibits & Events	(51%)	(78%)	(73%)	(74%)	(72%)	(80%)	(70%)	(83%)	(86%)	(69%)	(80%)	(79%)	(73%)	(76%)	(74%)	(62%)
Library	26%	(25%)	(14%)	(26%)	(15%)	(17%)	(17%)	(13%)	(18%)	(34%)	(34%)	(21%)	(28%)	(26%)	(33%)	(18%)
Religious Worship	(82%)	(90%)	(85%)	(90%)	(100%)	(110%)	(99%)	(111%)	(108%)	(96%)	(86%)	(90%)	(91%)	(78%)	(78%)	(72%)
Sports & Recreation	(26%)	(18%)	(12%)	(13%)	(18%)	(4%)	(14%)	(34%)	(16%)	(25%)	(29%)	(23%)	(22%)	(25%)	(41%)	(9%)
Large Office	8%	(7%)	3%	(8%)	3%	(2%)	(9%)	(6%)	(10%)	0%	(5%)	(7%)	5%	(7%)	(15%)	(5%)
Medium Office	9%	(5%)	7%	(0%)	6%	(6%)	(1%)	9%	4%	4%	(1%)	1%	2%	(4%)	3%	15%
Small Office	20%	2%	14%	12%	17%	5%	5%	9%	4%	13%	7%	8%	12%	6%	4%	28%
Restaurant	(22%)	(28%)	(20%)	(25%)	(27%)	(26%)	(21%)	(27%)	(25%)	(27%)	(30%)	(28%)	(30%)	(26%)	(29%)	(18%)
Large Retail	(24%)	(31%)	(20%)	(32%)	(29%)	(26%)	(30%)	(31%)	(31%)	(29%)	(26%)	(29%)	(26%)	(28%)	(29%)	(22%)
Medium Retail	(13%)	(25%)	(18%)	(30%)	(18%)	(21%)	(24%)	(25%)	(18%)	(26%)	(23%)	(9%)	(26%)	(25%)	(25%)	(21%)
Strip Mall	10%	2%	5%	3%	10%	9%	(1%)	(1%)	5%	12%	(3%)	1%	(2%)	8%	(7%)	12%
High School	(13%)	(33%)	(26%)	(26%)	(24%)	(26%)	(32%)	(17%)	(18%)	(12%)	(4%)	(28%)	(4%)	4%	5%	(20%)
K - 8 School	(33%)	(31%)	(23%)	(29%)	(24%)	(38%)	(33%)	(16%)	(12%)	(13%)	(5%)	(28%)	(2%)	4%	(2%)	(31%)
Large School	12%	(7%)	5%	(8%)	5%	(0%)	(12%)	(3%)	(10%)	1%	1%	0%	(7%)	(8%)	(12%)	(4%)
Warehouse	35%	30%	34%	38%	40%	33%	24%	44%	36%	42%	30%	36%	37%	35%	26%	36%

Lower Savings | Higher Savings

- Value = 2028 % savings – 2025 % savings

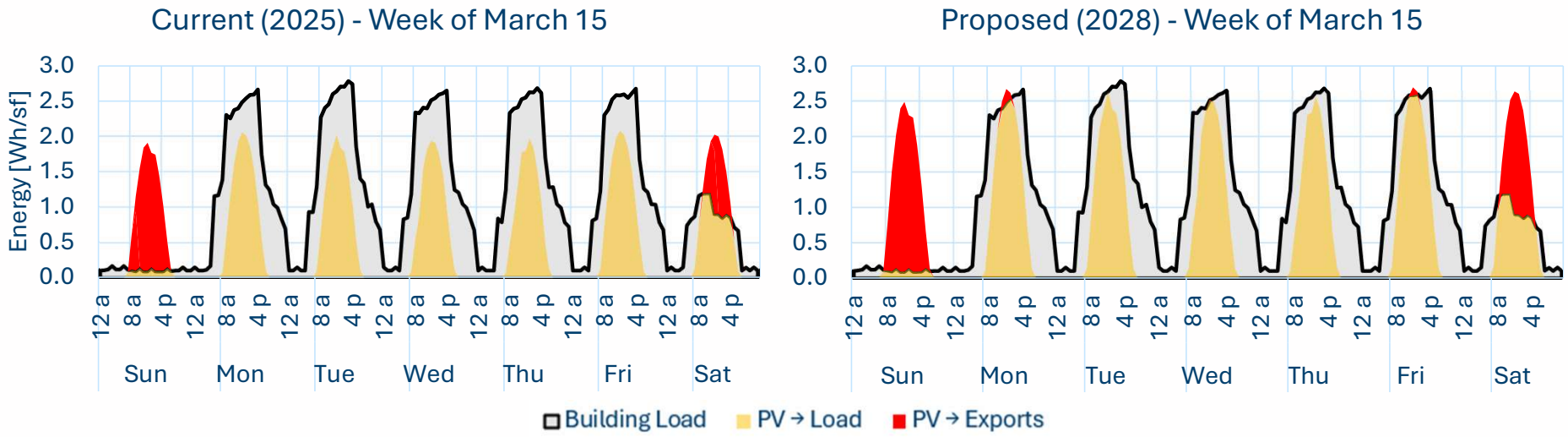
Standalone PV: Proposed 2028 vs Current 2025 Analysis

2028 vs. 2025: 5-day Workweek

Small Office Example

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PV Size - Proposed ÷ Current	154%	103%	131%	123%	137%	108%	108%	118%	107%	126%	114%	115%	127%	111%	107%	168%
Electricity Savings	20%	2%	14%	12%	17%	5%	5%	9%	4%	13%	7%	8%	12%	6%	4%	28%
Exports Increase	7%	4%	6%	6%	6%	4%	4%	5%	5%	7%	5%	4%	6%	5%	4%	11%

- 2025: Unoccupied weekends → Smaller PV (less than typical load)
- 2028: Larger PV → More Savings, Higher Exports



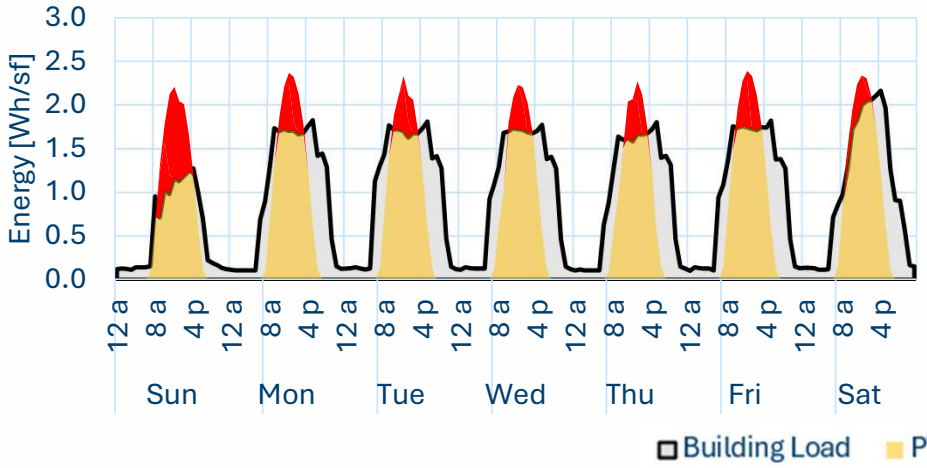
2028 vs. 2025: 7-day workweek

Medium Retail Example

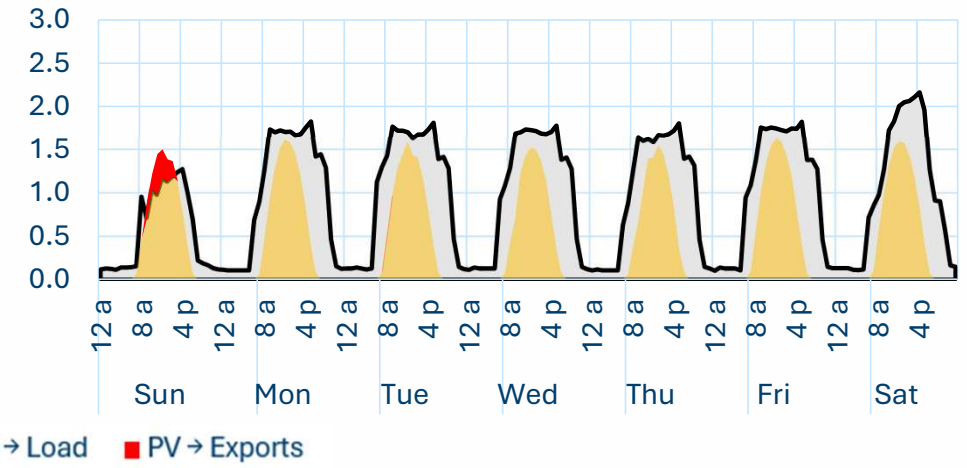
Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PV Size - Proposed ÷ Current	73%	60%	68%	53%	68%	66%	60%	63%	73%	62%	62%	84%	58%	62%	63%	66%
Electricity Savings	(13%)	(25%)	(18%)	(30%)	(18%)	(21%)	(24%)	(25%)	(18%)	(26%)	(23%)	(9%)	(26%)	(25%)	(25%)	(21%)
Exports Increase	(6%)	(15%)	(6%)	(10%)	(6%)	(6%)	(7%)	(8%)	(6%)	(8%)	(9%)	(2%)	(9%)	(8%)	(7%)	(7%)

- 2025: Daily consistent loads → Larger PV (higher than typical load)
- 2028: Smaller PV (min of seasons) → Lower Savings, Less Exports

Current (2025) - Week of March 15



Proposed (2028)- Week of March 15



Building Load PV → Load PV → Exports

2028 vs. 2025: Strip Mall vs Other Retail

Strip mall is mostly retail sales area

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Large Retail	1.79	1.93	2.05	1.94	1.73	2.06	1.91	2.17	2.07	2.24	2.47	2.03	2.40	2.21	2.70	2.11
Medium Retail	2.28	2.09	2.04	1.93	2.08	2.15	2.07	2.42	2.65	2.35	2.55	3.06	2.33	2.30	2.90	2.11
Strip Mall	3.95	3.58	3.35	3.81	3.75	3.90	3.36	3.70	3.99	4.67	3.79	3.72	3.76	4.29	4.02	4.12

- Strip Mall prototype is assumed to have less support spaces than other retail prototypes
- Retail sales has high load
- With higher load, the PV size increases for that prototype compared to other retail

Space Type	Large Retail	Medium Retail	Strip Mall	LPD [W/sf]	EPD [W/sf]
Retail Sales Area (Retail Merchandise Sales)	68%	83%	100%	0.95	1
Office Area (>250 square feet)	1%	-	-	0.6	1.5
Storage, Commercial/Industrial (Warehouse)	19%	17%	-	0.4	0.2
Lobby, Main Entry	8%	1%	-	0.7	0.5
Restrooms	3%	-	-	0.65	0

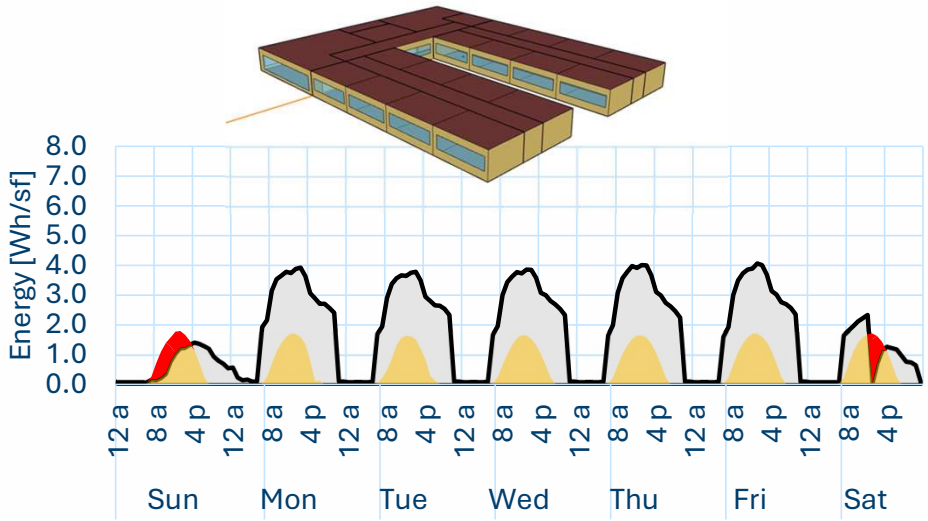
2028 vs. 2025: School Prototype Changes

Example: New K – 8 vs Previous Small School

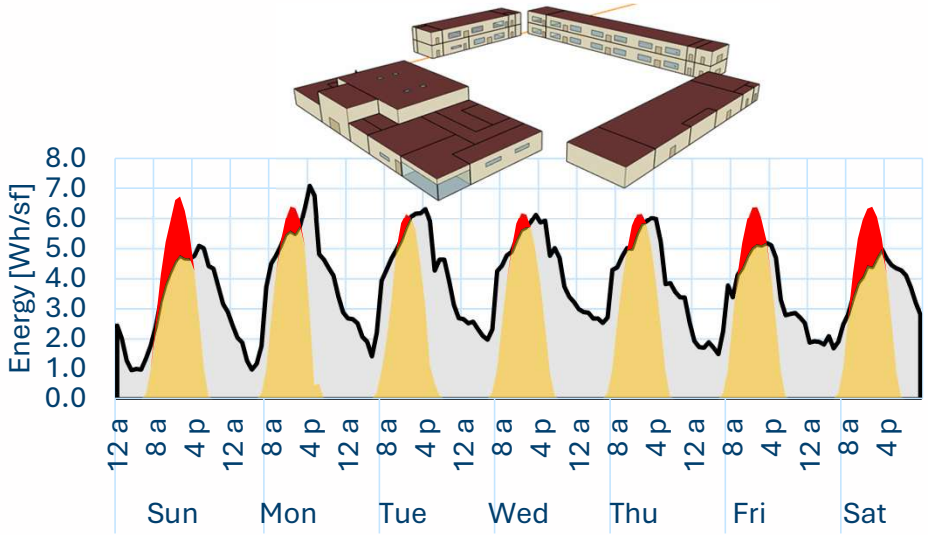
Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
High School	0.72	0.50	0.46	0.79	0.52	0.83	0.60	1.02	1.01	1.20	1.43	0.67	1.45	1.72	2.63	0.54
K - 8 School	0.12	0.46	0.50	0.58	0.50	0.42	0.51	1.02	1.17	1.13	1.38	0.57	1.50	1.74	2.33	0.18

- New summer break low loads → Generally lower than current requirement
- More exterior walls → Warmer climate zones high AC load

Small School – Current (2025) - Week of July 12



K – 8 School – Proposed (2028) - Week of July 12

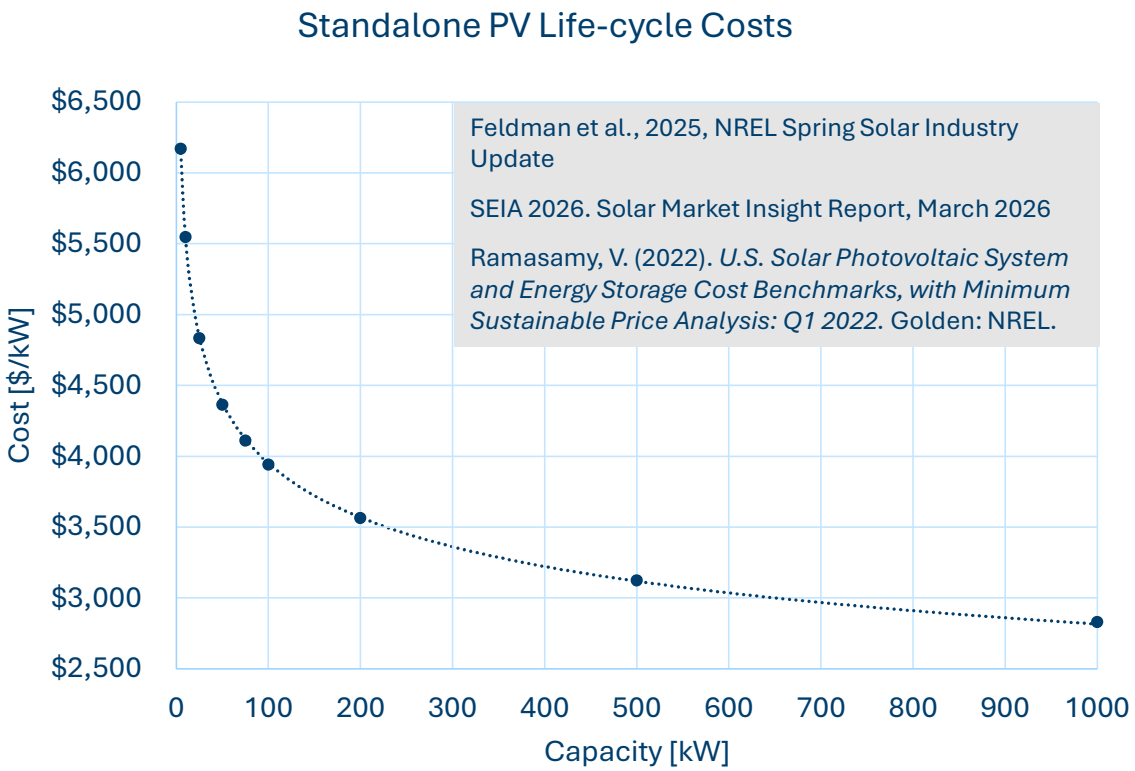


Building Load PV → Load PV → Exports

PV Cost-effectiveness

PV System Life-cycle Costs

Standalone (No BESS)



- Removed ITC tax credit
- Revised PV forecast accounts for 2025 SEIA price updates
- Apply assumptions for customer acquisition cost, inverter pricing from previous study
- Prices set in 2029 dollars
- Apply NREL conservative[1] forecast through 2029
- Curve has high "tail" of prices for small systems < 50 kW

[1] NREL's "Conservative" solar photovoltaic (PV) cost projection model assumed technology improves incrementally, but no massive transformative breakthroughs or regulatory leaps take hold.

BCR: Standalone PV

Cost-effective everywhere

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Exhibits & Events	1.24	1.52	1.57	1.64	1.62	1.68	1.61	1.63	1.70	1.62	1.52	1.57	1.56	1.79	1.74	1.62
Library	1.50	1.80	1.86	1.96	1.93	1.97	1.91	1.88	1.98	1.95	1.77	1.85	1.83	2.10	2.03	1.91
Religious Worship	1.21	1.44	1.48	1.59	1.54	1.55	1.53	1.56	1.59	1.61	1.46	1.51	1.45	1.68	1.68	1.52
Sports & Recreation	1.18	1.38	1.42	1.51	1.45	1.47	1.46	1.45	1.52	1.51	1.39	1.43	1.42	1.60	1.56	1.50
Large Office	2.24	2.70	2.76	2.93	2.89	2.94	2.86	2.88	2.98	2.95	2.70	2.78	2.76	3.10	3.10	2.79
Medium Office	1.66	2.01	2.04	2.18	2.13	2.17	2.13	2.15	2.23	2.21	2.02	2.07	2.07	2.33	2.33	2.08
Small Office	1.21	1.49	1.53	1.61	1.58	1.61	1.57	1.59	1.64	1.63	1.49	1.53	1.53	1.73	1.73	1.51
Restaurant	1.40	1.68	1.75	1.85	1.80	1.86	1.79	1.80	1.89	1.85	1.68	1.73	1.71	1.98	1.93	1.78
Large Retail	2.35	2.79	2.91	3.07	3.00	3.11	2.98	3.01	3.14	3.10	2.84	2.90	2.90	3.33	3.25	3.00
Medium Retail	1.74	2.03	2.13	2.22	2.22	2.27	2.18	2.19	2.28	2.25	2.06	2.08	2.10	2.42	2.35	2.18
Strip Mall	1.58	1.89	1.96	2.07	2.04	2.09	2.01	2.03	2.13	2.04	1.91	1.96	1.95	2.23	2.12	2.02
High School	1.82	2.04	2.09	2.22	2.19	2.16	2.13	2.17	2.27	2.27	2.11	2.14	2.18	2.44	2.53	2.26
K - 8 School	1.28	1.64	1.66	1.80	1.71	1.76	1.71	1.76	1.82	1.84	1.73	1.70	1.78	2.00	2.10	1.67
Large School	1.77	2.14	2.18	2.33	2.27	2.31	2.23	2.29	2.35	2.36	2.18	2.22	2.23	2.50	2.54	2.21
Warehouse	1.43	1.69	1.71	1.84	1.80	1.78	1.74	1.74	1.82	1.79	1.70	1.74	1.76	1.98	1.95	1.80

BCR < 1.00 < BCR

Battery Energy Storage System (BESS) Sizing

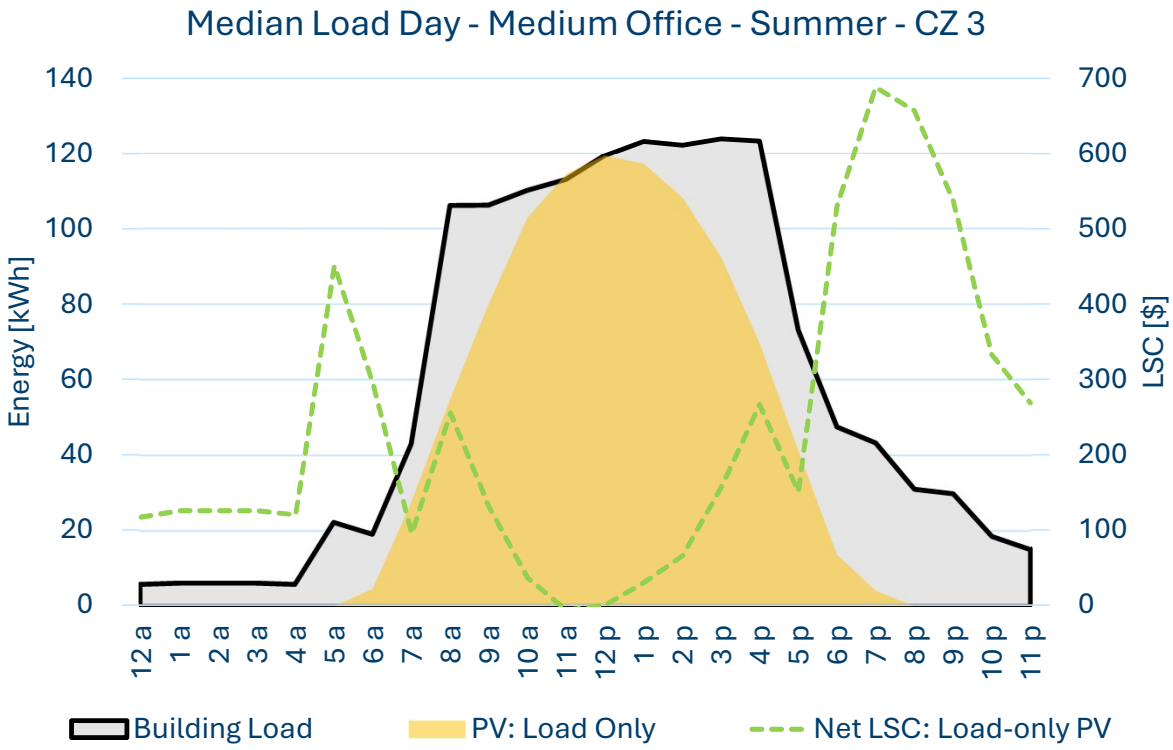
Overview of Comparison of Approaches

Proposed (2028) vs. Current (2025)

	2022 & 2025	2028
Sizing	Limit PV exports to 10% of annual generation	Reduce peak LSC hours for each season's median load day. Smallest selected.
Round-trip efficiency	80%	89%
Discharge Power	Total capacity / 4	Total capacity / 4
Discharge control	Peak Time-of-Use (4 pm – 9 pm)	At peak LSC hours of each season's typical load day
Charge control	Surplus PV	Fraction of PV generation to fully charge BESS for each season's median load day

2028 Proposed PV Sizing Review

*Size to the **Seasonal Median-Load-Day Minimum***



Median Load Day

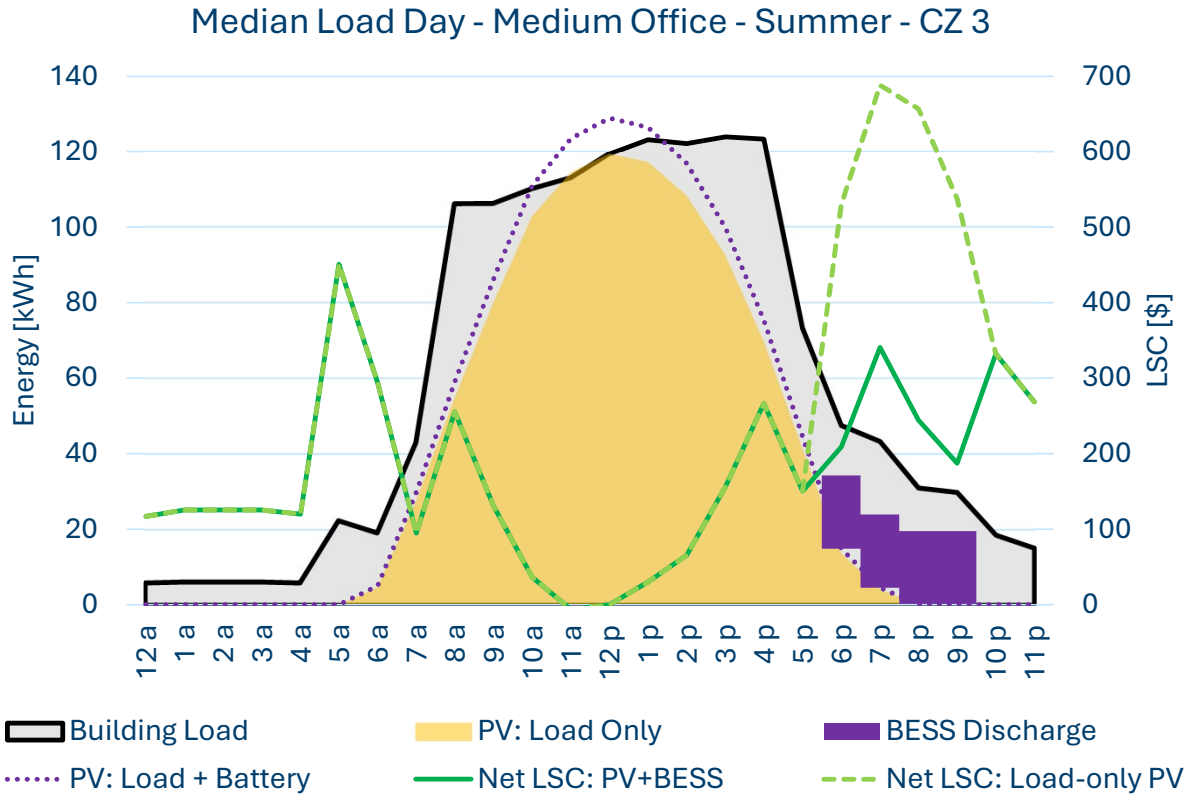
- Day with median total energy use for the season

Fit PV

- Peak PV output matches building load
- PV generation is 1 week average.

2028 Proposed PV with BESS Sizing

*Size to the **Seasonal Median-Load-Day Minimum***



Median Load Day
- Day with median total energy use for the season

Fit PV
- Peak PV output matches building load
- PV generation is 1 week average.

BESS Power
- Reduce top 4 LSC to the average LSC for the day
- Average reduction of top 4 LSC (e.g., total 400 kWh over 4 hours/4 hours = 100 kW)

Increase PV
- Charge BESS by fixed proportion (or exports)

BESS Size
- Select smallest BESS of all seasons
- PV size corresponds to that BESS size

Proposed PV Sizes

PV with BESS [W/ft^2]

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Exhibits & Events	2.09	1.39	1.31	1.56	1.50	1.18	1.58	1.36	1.25	1.88	1.47	1.38	1.60	1.45	1.43	1.24
Library	1.82	2.52	2.43	2.48	2.34	2.35	2.54	3.25	3.07	2.59	2.82	2.96	2.89	2.42	2.94	2.17
Religious Worship	1.50	2.30	1.64	1.85	1.55	1.53	1.92	2.03	1.99	2.07	2.66	2.87	2.13	1.64	2.29	1.37
Sports & Recreation	1.80	1.89	1.63	2.32	1.63	1.75	2.22	1.86	2.30	2.02	2.06	1.79	1.88	1.64	2.09	1.97
Large Office	3.51	3.19	3.05	3.18	2.95	3.31	3.16	3.20	3.05	3.48	3.31	3.28	3.92	3.28	3.31	2.68
Medium Office	3.69	3.18	3.12	3.64	3.36	3.14	3.41	4.17	3.68	3.90	3.47	3.49	3.51	3.23	4.24	3.99
Small Office	4.80	3.70	3.72	4.50	4.24	3.98	3.87	4.28	3.85	4.44	4.17	4.20	4.47	3.99	4.77	4.93
Restaurant	5.72	5.80	6.15	6.71	5.31	6.00	7.19	6.78	6.75	6.92	6.24	5.93	6.33	7.00	8.07	7.57
Large Retail	2.37	2.51	2.58	2.39	2.33	2.50	2.47	2.75	2.63	2.82	3.14	2.61	3.06	2.73	3.38	2.77
Medium Retail	2.85	2.62	2.69	2.57	2.82	2.83	2.70	3.00	3.21	2.93	3.43	3.91	2.92	2.91	3.86	2.77
Strip Mall	4.68	4.35	4.34	4.87	4.71	4.70	4.04	4.67	5.11	5.56	4.62	4.58	4.75	5.21	5.11	5.27
High School	0.85	0.61	0.58	0.86	0.65	0.83	0.76	1.08	1.09	1.39	1.57	0.84	1.62	1.85	3.05	0.59
K - 8 School	0.22	0.49	0.50	0.67	0.56	0.44	0.52	1.06	1.22	1.48	1.56	0.73	1.80	1.85	2.85	0.23
Large School	1.92	1.78	1.68	1.68	1.62	1.92	1.54	1.82	1.60	1.90	1.88	1.89	1.65	1.70	2.30	1.37
Warehouse	1.26	1.01	0.95	1.22	1.14	0.99	0.96	1.28	1.12	1.21	1.15	1.18	1.34	1.17	1.23	1.10

$\frac{Proposed\ (2028)}{Current\ (2025)}$ ≤ 10% | ≤ 30% | ≤ 50% | ≤ 70% | ≤ 90% | >100%< | ≥ 110% | ≥ 130% | ≥ 150% | ≥ 170% | ≥ 190% | ≥ 210%

- Slightly larger than Standalone PV to charge the BESS

Proposed 2028 Size & Comparison to 2025

BESS [Wh/ft^2]

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Exhibits & Events	1.44	1.53	1.52	0.90	1.53	0.99	1.39	1.14	1.57	1.38	1.84	1.71	1.60	1.58	1.64	1.43
Library	0.47	1.99	2.28	2.45	1.94	1.77	1.77	1.71	1.39	2.67	3.26	2.38	2.61	2.19	2.90	1.17
Religious Worship	3.95	4.81	4.39	5.11	3.84	4.33	4.50	4.34	4.95	4.44	5.60	4.29	4.64	4.97	4.84	3.73
Sports & Recreation	2.84	3.42	2.87	3.52	3.39	2.55	3.46	3.18	3.14	2.90	3.46	3.33	2.85	3.23	3.24	3.21
Large Office	2.11	2.02	1.89	1.98	1.65	1.68	2.13	1.90	1.93	1.77	1.75	2.33	2.11	2.18	1.87	1.81
Medium Office	2.31	1.93	1.54	2.87	2.30	1.96	1.87	2.17	1.84	1.87	2.06	1.76	1.72	1.87	1.34	2.84
Small Office	2.54	2.47	2.05	3.04	3.22	3.12	2.68	2.96	2.33	2.48	2.91	2.86	2.36	2.82	2.51	2.88
Restaurant	5.73	6.31	5.76	5.17	6.33	6.15	6.62	5.96	5.98	5.65	5.30	5.30	6.18	6.57	6.93	11.06
Large Retail	2.83	2.82	2.77	2.45	2.78	2.13	2.93	3.11	2.86	3.02	3.02	2.94	2.92	2.92	3.14	3.04
Medium Retail	2.85	2.67	3.26	3.44	3.40	3.42	3.32	3.09	3.04	3.16	3.92	4.90	2.74	2.94	4.10	3.63
Strip Mall	3.21	3.94	5.29	5.08	4.91	3.46	3.63	4.66	4.62	3.72	3.99	5.01	4.99	4.66	4.86	6.50
High School	0.62	0.49	0.50	0.50	0.59	0.34	0.66	0.46	0.63	1.76	1.59	0.86	1.78	1.15	2.02	0.26
K - 8 School	0.46	0.30	0.21	0.45	0.38	0.18	0.28	0.43	0.60	2.06	1.81	0.93	2.36	1.12	2.20	0.30
Large School	1.33	1.46	1.46	1.31	1.30	1.44	1.48	1.53	1.40	1.26	1.15	1.30	1.33	1.49	1.40	1.22
Warehouse	1.10	0.95	0.89	1.04	1.18	0.72	1.09	0.66	0.73	0.94	1.12	1.06	1.27	1.20	0.98	1.00

$\frac{Proposed\ (2028)}{Current\ (2025)}$

≤ 10%	≤ 30%	≤ 50%	≤ 70%	≤ 90%	>100%<	≥ 110%	≥ 130%	≥ 150%	≥ 170%	≥ 190%	≥ 210%

Proposed 2028 vs. Current 2025: Exports

PV with BESS

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Exhibits & Events	(14%)	(31%)	(29%)	(27%)	(27%)	(32%)	(27%)	(33%)	(34%)	(25%)	(33%)	(32%)	(29%)	(29%)	(30%)	(27%)
Library	3%	(6%)	(1%)	(5%)	(0%)	(1%)	(2%)	1%	3%	(5%)	(5%)	(0%)	(5%)	(4%)	(5%)	(3%)
Religious Worship	(37%)	(28%)	(30%)	(32%)	(32%)	(36%)	(30%)	(37%)	(33%)	(32%)	(25%)	(20%)	(28%)	(28%)	(28%)	(32%)
Sports & Recreation	(13%)	(4%)	(1%)	2%	(3%)	(2%)	2%	(8%)	(2%)	(6%)	(7%)	(7%)	(7%)	(7%)	(12%)	1%
Large Office	5%	2%	5%	3%	4%	4%	3%	3%	3%	5%	4%	3%	8%	4%	1%	3%
Medium Office	5%	3%	4%	4%	5%	2%	3%	6%	5%	6%	4%	4%	4%	3%	5%	9%
Small Office	10%	4%	6%	7%	8%	5%	4%	5%	5%	7%	5%	5%	7%	5%	6%	14%
Restaurant	(13%)	(17%)	(11%)	(14%)	(15%)	(13%)	(9%)	(14%)	(13%)	(13%)	(17%)	(16%)	(15%)	(11%)	(12%)	(6%)
Large Retail	(7%)	(12%)	(5%)	(10%)	(8%)	(6%)	(8%)	(8%)	(8%)	(8%)	(7%)	(9%)	(7%)	(8%)	(7%)	(4%)
Medium Retail	(2%)	(11%)	(3%)	(9%)	(2%)	(4%)	(5%)	(7%)	(4%)	(7%)	(5%)	3%	(7%)	(6%)	(5%)	(4%)
Strip Mall	9%	6%	6%	6%	9%	7%	2%	2%	6%	9%	2%	3%	2%	7%	3%	11%
High School	(8%)	(16%)	(14%)	(10%)	(11%)	(10%)	(13%)	(6%)	(6%)	(2%)	2%	(12%)	1%	4%	6%	(11%)
K - 8 School	(30%)	(18%)	(14%)	(12%)	(12%)	(20%)	(18%)	(5%)	(2%)	(0%)	2%	(11%)	3%	4%	5%	(21%)
Large School	7%	4%	7%	4%	5%	7%	2%	4%	3%	5%	6%	5%	3%	4%	3%	3%
Warehouse	10%	6%	8%	11%	10%	9%	7%	14%	11%	12%	8%	8%	11%	9%	7%	9%

Less Exports | More Exports

- Value = 2028 % exports – 2025 % exports

Proposed 2028 vs Current 2025: Electricity Savings

PV with BESS

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Exhibits & Events	(35%)	(74%)	(67%)	(70%)	(66%)	(77%)	(65%)	(80%)	(81%)	(67%)	(78%)	(74%)	(71%)	(72%)	(70%)	(58%)
Library	27%	(14%)	(3%)	(16%)	(3%)	(8%)	(9%)	(4%)	(4%)	(21%)	(17%)	(6%)	(16%)	(19%)	(23%)	(13%)
Religious Worship	(65%)	(59%)	(57%)	(65%)	(74%)	(83%)	(72%)	(87%)	(78%)	(77%)	(56%)	(46%)	(65%)	(61%)	(64%)	(56%)
Sports & Recreation	(14%)	(2%)	2%	6%	0%	(3%)	5%	(17%)	(4%)	(13%)	(13%)	(9%)	(16%)	(11%)	(28%)	3%
Large Office	18%	2%	12%	2%	10%	5%	2%	2%	(1%)	8%	5%	4%	17%	4%	(9%)	3%
Medium Office	18%	2%	11%	10%	16%	1%	6%	19%	11%	14%	6%	7%	7%	3%	8%	25%
Small Office	30%	9%	19%	22%	28%	14%	12%	17%	12%	20%	15%	16%	19%	14%	13%	37%
Restaurant	(16%)	(22%)	(14%)	(18%)	(20%)	(18%)	(12%)	(20%)	(19%)	(20%)	(25%)	(23%)	(24%)	(17%)	(20%)	(6%)
Large Retail	(14%)	(20%)	(9%)	(23%)	(16%)	(17%)	(20%)	(20%)	(20%)	(19%)	(15%)	(19%)	(16%)	(19%)	(19%)	(9%)
Medium Retail	(4%)	(16%)	(6%)	(19%)	(4%)	(9%)	(13%)	(15%)	(8%)	(16%)	(10%)	5%	(17%)	(14%)	(11%)	(9%)
Strip Mall	18%	11%	18%	17%	23%	20%	8%	10%	19%	23%	6%	11%	8%	19%	6%	27%
High School	(10%)	(30%)	(22%)	(24%)	(20%)	(26%)	(27%)	(16%)	(16%)	(7%)	(1%)	(23%)	0%	7%	13%	(19%)
K - 8 School	(30%)	(30%)	(23%)	(27%)	(22%)	(38%)	(33%)	(15%)	(11%)	(4%)	(1%)	(24%)	5%	6%	8%	(30%)
Large School	23%	7%	18%	3%	16%	13%	(3%)	8%	(0%)	11%	9%	11%	2%	4%	(4%)	5%
Warehouse	49%	41%	46%	57%	58%	47%	40%	62%	53%	59%	45%	50%	56%	52%	36%	45%

Lower Savings | Higher Savings

- Value = 2028 % savings – 2025 % savings

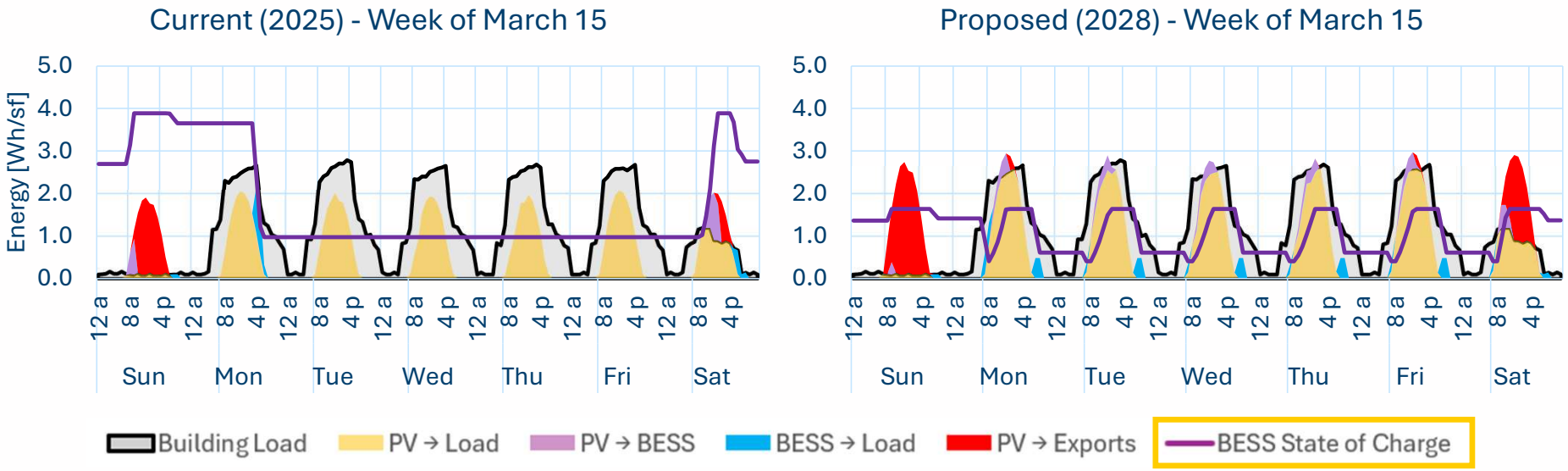
PV with BESS: Proposed 2028 vs Current 2025 Analysis

2028 vs. 2025: 5-day Workweek

Small Office Example

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BESS Size - Proposed ÷ Current	New	42%	42%	51%	66%	53%	45%	50%	39%	42%	49%	48%	40%	48%	35%	59%
Electricity Savings	30%	9%	19%	22%	28%	14%	12%	17%	12%	20%	15%	16%	19%	14%	13%	37%
Exports Increase	10%	4%	6%	7%	8%	5%	4%	5%	5%	7%	5%	5%	7%	5%	6%	14%

- 2025: Unoccupied weekends → Large BESS (must absorb full ½ day of exports)
- 2028: Low evening loads, no export limit → Smaller BESS

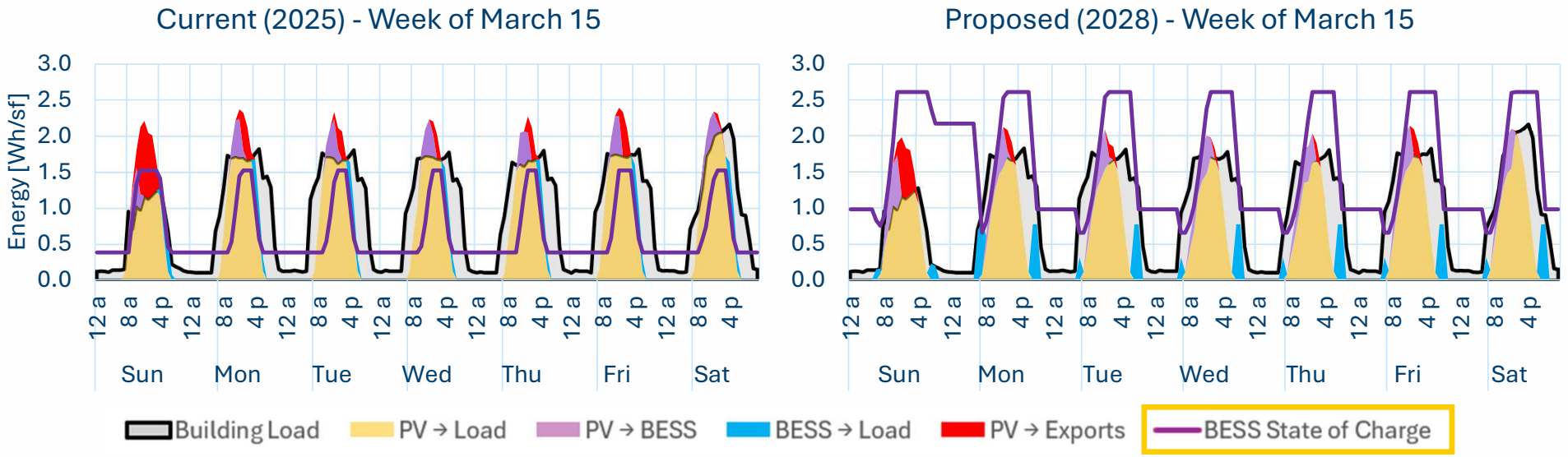


2028 vs. 2025: 7-day Workweek

Medium Retail Example

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BESS Size - Proposed ÷ Current	134%	131%	170%	169%	176%	169%	168%	143%	138%	138%	157%	224%	113%	115%	137%	169%
Electricity Savings	(4%)	(16%)	(6%)	(19%)	(4%)	(9%)	(13%)	(15%)	(8%)	(16%)	(10%)	5%	(17%)	(14%)	(11%)	(9%)
Exports Increase	(2%)	(11%)	(3%)	(9%)	(2%)	(4%)	(5%)	(7%)	(4%)	(7%)	(5%)	3%	(7%)	(6%)	(5%)	(4%)

- 2025: Constant load → Small BESS (only trims peak PV generation)
- 2028: Before- & after-hours shopping, dining, exercise, worship, etc. → Larger BESS

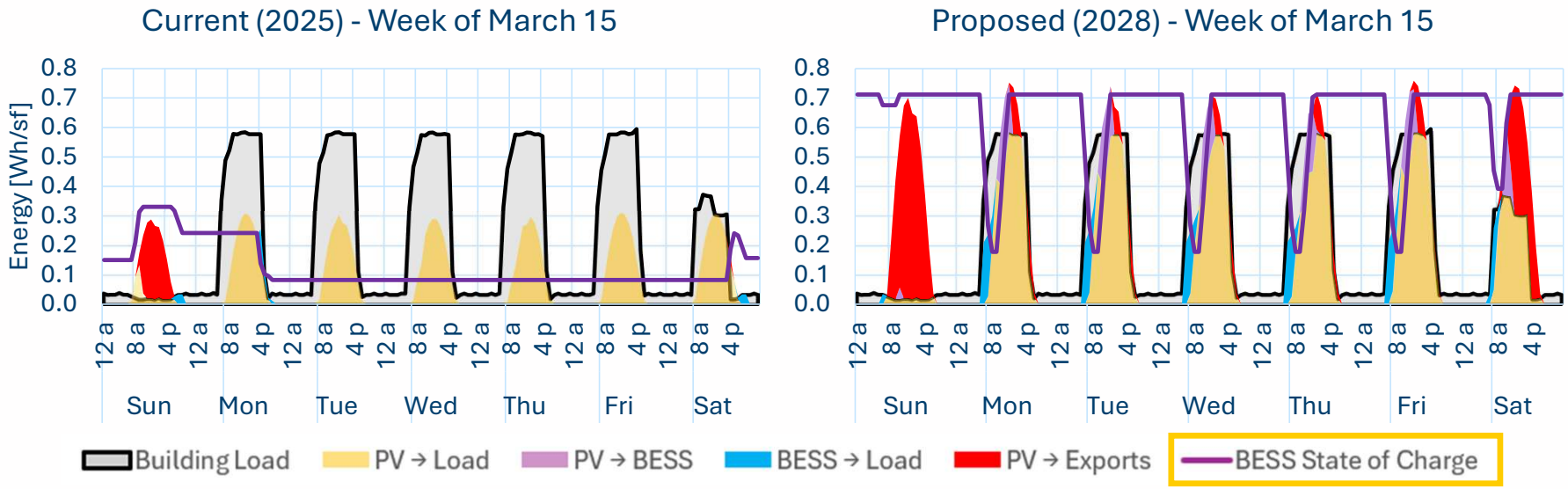


2028 vs. 2025: Warehouse

6-day week, early start

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BESS Size - Proposed ÷ Current	New	207%	212%	226%	281%	157%	237%	143%	159%	204%	244%	230%	276%	261%	161%	238%
Electricity Savings	49%	41%	46%	57%	58%	47%	40%	62%	53%	59%	45%	50%	56%	52%	36%	45%
Exports Increase	10%	6%	8%	11%	10%	9%	7%	14%	11%	12%	8%	8%	11%	9%	7%	9%

- 2025: Warehouse already had low PV exports → Small BESS
- 2028: Early weekday morning loads → Larger BESS



PV with BESS Cost-effectiveness

Comparison of Cost-effectiveness Parameters

Peak Time-of-Use vs. Peak LSC by Season

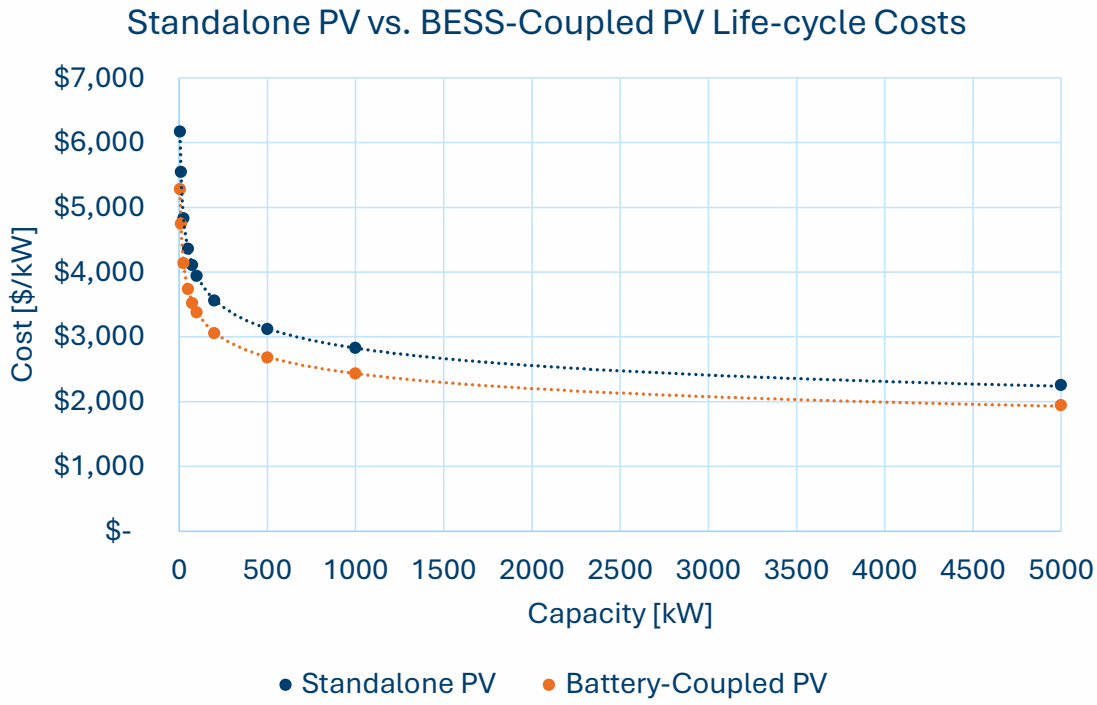
Parameter	2025	2028
Sizing constraint	Limit surplus PV to 10% exports	Reduce peak LSC of for each season's median load day
Round-trip efficiency	80%	89%
Discharge Power	Total capacity / 4	Total capacity / 4
Minimum State of Charge	20% of Total Capacity	20% of Total Capacity
Maximum State of Charge	80% of Total Capacity	80% of Total Capacity
Discharge control	Peak Time-of-Use (4 pm – 9 pm)	Reduce peak LSC for each season's typical load day, excluding hours where PV was 40% of load.
Charge control	Surplus PV	PV fraction for each season's median load day.

- Increased round-trip efficiency in 2028
- **Conservatively predictive BESS control**
  - Reduces peak LSC instead of TOU
  - PV charge fraction & BESS discharge hour change seasonally, based on that season's typical load day

PV System Life-cycle Costs

BESS-Coupled

- Installing PV and storage together reduces hardware, labor, and permitting and interconnection costs
- Reduces PV system costs by 15%



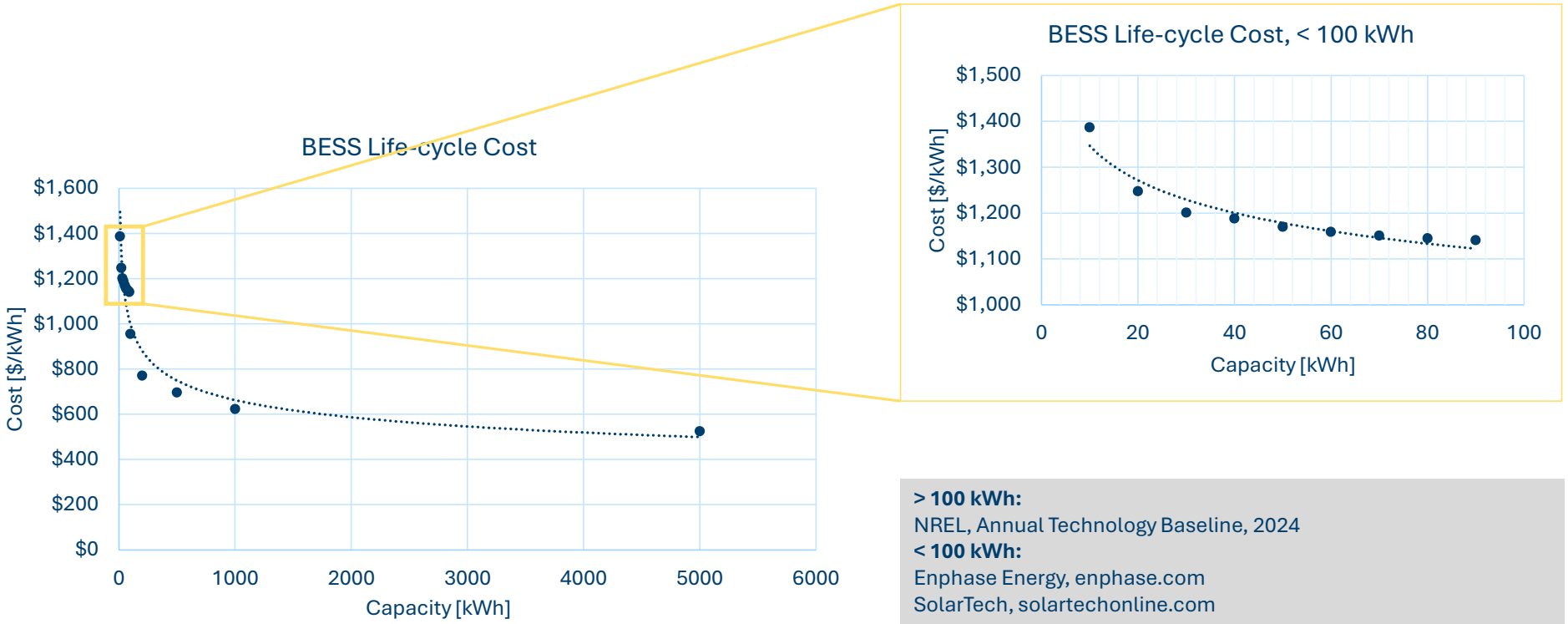
References:

Cole, W. & Frazier, A. W. (2020). Cost Projections for Utility-Scale Battery Storage: 2020 Update. NREL.

SEIA 2026. Solar Market Insight Report, March 2026

BESS System Life-cycle Costs

- Projected BESS costs are reduced due to current prices
- Costs based on NREL and market studies



> 100 kWh:
NREL, Annual Technology Baseline, 2024
< 100 kWh:
Enphase Energy, enphase.com
SolarTech, solartechonline.com

BCR: PV with BESS

Has a BCR > 1.00 for nearly all cases

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Exhibits & Events	1.20	1.41	1.47	1.65	1.56	1.60	1.55	1.59	1.59	1.64	1.39	1.45	1.50	1.64	1.61	1.51
Library	1.61	1.75	1.75	1.85	1.91	1.91	1.88	1.91	2.04	1.80	1.64	1.80	1.75	1.97	1.91	1.94
Religious Worship	0.91	1.09	1.05	1.18	1.13	1.11	1.14	1.22	1.28	1.36	1.20	1.24	1.16	1.23	1.38	1.15
Sports & Recreation	1.02	1.22	1.22	1.29	1.25	1.33	1.24	1.26	1.34	1.33	1.22	1.20	1.25	1.31	1.38	1.35
Large Office	2.29	2.80	2.83	3.00	3.01	3.05	2.92	2.97	3.13	3.10	2.81	2.82	2.84	3.14	3.24	2.87
Medium Office	1.70	2.07	2.13	2.18	2.21	2.21	2.20	2.21	2.33	2.30	2.06	2.15	2.15	2.37	2.48	2.09
Small Office	1.23	1.49	1.56	1.61	1.56	1.57	1.57	1.60	1.67	1.66	1.50	1.55	1.58	1.69	1.76	1.51
Restaurant	1.31	1.59	1.65	1.76	1.68	1.75	1.67	1.75	1.81	1.78	1.62	1.68	1.64	1.89	1.86	1.56
Large Retail	2.18	2.59	2.72	2.95	2.87	3.00	2.74	2.84	3.02	2.95	2.75	2.77	2.79	3.13	3.17	2.84
Medium Retail	1.60	1.88	1.93	2.03	2.08	2.06	1.96	2.03	2.15	2.08	1.89	1.82	2.01	2.22	2.21	2.01
Strip Mall	1.51	1.78	1.73	1.91	1.86	1.98	1.88	1.95	2.07	1.99	1.81	1.82	1.81	2.07	2.00	1.82
High School	1.84	2.02	2.04	2.30	2.14	2.29	2.07	2.30	2.37	2.15	2.03	2.06	2.14	2.52	2.61	2.40
K - 8 School	1.08	1.66	1.73	1.80	1.71	1.83	1.74	1.85	1.91	1.69	1.64	1.57	1.70	2.04	2.10	1.52
Large School	1.80	2.14	2.17	2.35	2.31	2.30	2.24	2.35	2.39	2.43	2.25	2.25	2.25	2.44	2.60	2.25
Warehouse	1.37	1.62	1.62	1.73	1.67	1.72	1.59	1.71	1.77	1.71	1.61	1.65	1.63	1.83	1.87	1.71

BCR < 1.00 < BCR

Input Requests

Input Request

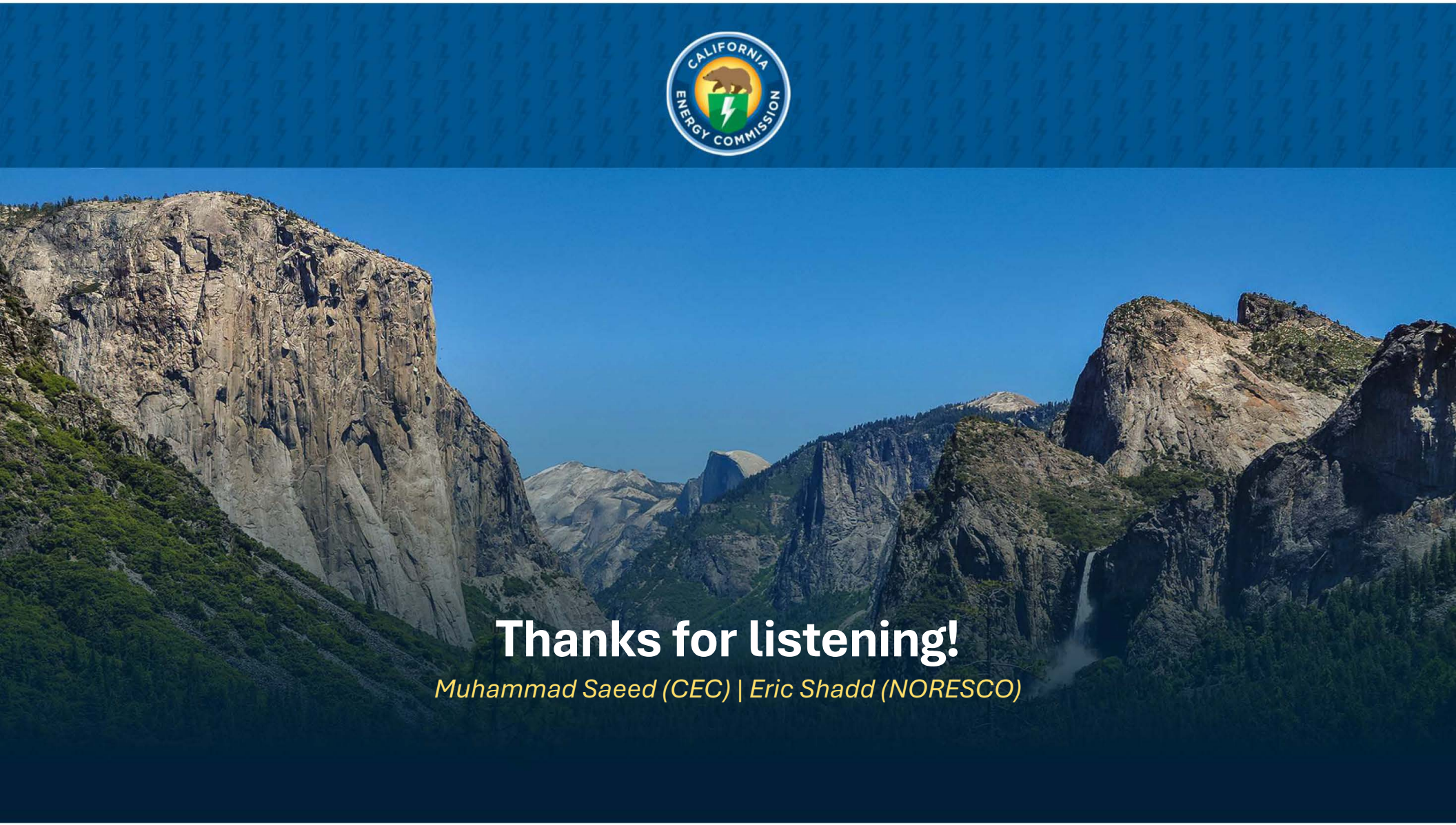
Market

- For commercial PV system and commercial BESS costs, what are the customer acquisition costs?
- What is the expected useful life of a commercial BESS system, under typical charging and discharge cycles?
- What is the minimum capacity commercial BESS that is available and practical for commercial buildings?

Input Request

Performance

- How are commercial PV systems sized?
- What is a typical minimum and maximum state of charge for BESS installed in commercial buildings?
- What is a typical roundtrip efficiency for BESS installed in commercial buildings?
- What are typical BESS charging and discharging control strategies (TOU, energy arbitrage, peak shaving, traditional predictive, AI predictive, etc.).
  - If possible, please provide a ranking of the stage of adoption of these technologies: 1 (innovators), 2 (early adopters), 3 (early majority), 4 (late majority), 5 (laggards).



Thanks for listening!

Muhammad Saeed (CEC) | Eric Shadd (NORESCO)

Comments for Today's Workshop

Due Date: June 17, 2026, by 5:00PM

Comments to be submitted to:

https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=25-BSTD-03

Thank you for participating in today's workshop!

Questions?

Existing Building Performance: HVAC Upgrades and Commissioning

June 23, 2026

Hab Tewelde, P.E. (CEC)

W. Michael Goodrum, P.E. (NORESCO)

Agenda

- Background
- Proposed Measures
- Existing Code Requirements
- Proposed Code Changes
- Market
- Cost-effectiveness
- Statewide Impact
- Stakeholder Input

Terms & Abbreviations

Pneumatic Control Uses compressed air pressure to operate HVAC valves and dampers

Direct Digital Control (DDC) Uses digital controllers and programmed logic to monitor and control HVAC equipment

Existing Building Commissioning (EBCx) Evaluates, improves, verifies, and documents existing HVAC system operation with recommendations for ongoing improvement

Chilled Water (CHW) Plant consists of one or more chillers to provide cooling for air handling systems

Condenser Water (CW) serves the chilled water plant to reject heat from the chilled water loop, typically through a cooling tower

Heating Hot Water (HHW) Plant -consists of one or more boilers to provide heating for air handling systems

Air Handling Unit (AHU) conditions and distributes air

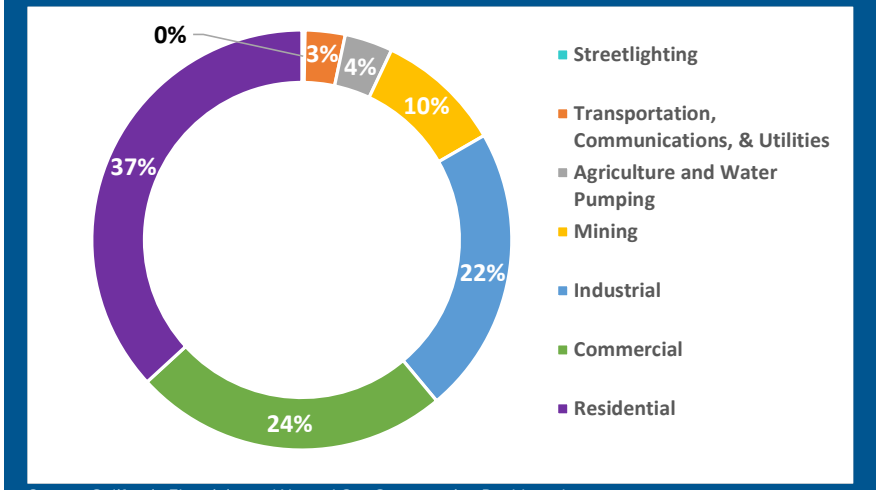
Packaged Rooftop Unit (RTU) provides heating, cooling, and air distribution

Fan Coil Unit (FCU) typically connected to chilled water and hot water plants; provides heating, cooling, and air distribution

Variable Air Volume (VAV) box controls flow, and may adjust temperature, air distributed from AHU to zones

Why Existing Buildings?

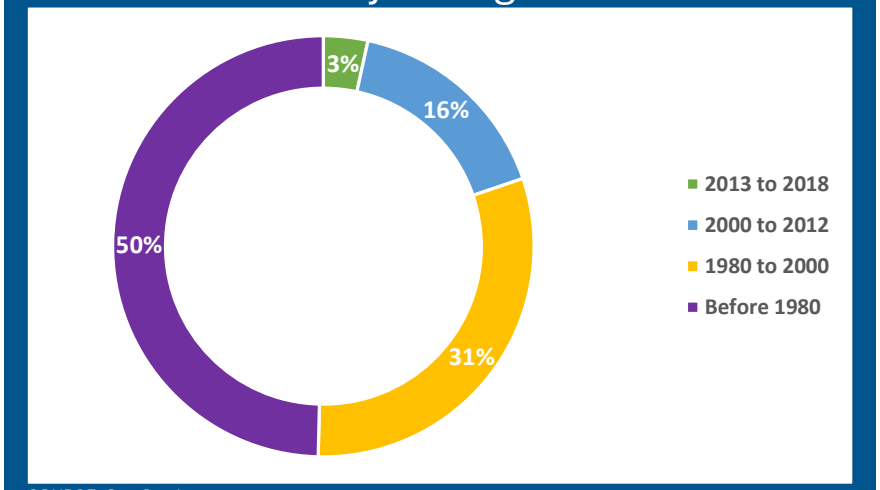
California Energy Use by Sector



Source: California Electricity and Natural Gas Consumption Dashboards

~24 % of California energy use **from nonresidential buildings**

California Commercial Building Energy Use by Vintage



SOURCE: ComStock

~80 % nonresidential energy use from buildings constructed prior to 2000

Proposing two requirements to enhance energy performance of existing buildings

DDC Upgrades
▪ Enables energy saving sequences not available for vintage pneumatic controls (or when no HVAC controls in place) ▪ Creates a stronger foundation for right-sizing, controls modernization, and future building performance work ▪ Positive statewide first year energy savings

Existing Building Commissioning
▪ Captures quick wins for energy efficiency ▪ Investigates key aspects for future HVAC electrification ▪ Provides foundation for more efficient future HVAC replacements ▪ Low to moderate cost to perform ▪ Positive statewide first year energy savings

DDC Upgrades

Existing Code Requirements

- Requirements for nonresidential and hotel/motel buildings covered in **Section 100.3**
- **Section 401.2.2.10**: Direct Digital Controls (DDC)
  - Specific requirements for DDC capability
- DDC to the zone per **Table 401.2-D**
  - Additions/Alterations specifically addressed
- **Section 401.2.2.12**: HVAC hot water temperature
  - Design for HHW supply temp ≤ 130°F

Summary of Additions/Alterations Requirements in Table 401.2-D

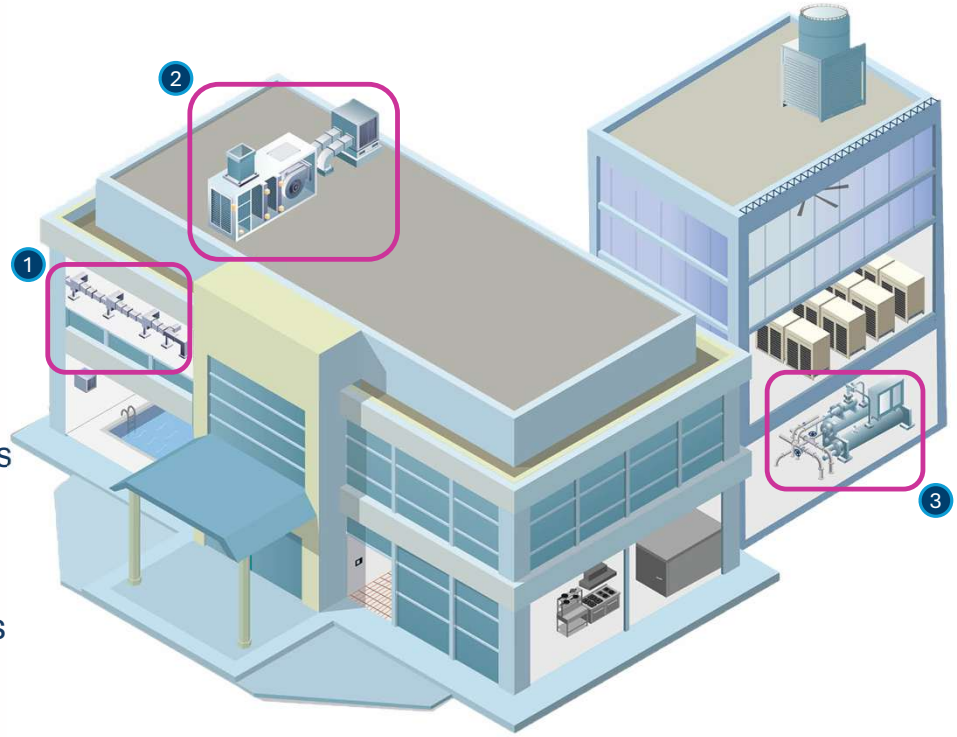
Zone terminal units (VAV boxes)	Existing zones served by same AHU, CHW, or HHW systems with DDC
AHU or FCU	Existing AHU/FCU served by same CHW, or HHW systems with DDC
New AHU + zones	Capacity ≥ 300 kBtu/h Zones > 3 New zones > 75% of all zones
CHW Plant	Capacity ≥ 300 kBtu/h All chillers new/upgraded
HHW Plant	Capacity ≥ 300 kBtu/h All boilers new/upgraded

DDC Upgrades

Proposed Changes Summary

2028 proposed changes for nonresidential buildings

1. **Terminal Units (example = VAV boxes)**
   - Expand DDC at zone level
   - Extend to AHU when majority of zones are DDC
2. **Airside System (example = Air Handling Unit)**
   - Include DDC for any medium - large AHU/RTU replacements
   - Clarify DDC for any size AHU / RTU served by chiller/boiler plant with DDC
   - Extend DDC to all zones in AHU when already in most zones
3. **Central Plants (chillers or boilers)**
   - Extend DDC to full plant when majority is replaced



Source: BuildUp MN

Additional Exceptions

- Building types
- Climate zones for specific equipment

DDC Upgrades

Proposed Code Changes shown in underlined text

- Requirements for nonresidential buildings covered in **Section 100.3**
  - **Exceptions:** Healthcare, Hotel/Motel
- DDC to the zone per **Table 401.2-D**
  - Additions/Alterations modified
  - **Exceptions:** Chiller plant upgrades CZ 1, 3, 5, 16
  - **Exceptions:** Boiler plant upgrades CZ 6, 7
- **Section 401.2.2.12**: HVAC hot water temperature
  - Design for HHW supply temp ≤ 130°F
  - New/replacement terminal units designed for existing HHW supply temp, capable of operating at HHW supply temp < 130°F

Summary of Additions/Alterations Requirements in Table 401.2-D

Zone terminal units (VAV boxes)	Any new/replaced terminal unit If > 50% of terminal units served by AHU are DDC, provide DDC at AHU
AHU or FCU	Capacity > 150 kBtu/h Any capacity existing AHU/FCU served by same CHW, or HHW systems with DDC
New AHU + zones	Capacity ≥ 150 kBtu/h Zones > 3 New zones > 75% of all zones When > 85% of zones are new, DDC to all zones
CHW Plant	Capacity ≥ 300 kBtu/h When > 50% of capacity new, DDC for entire plant, including pumps
HHW Plant	Capacity ≥ 300 kBtu/h When > 50% of capacity new, DDC for entire plant, including pumps

Commissioning for Existing Buildings

Existing Code Requirements

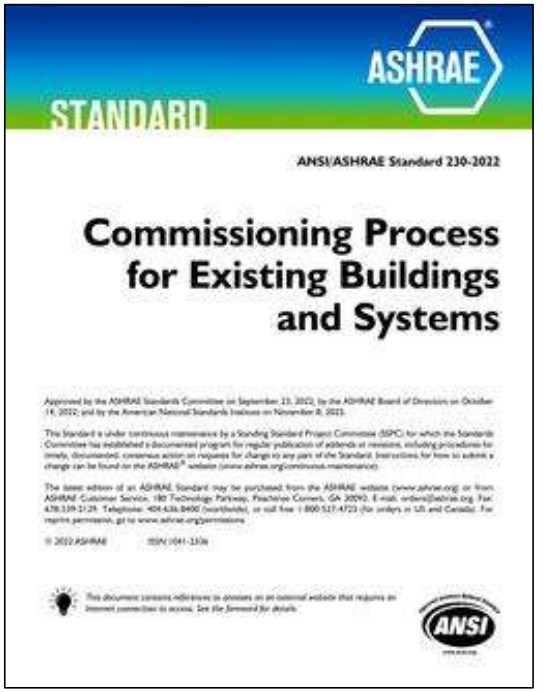
- Commissioning requirements incorporated for equipment additions/alterations
  - Section 1001.2.6: Functional performance testing
    - Section 401.2.7: Mechanical system acceptance

- No current requirements specific to existing buildings
  - Section 1001.5: Additions and alterations to existing buildings
  - RESERVED

Commissioning for Existing Buildings

Proposed Changes Summary

- Performed upon new/replacement space-conditioning equipment
- Process based on ASHRAE Standard 230
- General requirements included for all space-conditioning equipment
- Specific requirements included by space-conditioning equipment type



ASHRAE Standard 230

The goals of EBCx for buildings:

- Document what exists
- Correct obvious operating issues
- Identify next step improvements
- Collect information for future equipment decisions

Commissioning for Existing Buildings

Proposed Code Changes shown in underlined text – General Requirements

- **Section 401.3.4.1 Heating and cooling loads**
  - When sizing new/replacement space-conditioning equipment for nonres alteration, existing HVAC energy use/trend data used in load calculations and submitted to AHJ
    - **Exceptions:** Healthcare, Hotel/Motel
- **Section 401.5.2.2.1.3 & 401.5.2.2.2.3 Existing Building Commissioning**
  - Requires EBCx performed according to Section 1001.5.2.1.1
    - **Exceptions:** Healthcare, Hotel/Motel
- **Section 1001.5.2 Alterations**
  - Alterations to components of existing nonresidential comply
    - **Exceptions:** Healthcare, Hotel/Motel
  - EBCx in accordance with ASHRAE Standard 230
  - EBCx results documented in EBCx report, delivered to owner/rep prior to final inspection
  - Expected remaining useful life and replacement schedule for chillers, boilers, AHUs > 150 kBtu/h, packaged RTUs
  - Benefits of installing devices for pneumatic to DDC interface
  - Compatibility/capability for ASHRAE Guideline 36 sequences (2025 JA18)
  - List of identified issues and corrective actions taken

Commissioning for Existing Buildings

Proposed Code Changes shown in underlined text – Equipment Specific Requirements

Summary of Equipment Specific Requirements in Table 1001.5-A

Equipment	EBCx Evaluation	EBCx Strategies
Zone terminal units (VAV boxes) served by same AHU	Zone heating/cooling overlap between central and perimeter systems, implement deadband	Occupancy based schedules Occupancy based temp setpoint resets
AHU/RTU or FCU > 150 kBtu/h	Outdoor air ventilation per 401.2.1.2 Visually inspect outdoor air/economizer dampers and linkages for restrictions	Occupancy based schedules Occupancy based temp setpoint resets Supply air temp reset Static pressure reset
CHW Plant > 300 kBtu/h	*For all AHU/RTUs or FCUs served by plant:* Outdoor air ventilation per 401.2.1.2 Visually inspect outdoor air/economizer dampers and linkages for restrictions	CHW supply temp reset CW temp reset Pump differential pressure reset
HHW Plant > 300 kBtu/h	Capability of plant to meet zone heating loads at HHW supply temp down to 130°F *For all AHU/RTUs or FCUs served by plant:* Outdoor air ventilation per 401.2.1.2 Visually inspect outdoor air/economizer dampers and linkages for restrictions	HHW supply temp reset Pump differential pressure reset

Existing Building Market

~45 % of nonresidential buildings candidates for DDC

2022 Commercial End Use Survey

50 % of office floor area covered by audit/RCx ordinances

Market Readiness

DDC Widely Available: Capability to be implemented for individual equipment, systems, or for entire building

Strong Network: Existing HVAC controls suppliers, designers and contractors, commissioning consultants

Active Commissioning: Commissioning consultants serving existing energy code requirements

Adjacent Regulation: Existing ordinances in six local jurisdictions require regular energy audits and RCx

Cost-Effectiveness Summary

DDC Upgrades – Airside Systems

- 10% Reduction in HVAC system energy based on previous CASE reports
- Office Building prototype as representative
- Installation costs from RS Means and other industry sources
- Incremental maintenance costs based on typical maintenance contract

Measures	30-Year LSC Savings Total Energy (PV$/ft^2)	Cost ($/ft^2)	BCR
DDC – AHUs + VAV	$1.07	$0.41	BCR > 1 in all CZ

Cost-Effectiveness Summary

DDC Upgrades – Chilled Water and Hot Water Plants

- Modest Estimate for cooling/heating energy savings potential
  - 15% reduction for control upgrades with some existing strategies
- Installation costs from RS Means and other industry sources
- Incremental maintenance costs based on typical maintenance contract

Measures	30-Year LSC Savings Total Energy (PV$/ft^2)	Cost ($/ft^2)	BCR
DDC – Chiller	$0.60	$0.256	BCR > 1 in all but CZ 1, 3, 5, 16
DDC - Boiler	$0.69	$0.295	BCR > 1 in all but CZ 6, 7

No requirements in climate zones where BCR < 1

Cost-Effectiveness Summary

EBCx

Meta-Study of EBCx across nearly 1,300 buildings basis for savings and cost estimates (Crowe 2020)

- 6% Reduction in HVAC system energy
- Office Building prototype as representative
- Installation costs from meta-study
- No incremental maintenance costs included
  - Did not include possible maintenance savings either

Measures	30-Year LSC Savings Total Energy (PV$/ft^2)	Cost ($/ft^2)	BCR
EBCx	$0.64	$0.366	BCR > 1 in all CZ

Statewide First Year Savings

Measures	Electricity LSC Savings ($PV)	Natural Gas LSC Savings ($PV)	GHG Emissions Savings (MT CO_2e/year)
DDC – AHUs + VAV	$7,553,646	$3,167,958	33,590
DDC – Chillers	$1,062,524	$0	1,587
DDC – Boilers	$0	$257,409	23,055
EBCx	$4,532,187	$1,900,775	20,154

No savings included for climate zones where BCR < 1

Requested Stakeholder Input

OPEN QUESTIONS FOR THE 2028 RULEMAKING PROCESS – DDC Upgrades

Q1 Pneumatic Control Market Presence

What percentage of buildings with HVAC controls rely on pneumatic controls for all, or part, of the system?

Q2 DDC to Zone Level Upgrades

When upgrading terminal units (such as VAV boxes), would it be advantageous to upgrade all terminal units served by the same AHU to DDC or to make DDC upgrades by zones as replacement warrants?

Q3 Trend Data Collection

What percentage of buildings with DDC have enabled trend data collection and storage?

Q4 Trend Data Storage

For those buildings with trend data collection and storage, how many hours'/days' worth of trend data are typically stored?

Requested Stakeholder Input

OPEN QUESTIONS FOR THE 2028 RULEMAKING PROCESS - EBCx

Q1 EBCx Market Presence

What percentage of buildings have already completed EBCx?

Q2 EBCx Improvement/Correction Scope

What operational improvements do you expect a Cx Agent to make during the EBCx study?

Q3 Additional EBCx Testing Requirements

Are there any EBCx-specific testing requirements that should accompany the proposed changes to Section 1001.5 in the Reference Appendices?

Comments for Today's workshop

Due Date: July 17, 2026, by 5:00 PM

Comments to be submitted to:

https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=25-BSTD-03

Thank you for participating!

Questions?

Appendix

Cost-Effectiveness Summary – All Climate Zones

DDC Upgrades – Airside Systems

Climate Zone	Benefit: Total Incremental LSC Savings + Other Savings (PV$/ft²)	Cost: Total Incremental First Costs + Maintenance Costs ($/ft²)	Benefit Cost Ratio (BCR)
1	$0.844	$0.41	2.06
2	$0.961	$0.41	2.34
3	$0.769	$0.41	1.88
4	$0.872	$0.41	2.13
5	$0.830	$0.41	2.02
6	$0.841	$0.41	2.05
7	$0.867	$0.41	2.11
8	$1.044	$0.41	2.55
9	$0.990	$0.41	2.41
10	$1.086	$0.41	2.65
11	$1.193	$0.41	2.91
12	$1.034	$0.41	2.52
13	$1.132	$0.41	2.76
14	$1.240	$0.41	3.02
15	$1.384	$0.41	3.38
16	$1.332	$0.41	3.25

Cost-Effectiveness Summary – All Climate Zones

DDC Upgrades – Chiller Systems

Climate Zone	Benefit: Total Incremental LSC Savings + Other Savings (PV$/ft²)	Cost: Total Incremental First Costs + Maintenance Costs ($/ft²)	Benefit Cost Ratio (BCR)
1	$0.032	$0.256	0.13
2	$0.315	$0.256	1.23
3	$0.198	$0.256	0.77
4	$0.377	$0.256	1.47
5	$0.244	$0.256	0.95
6	$0.501	$0.256	1.96
7	$0.524	$0.256	2.05
8	$0.690	$0.256	2.70
9	$0.657	$0.256	2.57
10	$0.728	$0.256	2.84
11	$0.659	$0.256	2.57
12	$0.493	$0.256	1.93
13	$0.703	$0.256	2.75
14	$0.644	$0.256	2.52
15	$1.231	$0.256	4.81
16	$0.199	$0.256	0.78

Cost-Effectiveness Summary – All Climate Zones

DDC Upgrades – Boiler Systems

Climate Zone	Benefit: Total Incremental LSC Savings + Other Savings (PV$/ft²)	Cost: Total Incremental First Costs + Maintenance Costs ($/ft²)	Benefit Cost Ratio (BCR)
1	$0.78	$0.295	2.66
2	$0.65	$0.295	2.21
3	$0.50	$0.295	1.7
4	$0.46	$0.295	1.56
5	$0.54	$0.295	1.84
6	$0.28	$0.295	0.94
7	$0.25	$0.295	0.84
8	$0.31	$0.295	1.04
9	$0.34	$0.295	1.16
10	$0.37	$0.295	1.25
11	$0.66	$0.295	2.23
12	$0.60	$0.295	2.03
13	$0.52	$0.295	1.77
14	$0.68	$0.295	2.31
15	$0.29	$0.295	1.00
16	$1.32	$0.295	4.49

Cost-Effectiveness Summary – All Climate Zones

EBCx

Climate Zone	Benefit: Total Incremental LSC Savings + Other Savings (PV$/ft²)	Cost: Total Incremental First Costs + Maintenance Costs ($/ft²)	Benefit Cost Ratio (BCR)
1	$0.506	$0.366	1.38
2	$0.577	$0.366	1.58
3	$0.461	$0.366	1.26
4	$0.523	$0.366	1.43
5	$0.498	$0.366	1.36
6	$0.505	$0.366	1.38
7	$0.520	$0.366	1.42
8	$0.626	$0.366	1.71
9	$0.594	$0.366	1.62
10	$0.652	$0.366	1.78
11	$0.716	$0.366	1.96
12	$0.620	$0.366	1.70
13	$0.679	$0.366	1.86
14	$0.744	$0.366	2.03
15	$0.830	$0.366	2.27
16	$0.799	$0.366	2.18

Expanding the Heat Pump Alteration Requirement to Large Single-Zone RTUs

Habtom Tewelde, P.E. | CEC
Nasim Mirian, PhD. , John Arent, Rahul Athalye | NORESCO

Presentation Roadmap

1. **Existing Code Requirements**
   2025 Energy Code §141.0(b) baseline
2. **Proposed Measure & Exceptions**
   Scope, capacity range, prescriptive and alternate paths
3. **Market Characterization**
   Market Size, Installation practices
4. **Code Sections Affected**
   §141.0(b) / §401.5.2.2, ACM, Reference Appx
5. **Energy Savings Methodology**
   Prototypes, vintages, baseline, modeling
6. **First-Year Energy Impacts**
   Site, source, GHG, therms
7. **30-Year Cost Savings (LSC)**
   Present-value statewide benefit
8. **Incremental Cost**
   Equipment + labor by capacity
9. **Cost-Effectiveness**
   BCR by climate zone and vintage
10. **Stakeholder Input Requested**
    Open questions for the rulemaking
11. **Contact & References**
    Project team and citations

Terms & Abbreviations

SZVAVHP: Single Zone Variable Air Volume Heat Pump

SZVAVDFHP: Single Zone Variable Air Volume Dual Fuel Heat Pump

SZVAVAC: Single Zone Variable Air Volume Air Conditioner with Gas Furnace for Heating

SZVAVAC1(Gas Pathway): Single Zone Variable Air Volume Air Conditioner with Gas Furnace for Heating and Energy efficiency Measures

BCR: Benefit-Cost Ratio

DX: Direct Expansion

ERR: Energy Recovery Ratio

GHG: Greenhouse Gas

kBtu: Thousands of British Thermal Units

LSC: Long-term System Cost (30-year $)

Ton: nominal rated capacity (1 ton = 12 kBtu/h)

Existing Code Requirements

2025 ENERGY CODE — STARTING POINT

2025 Energy Code §141.0(b)

Single-Zone HP Alteration Requirement (Small Capacity)

Applicability: Single-zone packaged AC alterations with rated capacity **≤ 65,000 Btu/h** (≤ 5.4 tons).

Compliance options:

- Heat pump (default prescriptive path)
- Alternative gas-pack with prescribed efficiency add-ons
- CZ 16 dual-fuel option (gas backup permitted)

Coverage in California stock: Does not address the 65–240 kBtu/h capacity range, which accounts for approximately 40% of cooling capacity sold in 2024.

THE GAP

Large Single-Zone RTUs Are Not Yet Covered

65 — 240 kBtu/h

(5.4 — 20 tons)

≈ 40% of all cooling capacity installed in 2024 falls within this range— and 78 % of replacements are still gas packs (Sathe 2025).

What Is Being Proposed

EXTEND §141.0(b) TO LARGER CAPACITY — RETAIL & RESTAURANT

1 SCOPE

65,000 – 240,000 Btu/h
(5.4 – 20 tons)
Retail & restaurant

Vintages:
Pre-1978, 1978-1997

2 DEFAULT PATH

Replace gas-pack with SZVAVHP

3 ALTERNATIVE

Gas pack :
85 % Energy Recovery Ratio heat recovery
3-stage DX, 2-stage gas
25 % no-load fan

4 EXCEPTIONS

CZ 16: dual-fuel HP
CZ 15: not required

Panel capacity exception

KEY BENEFITS

GHG Reduction
8,798 MT CO_2e saved per year statewide

LSC Savings
69.7 million dollars statewide reduction

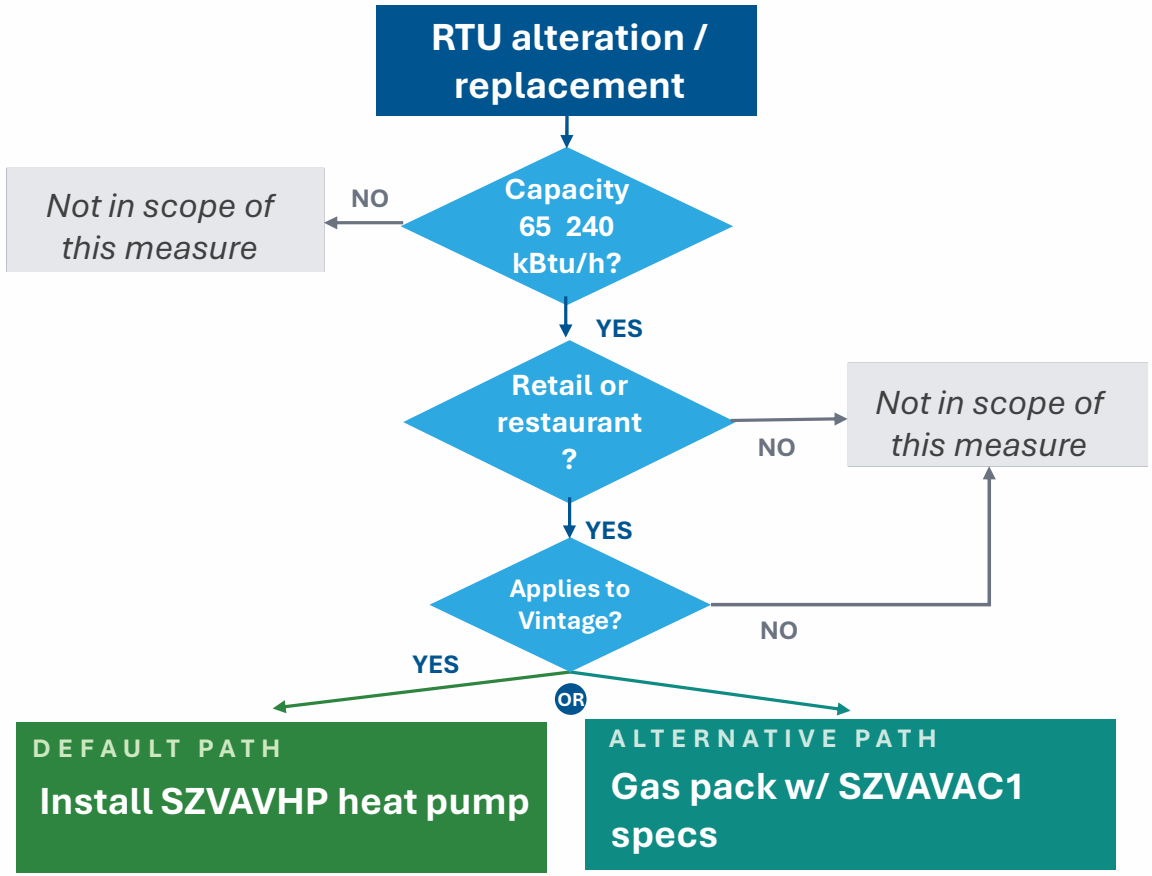
Natural Gas Savings
2.0 million therms reduced annually

Market Ready
Available 65,000 – 240,000 Btu/h units from major manufacturers

Proposed Code Language — §141.0(b) Extension

ALTERATION TRIGGER · COMPLIANCE PATHS · EXCEPTIONS

Code Trigger — Decision Flow



Proposed Exceptions

EX 1 — **CZ 16 — Dual-Fuel HP**

Heat pump with gas backup permitted (SZVAVDFHP rating). Severe heating loads make HP-only impractical.

EX 2 — **CZ 15 — Not Required**

Federal HP cooling minimum below gas-pack cooling-only minimum. Cooling-dominated Palm Springs profile.

EX 3 — **Electrical Service**

Where alteration would exceed main service panel or transformer capacity. PE-stamped CEC Article 220 calc required.

Gas Pathway — Alternative Compliance

For Projects Using Gas Furnaces

Gas-pack RTUs are permitted when their performance is equal to or better than the heat-pump scenario.

HEAT RECOVERY

ERR = 85 %

Pre-condition outside air; cuts both heating and cooling loads

COOLING STAGES

Three stages

3-stage DX coil; replaces 2-stage baseline; reduces part-load short-cycling

GAS HEAT STAGES

Two stages

Two-stage burner; improves turndown vs. single-stage 81% AFUE baseline

FAN CONTROL

25 % no-load

25 % no-load speed + 15 % power reduction; no extra Table 141.0-D allowance

Proposed Code Language — §141.0(b) Extension

ALTERATION TRIGGER · COMPLIANCE PATHS · EXCEPTIONS

For Buildings Newly Constructed Between 1978 and 1997																
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**
Sit-Down Restaurant	NR	NR	NR	NR	NR	SZVAVHP or SZVAVAC 1	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	SZVAVDFHP or SZVAVAC1
Large Retail	NR	SZVAVHP or SZVAVAC 1	NR	SZVAVHP or SZVAVAC 1	NR	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	SZVAVDFHP or SZVAVAC1

For Buildings Newly Constructed Before 1978																
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**
Sit-Down Restaurant	NR	NR	NR	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVDFHP or SZVAVAC1
Large Retail	NR	NR	NR	SZVAVHP or SZVAVAC 1	NR	NR	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	NR	SZVAVHP or SZVAVAC 1	SZVAVHP or SZVAVAC 1	NR	SZVAVDFHP or SZVAVAC1

Market Characterization

MARKET PENETRATION SIGNALS | V&E 2024 + Sathe 2025

54 %

of CA commercial floor area
served by single-zone RTUs

Comstock + CSS 2014

79 %

of RTU installations
are alteration (replacement) projects

Sathe 2025

78 %

of alterations still use
conventional gas-pack units

Sathe 2025

40 %

of CA single-zone RTU market by capacity
falls in the 5.4 – 20 ton band

Sathe 2025

Market Readiness

Current HP penetration: ≈ 19 % of large-RTU replacements (Sathe 2025) — HP share grew 9 % → 20 % from 2018–2020

Emergency replacements: ≈ 85 % of CA RTU replacements are emergency; contractors default to in-stock equipment

Equipment availability: All major manufacturers offer 5.4–20 ton HP units; several offer direct-fit roof-curb replacements

Adjacent regulation: Zero-NOx furnaces only from 2029; ultra-low NOx for ≤ 175 kBtu/h heating — both accelerate HP adoption

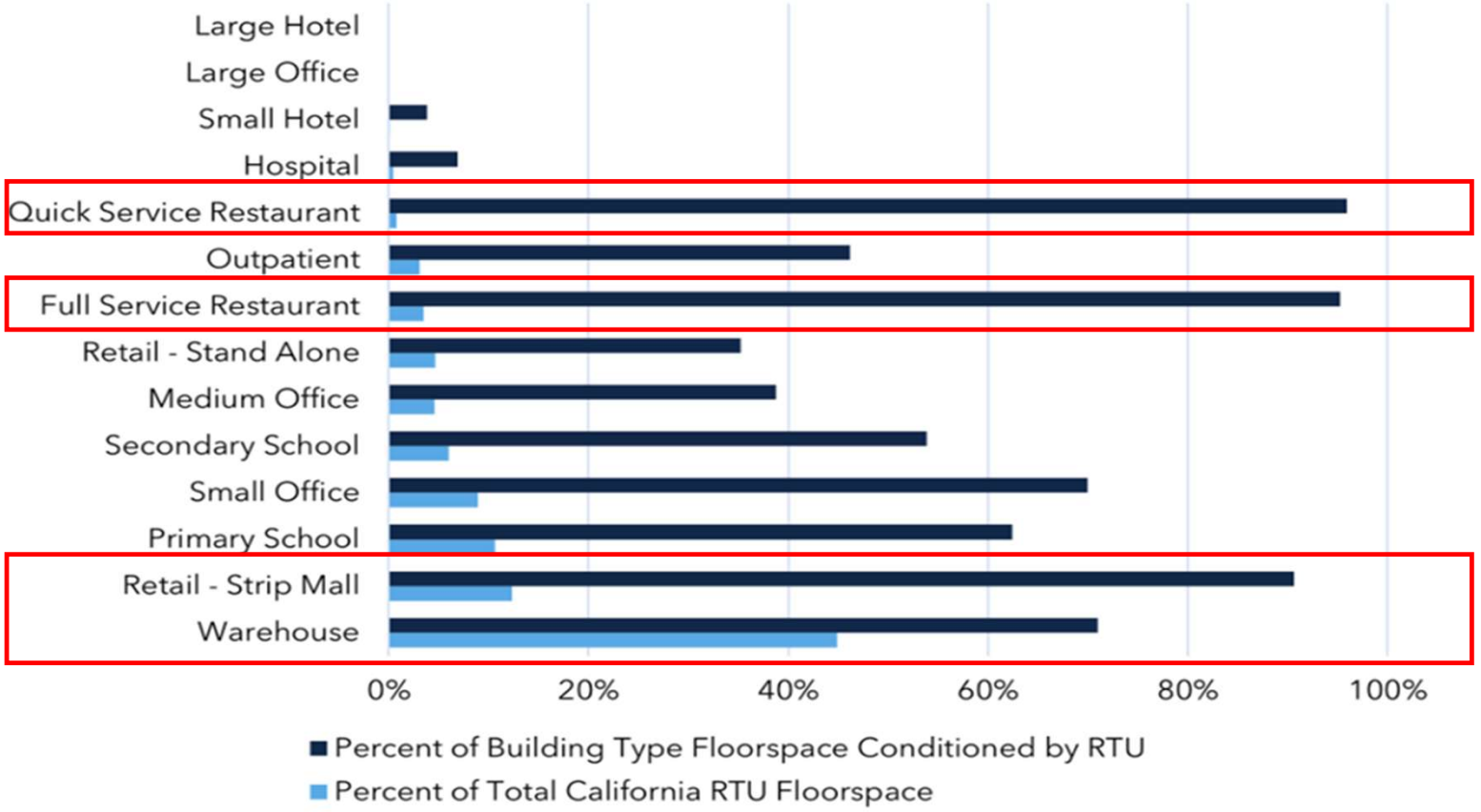
Code Sections Affected by the Proposal

ENERGY CODE | ACM REFERENCE MANUAL | COMPLIANCE TOOLS

DOCUMENT	CODE LOCATION	PROPOSED CHANGE
T24 Part 6 (restructured)	§401.5.2.2.1.2 (§141.0(b)2.C)	Extend alteration requirement to single-zone packaged RTUs with rated cooling capacity ≥ 65,000 and ≤ 240,000 Btu/h in retail and restaurant occupancies.
T24 Part 6 (restructured)	Table 401.5-C (new)	New table specifies SZVAVHP requirement by climate zone and vintage; identifies CZs where measure does not apply (CZ 15 retail/restaurant; CZs 7,8 retail pre-1978; CZ 7 restaurant 1978-97).
T24 Part 6 (restructured)	§401.5.2.2.1.2 Exception	Exception applies if alteration requires both larger capacity than existing AND exceeds main service panel or service transformer capacity (PE-stamped load calc required, per CEC Article 220).
T24 Part 6	Table 141.0-D	Gas-pathway alt-compliance with heat recovery (ERR = 85 %), three-stage DX cooling, two-stage gas heat, 25 % no-load fan, no extra Table 141.0-D fan allowance.
Nonresidential ACM	ACM §5.1.4	Standard-design HVAC for alterations updated: SZVAVHP becomes baseline system for retail and sit-down restaurants in cost-effective CZs (≤ 20 ton range).
Joint Appendices	CBECC / Reference Appendices	No new JA tests. CBECC-Com updates to recognize SZVAVHP and the SZVAVAC1 gas pathway. Modeled via AirLoopHVAC:UnitarySystem in EnergyPlus.

Methodology: Selecting Building Types and Vintages (Scope)

RETAIL & RESTAURANT



California statewide saturation and distribution of single-zone RTU conditioned floor area, by building type

Methodology: Selecting Building Types and Vintages

RETAIL & RESTAURANT

Floor area % considering demolished area ((BSD1970 -Demolished) +NEW+ ADD))						
Building Type	Proposed vintage bins					Total %
	Pre-1978	1978-1997	1998-2007	2008-2018	New Construction (2019+)	
Retail - All Sizes	37.5%	33.1%	18.1%	9.7%	1.7%	100.0%
Retail > 50,000 sf	31.5%	25.8%	25.5%	15.2%	2.0%	100.0%
Restaurant - All Sizes	49.6%	28.9%	13.2%	5.8%	2.5%	100.0%
Restaurant > 3,500 sf	48.7%	27.9%	13.4%	6.8%	3.2%	100.0%
Warehouse - All Sizes	22.9%	37.5%	21.1%	11.2%	7.2%	100.0%
Warehouse > 50,000 sf	12.3%	29.6%	29.3%	17.2%	11.5%	100.0%

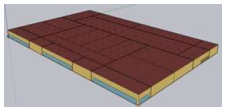
Source: Dodge Data & Analytics (2023)

70%+ of retail and restaurant floor area is pre-1997 — large stock at or near RTU replacement age

Methodology — Prototypes & Vintages

BUILDING TYPE SELECTION | DODGE 2023 STOCK DATA

Large Retail

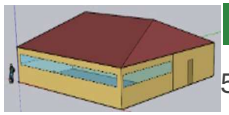


INCLUDED

240,023 sf · 1 story

≈ 470 M sf statewide

Sit-Down Restaurant



INCLUDED

5,503 sf · ≥ 3,500 sf

≈ 195 M sf statewide

Warehouse

EXCLUDED

52,050 sf · 1 story

≈ 1,208 M sf statewide

No viable gas-pathway alternative that meets HP performance.

Vintage Bins Modeled — Selected from Dodge 2023 Stock Distribution

← older stock

newer stock →

Pre-1978	1978-1997	1998-2007	2008-2018	New
38% ✓ MODELED	30% ✓ MODELED	15%	8%	8%

Methodology — Baseline Conditions

EXISTING BUILDING REPRESENTATION | ENVELOPE · LIGHTING

Modeled Envelope/Lighting Specifications

Vintage	Component	Value	Source
Both	Roof	Title 24 1992	30-year replacement
Pre-1978	Wall	U-0.352	Minimum insulation pre-Title 24
1978-1997	Wall	U-0.152	Low code-minimum levels of insulation
Both	Window	U-0.74 SHGC-0.52	Single and double-pane mix
Both	Lighting	Title 24-2016	Space-by-space LPDs

- Envelope per original vintage
- Roof per 1992 T24
  - 30-yr replacement
- Lighting per 2016 T24 LPDs

Baseline reflects realistic existing conditions, so savings represent what would actually occur at replacement.

Methodology — Baseline Conditions

EXISTING BUILDING REPRESENTATION | HVAC

Modeled System Specifications:

- **Existing HVAC for both vintage bins is modeled from minimum code requirements of 2008 Title 24**
- **Based on 15 year expected useful life**

- **Two-stage control** for DX units
- **Constant Volume** fan
- **Economize**r required (Per 2008 T24 §144)
- No Demand Control Ventilation (per T24 2008 §121-A)
- No Heat Recovery
- **Gas furnace** has minimum efficiency (81% AFUE)
  - Single-stage burner

Baseline reflects realistic existing conditions, so savings represent what actually occurs at replacement.

Methodology — Modeling Approach

PROTOTYPE SIMULATION · CBECC 2025 + EnergyPlus v25.1 · 16 CZs

BASELINE

2008-T24 SZAC + gas furnace
Reflects realistic stock

ADOPTION

35 % naturally occurring (HP 9 %→20 % 2018–2020 + zero-NOx pull)

SCALING

1/15 of stock annually (15-yr life, CEC 2029 forecast)

CZ 16

Dual-fuel HP modeled (electric resistance also evaluated)

- Most projects do not include electric resistance heat – reverse cycle used for defrost
- Without resistance heat, replacement HP units do not carry any additional weight

Methodology — Modeling Approach

PROTOTYPE SIMULATION · CBECC 2025 + EnergyPlus v25.1 · 16 CZs

SIMULATION MATRIX

2	16	2	3	192
Prototypes Retail · Restaurant	**Climate zones** All CA CZs	**Vintage bins** Pre-1978 · 1978-1997	**Compliance paths** SZVAVHP · SZVAVAC . SZAC	**Total number of cases** Prototype × vintage × CZ × path

Analysis Pipeline

1. INPUTS

- CEC nonresidential prototypes
- 2008-T24 baseline envelope/HVAC
- CEC LSC + source + GHG hourly factors
- 2028 CZ-CA weather
- Equipment costs: Manufacturer outreach and professional cost estimating (RSMeans 2026)

2. SIMULATION ENGINE

CBECC 2025
EnergyPlus v25.1

- AirLoopHVAC:UnitarySystem
- Explicit no-load fan-speed control
- Timed reverse-cycle defrost (no elec. backup CZs 1–15)

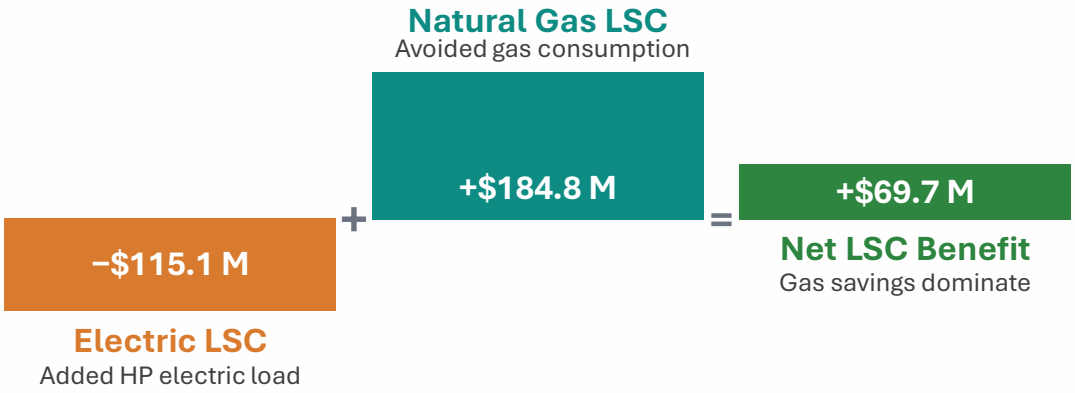
3. OUTPUTS

- Site energy (kBtu/sf-yr)
- Source energy (CEC factors)
- LSC ($, 30-yr PV)
- GHG (MT CO_2e/yr)
- Therms saved · BCR by CZ

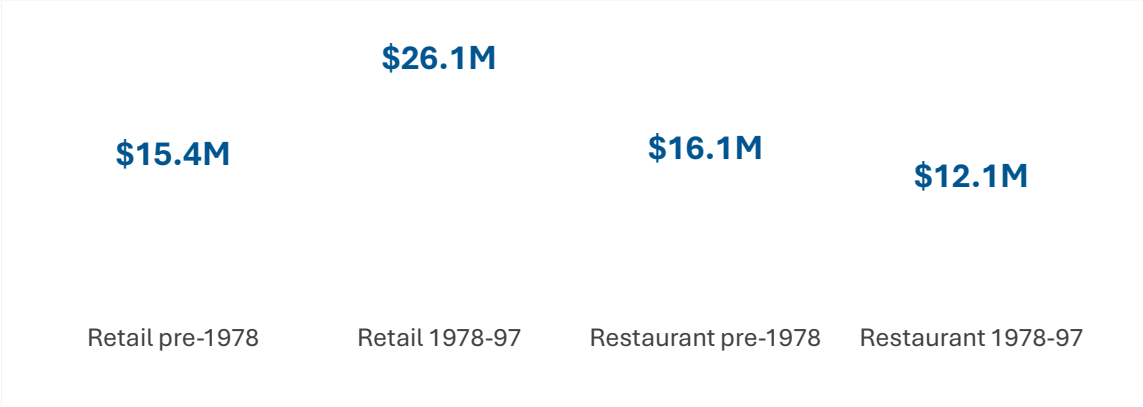
Energy Impact Results — First Year

STATEWIDE · ANNUAL · WEIGHTED BY FLOOR AREA AND REPLACEMENT RATE

Where Does the Energy Savings Come From?



Net LSC by Prototype × Vintage (Table 19, $M Present Value)



STATEWIDE NET LSC

(First Year)

$69.7 M

Net PV LSC benefit from first-year compliant alterations, statewide.

Horizon: 30 year LSC (replaces TDV for 2025+)

Discount: 3 % annual real

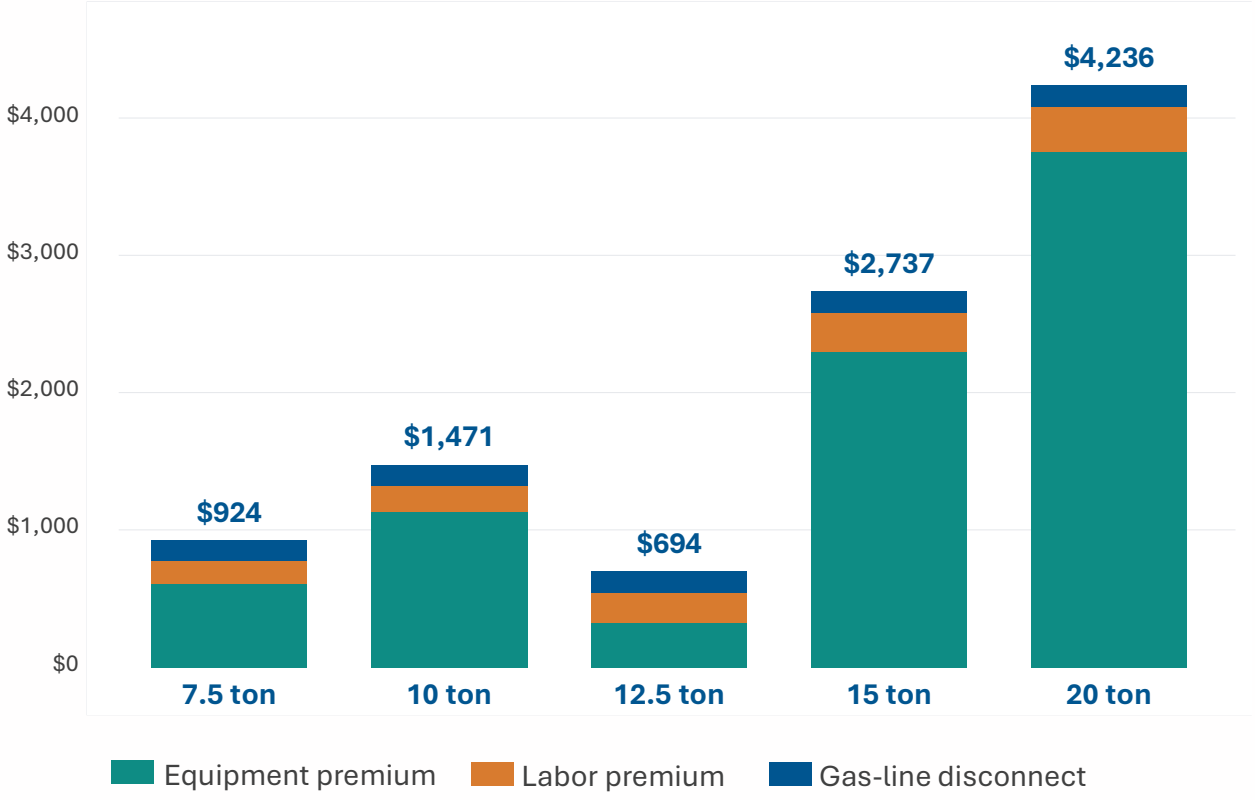
Adoption: 35 % (HP momentum + zero NOx pull)

Stock: 1/15 of applicable RTU stock / yr

Incremental Cost

HP PREMIUM OVER GAS-PACK | EQUIPMENT + LABOR | RSMEANS 2026

Incremental Cost by Capacity (Table 14, Region 5: CZ 11-13)



Measure Costs:

- Cost basis: Manufacturer outreach and professional cost estimating team (RSMeans 2026). Labor costs vary across five cost regions. A 15-year useful life was assumed, with equivalent maintenance costs for heat pumps and gas-pack systems.
- Larger units have higher incremental cost; HP Equipment cost premiums are very low for all unit sizes below 15 tons
- Labor costs vary slightly with climate zone; equipment costs are constant across climates

⚠ 12.5 TON ANOMALY

Gas-pack 12.5 T pricing high → compresses HP premium. Source data verified.

Cost-Effectiveness — BCR ≥ 1.0 Across Most CZs

BENEFIT-COST RATIO | LSC FRAMEWORK | ALL VINTAGES

CZ 15 EXCLUSION — PALM SPRINGS

Cooling-dominated load profile; federal HP min cooling efficiency is slightly below gas-pack cooling-only minimum, eroding seasonal cooling performance.

Result: Net LSC negative in CZ 15.

Action: CZ 15 excluded from the proposed requirement.

BCR Range by Building Type & Vintage

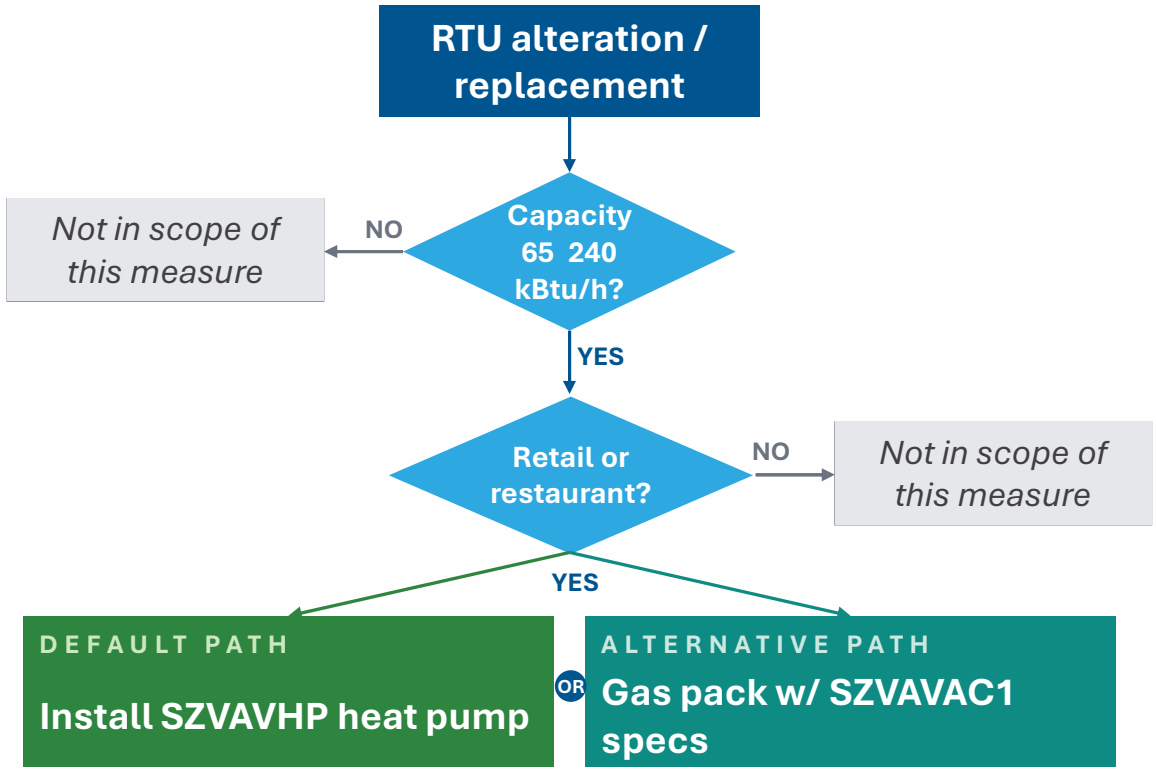
Building Type	BCR Range	Cost-Effective CZs	Excluded CZs
Retail Pre-1978	**1.4 – 5.7**	1–6, 9–14, 16	7, 8, 15
Retail 1978–1997	**1.2 – 6.0**	All CZs except CZ 15	15
Restaurant Pre-1978	**1.6 – 12.1**	All CZs except CZ 15	15
Restaurant 1978–1997	**1.4 – 9.9**	1–6, 8–14, 16	7, 15

BCR threshold for cost-effectiveness is 1.0. Restaurants reach BCR > 12 in milder climates due to high operating-hour leverage.

Proposed Code Language — §141.0(b) Extension

ALTERATION TRIGGER · COMPLIANCE PATHS · EXCEPTIONS

Code Trigger — Decision Flow



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EX 1 — **CZ 16 — Dual-Fuel HP**

Heat pump with gas backup permitted (SZVDFHP rating). Severe heating loads make HP-only impractical.

EX 2 — **CZ 15 — Not Required**

Federal HP cooling minimum below gas-pack cooling-only minimum. Cooling-dominated Palm Springs profile.

EX 3 — **Electrical Service**

Where alteration would exceed main service panel or transformer capacity. PE-stamped CEC Article 220 calc required.

Stakeholder Input Requested

OPEN QUESTIONS FOR THE 2028 RULEMAKING PROCESS

Q1 Dual-fuel HP availability in CZ 16

Incremental cost for SZVAVDFHP is $1,500–$4,210 per unit. Considering current and projected product offerings, is there sufficient single-zone variable-capacity dual-fuel heat pump (SZVAVDFHP) availability in the 65,000–240,000 Btu/h range to support the CZ 16 compliance pathway by the 2029 effective date?

A. Yes — sufficient products are available today across the full 65,000–240,000 Btu/h range.
B. Partially — products are available in the lower capacity range (≈65,000–135,000 Btu/h) but limited above ~135,000 Btu/h.
C. Not yet, but availability is expected to be sufficient by the 2029 effective date.
D. No — insufficient availability is anticipated to remain a barrier through 2029.
E. Unsure / insufficient information to assess.

Q2 Electrical-service exception

The current draft requires a PE-stamped load calculation per California Electrical Code (Title 24, Part 3) Article 220. Which compliance-trigger mechanism do you consider most appropriate for identifying buildings subject to this pathway?

A. PE-stamped Article 220 load calculation, as currently drafted.
B. A numerical connected/calculated load threshold (e.g., a fixed kW or kVA cutoff) requiring no stamp.
C. A service/panel rating test (e.g., based on existing service ampacity or main breaker rating).
D. A simpler administrative trigger (e.g., building type + floor area, or nameplate-based screening).
E. Other / combination — please specify.

Contact & Acknowledgments

QUESTIONS · COMMENTS · DATA REQUESTS

Project Team

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ACKNOWLEDGMENTS

California Energy Commission

Gypsy Achong, Habtom Tewelde, Bill Pennington, Payam Bozorgchami, Michael Shewmaker, Ram Narayanamurthy, Gabriel Taylor, Ronald Balneg

Comments for Today's Workshop

Due Date: July 17, 2026, by 5:00PM

Comments to be submitted to:
https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=25-BSTD-03

Thank you for participating in today's workshop!

Questions?